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## CONTENTS



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# TO OUR READERS

Perhaps the year 1995 will enter the history of computation as being the year that introduced the "network-centric" idea. This idea came and went without arousing much attention among computer specialists and users. Yet it may however, be an approach that could profoundly change the manner in which the common user is interfaced to information technology. And for this reason it should not go unnoticed by readers of the *Microelectronics Monitor*.

The main advantage of the NC idea is its potential to overcome software incompatibility by allowing the user to download and run applications written for any system on equipment with a price tag of less than US$500. The proposal is based on the Internet being accessed by the user from an inexpensive console with a fast processor and a few megabytes of RAM. The NC configuration does not include any hard disk drive or floppy drives, and relies on the Internet for storage and applications.

The proposal will be of considerable appeal to most users who never fully utilize the computer power being currently offered on present day PCs. These users usually work with only a small fraction of the software and computational power included in modern PCs, which are available at prices as low as US$2,000. However, prices as low as that can still be too high for many potential users with limited financial resources, as in the case of many developing countries, which lag behind in accessing information technology.

Although in my opinion the NC approach will progess and finally prevail, there are some obstacles along the path of such new developments. The main and most crucial, is the matter of bandwidth limitations that result from unsatisfactory Internet connection speeds. Other obstacles are the reliability of the Internet, as well as the psychological factor of distrust in leaving information and tasks that are important to the user on the network.

Therefore, the NC will not prevail from one day to the other. For developing countries however, the NC offers the chance of a short cut to access information technology , from which it follows that the expansion and fostering of Internet access in these countries is and should in future be a priority, and UNIDO's role is to make the developing countries aware of this.

Konrad Fialkowski
Scientific Editor

## PREFACE

One of the main thrusts of UNIDO's promotional activities is to monitor technological advances and sensitize the Member States on the issues that emerge, and which will have an impact on the performance and competitiveness of their industries in the very near future. In our opinion, the fault-tolerance approach is such an issue. With the proliferation of information technology to most or nearly all branches of industry, the problem of reliable performance of processors has become critical. A commonly known example is ABS, which is a computer application in the car industry. The brakes of the car are supervised by computers. At present, in the case of brakes failing, traditional mechanical braking is activated. Soon, however, for reasons justified in this paper, there will no longer be any mechanical braking process. The situation will resemble that of an aeroplane, which is controlled by the pilot through computers. Further progress of ever-more complicated computer systems in industry is unavoidable, and therefore the fault-tolerance approach will be an essential issue in industry in the coming years. This paper, written by an outstanding specialist in the field, Professor H. Kopetz, from the Technical University of Vienna, who is also working with leading car manufacturers and companies on instrumentation, is issued by UNIDO to alert the Member States to this situation.

Konrad Fialkowski
Scientific Editor
*Microelectronics Monitor*
16 November 1995

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# A. SPECIAL ARTICLE

## WHAT INDUSTRY CAN GAIN FROM FAULT-TOLERANCE

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**Abstract**

The ever-progressing reliance of industry and society on the proper operation of the information processing systems is focusing attention on the dependability of these systems. In case the inherent reliability of the microelectronics technology does not suffice, it is possible to increase the dependability of a computer system by the implementation of fault-tolerance. This article intends to give a survey of the present state-of-the-art of fault-tolerant computing, speculates on the medium-term developments in this important field, looks at the evolving markets for fault-tolerant systems, and discusses the benefits industry can gain from the proper application of this technology.

### *Introduction*

A computer system is fault-tolerant if a specified fault in one subsystem will not result in a failure of the system service at the system/user interface. Fault-tolerance is based on redundancy and the provision of more resources than are needed for the normal operation of the system, e.g., if a critical hardware component is duplicated within a fault-tolerant architecture, a single failure of such a component can be tolerated without any effect on the system operation.

In the last 10 years, the technology of fault-tolerant computing has grown in importance for the following two reasons:

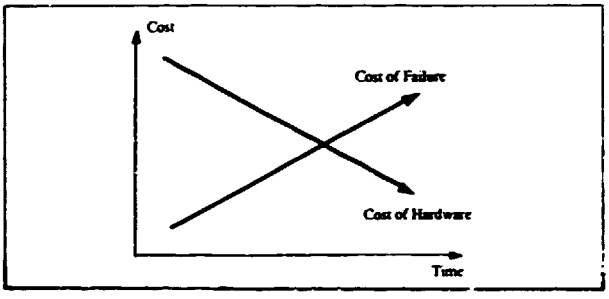
(i) The significant expansion of the automation of many critical business procedures (e.g., on-line banking) or technical processes (e.g., flight control of an aeroplane) has drastically increased the dependence of organizations on the proper operation of computer systems. As a consequence, the cost of computer system failures to an organization has become very significant.

(ii) A remarkable decrease of the cost of VLSI components, disk drives, communication lines and computer systems in general, led to a notable reduction of the cost of fault-tolerant system solutions that require replicated hardware resources.

These developments are depicted in figure 1. As a result of these trends (which are expected to continue over the next 10 years), the break-even point for the deployment of fault-tolerant computer architectures in a number of industries has been significantly lowered.

It is the objective of this contribution to explain the basic concepts of fault-tolerant computing, to discuss some of the fault-tolerance techniques that have been developed in the last two decades, and to explore applications areas where the deployment of fault-tolerant architectures can lead to economic advantages.

**Figure 1. Cost of system failure in relation to hardware costs**




### *Basic concepts*

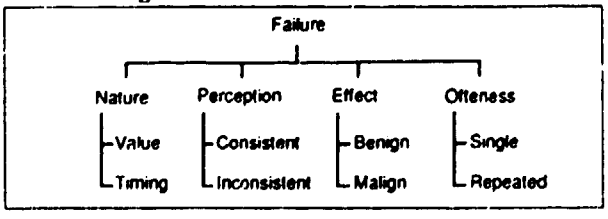
In this section a short overview of the basic concepts that have been established in the field of fault-tolerant computing are given. The International Federation of Information Processing (IFIP) via its Working Group 10.4 on Fault-Tolerant Computing has published a five-language document [Laprie, 1992] where these concepts are explained in more detail.

#### Failures

Computer systems are installed to provide a dependable service to their users. A user can be a human user or another (higher level) system. Whenever the service of a system, as seen by the user of the system, deviates from the agreed specification of the system, then the system has failed. A *failure* is thus an event occurring at a particular point in real time.

The following classifications of failures can be made:

**Figure 2. Classification of failures**



**Failure nature**: According to the nature of the failure we distinguish between *value failures* and *timing failures*. A value failure means that an incorrect value is presented at the system-user interface. A timing failure means that a value is presented outside the specified interval of real time. Timing failures can only exist if the system specification contains information about the expected temporal behaviour of the system.

**Failure perception**: In a system where there is more than one user, we can distinguish between *consistent failures* and *inconsistent failures*. In a consistent failure scenario, all users see the same (possibly wrong) result. If a subsystem either produces correct results or no results at all, i.e., it is quiet in case it cannot deliver the correct service, we call this special consistent failure a *fail-silent failure*. A fail-silent failure is the simplest failure mode a system can exhibit. In an inconsistent failure situation different users may perceive differing false results. It is evident that a malicious subsystem can disturb the correctly operating subsystems by showing contrary faces of a failure to each one of the correctly operating subsystems. This is the reason why inconsistent failures are sometimes called *two-faced failures*, *malicious failures*, or Byzantine failures. A number of theoretical results [Hdzilacos and Toueg, 1993] have been published concerning the minimum number of components needed in order to tolerate a specific type of failure. If we want to tolerate k failures of a certain type we need:

- k+1 components if the failures are of the type *fail-silent*,
- 2k+1 components if the failures are of the type *fail-consistent*, and
- 3k+1 components if the failures are of the type *malicious*.

It is therefore a wise decision to put enough error detection logic inside a component in order to guarantee a fail-silent behaviour at the system level. This approach is followed in many commercial fault-tolerant systems, such as, for example, in Stratus [Wilson, 1985].

**Failure effect**: Depending on the effect a failure has on its environment, we distinguish between *benign* failures and *malign* failures. A benign failure can only cause failure costs that are in the same order of magnitude as the loss of the normal utility of the system, whereas a malign failure can cause failure costs that are orders of magnitudes higher than the normal utility of a system, e.g., a malign failure can cause a catastrophe such as the crash of an aeroplane. We call applications where malign failures can occur *safety critical* applications. The fact whether a failure is benign or malign depends on the characteristic of the application the computer system is controlling.

**Failure frequency**: Within a given time-interval a failure can occur only once or a repeated number of times. If it occurs once only, we call the failure a *single* failure. A special case of a failure is a *permanent* failure, i.e., a failure after which the system ceases to provide a service until an explicit repair action has eliminated the cause of the failure. If a system continues to operate after the failure and we observe further failures within a specified time interval, we call the failure a *repeated* failure.

**Errors**

Most computer system failures can be traced back to an incorrect *internal state* of the computer, e.g., a wrong data element in the memory or a register. We call such an incorrect internal state an *error*. An error is thus an unintended state. If this state error exists only for a short period of time and disappears without an explicit repair action, we call the error a *transient* error. If the error exists permanently until an explicit repair action removes it, we call it a *permanent* error.

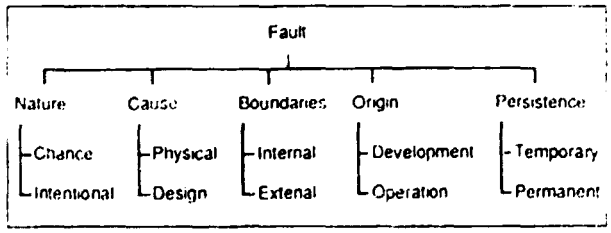
**Transient errors**: Transient errors form the predominant error class in many computer systems. There are a number of applications, particularly in the field of small real-time systems, where the system behaviour can be characterized by periodic duty cycles (e.g., control loops). A cycle starts with the sampling of the input data, it continues with calculating a given control algorithm and terminates after the output of the results to an actuator in the environment. If at the beginning of each cycle all internal data structures are initialized, then a result of the previous cycle cannot have an effect on the current cycle. In such a system a transient data error that occurs in one of the duty cycles cannot have a direct impact on any of the subsequent duty cycles. In many control applications a failure of a single control loop will not have a serious effect on the environment (there is only a finite amount of energy to move the actuator in a single cycle). Such systems are, by their design, tolerant to transient errors.

**Permanent errors**: In a large database system there is a huge amount of internal state—all data elements that are stored in the database. An error in any one of these data elements is very likely to be permanent, i.e., it stays in the system until an explicit repair action is called to repair the state. Since the data elements of the database act as inputs to future database transactions, an erroneous data element will cause the subsequent transaction to produce an incorrect output and store another erroneous data element into the database. We call such a steady increase in the number of errors in the database a *database erosion*. It is evident that utmost care must be taken to detect any transaction failure before the results of this transaction are permanently stored in the database.

**Faults**

The cause of an error, and thus indirectly of a failure, is called a *fault*. Faults can be classified as follows:

**Figure 3. Classification of faults**




**Fault nature**: A fault that has its origin in a chance event, e.g., the random break of a wire, is called a *chance*

*fault*. If the fault can be tracked to an intentional action by somebody, e.g., the implanting of a Trojan horse by a programmer to break the security of a system, then the fault is called an *intentional fault*.

**Fault cause**: A fault can be caused either by some physical phenomenon, e.g., the breakdown of a computer chip, or by an error in the design, such as a programmer's mistake or an error in the system specification [Gray, 1986]. In the field of fault-tolerant computing a number of techniques have been developed that are effective in handling *random physical faults*, such as the provision of active hardware redundancy by replicating the hardware components [Anderson and Lee, 1990].

No comparable progress has been achieved to handle design faults: subtle design faults in large systems are difficult to avoid and it is nearly hopeless to diagnose them by testing in a reasonable amount of time [Littlewood and Strigini, 1995]. The most promising approach tries to limit the complexity of a design by providing a clear structure and an understandable behaviour, e.g., by the partitioning of a large system into a set of composable autonomous subsystems that are interconnected by small, stable and testable interfaces [Kopetz, 1995].

A safety critical application is *fail-safe* if there always exists a safe state that can be visited in case the computer system fails, e.g., a railway signalling system where all trains can be stopped by setting all signals to "halt". In such a fail-safe application two or more diverse computational channels can check a safety assertion on the current state of the system. If any one of these diverse computations decides that the current state is unsafe, then the system can be switched to the safe state immediately. This form of design diversity is used in a number of fail-safe safety critical applications [Voges, 1988].

**Fault boundaries**: It is very useful to distinguish whether a fault is caused by a deficiency within the system or by some external disturbance, e.g., a stroke of lightning causing spikes in the power supply.

**Fault origin**: Faults that have their origin in an incorrect development of the system have to be distinguished from faults that are related to system operation, e.g., a wrong input by the operator.

**Fault persistence**: Finally, it is important to distinguish between faults that occur only once and disappear by themselves (e.g., the mentioned stroke of lightning), or faults will remain in the system until they are removed by an explicit repair action.

A more detailed description of the different types of failures and faults can be found in the above-mentioned book [Laprie, 1992]. It is the goal of the fault-tolerant computing effort to detect and mask, or repair errors before they show up as failures at the system-user service interface. The key to the design of a fault-tolerant system is the provision of redundancy.

## Redundancy

Fault-tolerance is achieved by the proper provision of redundancy, i.e., additional resources, for the detection and handling of errors. We distinguish between three types of redundancy:

- Physical resource redundancy,
- Time redundancy, and
- Information redundancy.

*Physical resource redundancy* refers to the replication of physical resources. For example, let us provide three independent computers instead of one and ascertain that all three computers will always visit the same states at about the same time, i.e. they are *replica determinate* [Poledna, 1995]. If the results of each computation are compared by a voting unit and the result that is in the majority is selected as the output, then a failure of a single computer can be masked. This is an example of a TMR (Triple Modular Redundancy) architecture [Johnson, 1989]. If the assumption can be made that all computers exhibit fail-silent failures only, then it is sufficient to provide two replica determinate computers. As long as at least one of the two computers produces a result (which, by definition of fail-silence is correct), then the fault-tolerant service can be maintained. The key assumption in such a fail-silent architecture is the *error detection coverage* of the fail-silent computers and the probability that a failure will be detected within the computer before it has propagated to the system user interface.

*Time redundancy* refers to the repetition of a computation or communication action in the domain of time. For example, it is an established technique in communication systems to re-send a message (at a different time) if the receipt of the first message is not acknowledged by the receiver. The implicit assumption that justifies such a procedure is that a temporary disturbance will have disappeared and will not mutilate the second message transmission.

*Information redundancy* refers to a specific encoding technique. A source text is encoded into an object text so that the object text has a larger code space than the source text, thus deliberately increasing the redundancy of the object text to enable the detection and correction of errors introduced into the object text. The addition of a check digit to a credit card number is a good example of information redundancy.

All three forms of redundancy are used in the design of fault-tolerant systems. Information redundancy is used to protect state information (e.g., error detecting and correcting codes in computer memory) and to protect the transport of messages (cyclic redundancy check fields in a message). Time redundancy is employed to detect and possibly tolerate the occurrence of temporary faults, particularly in communication systems. Resource redundancy is needed if permanent hardware or software faults have to be tolerated. To tolerate random hardware faults it is sufficient to replicate the hardware. Handling software faults by resource redundancy is much more delicate, since a simple replication of a software module will also replicate the fault. Different versions of software must be developed by different teams to reduce the probability of correlated design errors. There are some examples in safety critical systems where the systematic application of design diversity to tolerate software faults is used in industry [Voges, 1988].

## Assumption coverage

If we intend to guarantee that the given functional and temporal requirements of the service requests can be satisfied by the computer system despite the occurrence of faults, then we have to postulate a set of assumptions about the behaviour of the environment. The concept of *assumption coverage* [Powell, 1992] defines the probability that all these assumptions made

about the behaviour of the environment are in agreement with reality.

Two important assumptions that relate to the operation of a fault-tolerant computer system are the *fault hypothesis* and the *load hypothesis*.

**Fault hypothesis**

The fault hypothesis defines the types and frequency of faults that a fault-tolerant system must be capable of tolerating. If the specified fault scenario develops, the fault-tolerant system must still provide an acceptable level of service to its users. If the environment generates more or other faults than specified in the fault hypothesis, then even a perfect fault-tolerant system may fail. It is important to explicitly state the fault hypothesis and to validate that the fault hypothesis captures the behaviour of the actual environment of the planned system. The probability that the stated fault hypothesis is met by the reality is the limit to the dependability of any fault-tolerant computer system.

**Load hypothesis**

The load hypothesis defines the *peak load* that is assumed to be generated by the environment. It can be expressed by specifying the minimum time interval between, or the maximum rate of, requested transactions. Peak load implies that all specified transactions will occur with their maximum rate. In many real-time applications the utility of the computer system is highest in a *rare event situation* that leads to a peak load scenario. Consider the case of a nuclear power station monitoring and shutdown system. It is probable that in case of the rare event of a reactor incident—e.g., the rupture of a pipe—many alarms will be activated simultaneously, and will thus generate a correlated peak load. Statistical arguments about the low probability for the occurrence of a peak load scenario, based on the argument that the tail of a load distribution of independent events is very small, are not valid in such a situation. If a real-time system is not designed to handle the peak load it can happen that the system will fail when it is most urgently needed.

## *Fault-tolerance techniques*

A fault-tolerant system has to be so structured that the consequences of an error that has occurred in one of its subsystems are confined to this subsystem and are detected before consequences affect the operation or the state of the rest of the system. We call this activity *error confinement*. In a second step, the missing or erroneous results of this failed subsystem have to be masked or replaced by the results of a correctly operating redundant subsystem. We distinguish between passive and active redundancy.

**Error confinement**

Error confinement is only possible if an appropriate system structure is available, i.e., if the system can be decomposed into a set of autonomous subsystems with small and well-defined interfaces between these subsystems. The information flow across these interfaces, both in the domains of value and time, has to be monitored by an independent authority that can detect deviations between the actual behaviour and the specified intended behaviour. The knowledge of this intended behaviour can be derived from *a priori* knowledge of the intended system behaviour, from the comparison of two or more results produced by independent subsystems or from structural characteristics of the information passing the subsystem surface.

In a hard real-time system, the behaviour in the domain of time can be as important as the behaviour in the value domain. It is therefore necessary to check the temporal behaviour of subsystems at the subsystem interfaces. This is only possible if the subsystem interface specification contains sufficient information on the intended temporal behaviour of the subsystem. At present this important issue is not properly addressed in many industrial system architectures.

The error confinement in the temporal domain can be simplified if the subsystem interfaces are designed as strict data-sharing interfaces, without any temporal control signals crossing the interfaces. In such an architecture it is not possible that temporal control errors propagate from one subsystem to another subsystem. This implies that the temporal control of the subsystems is autonomous within each subsystem. An example of such an architecture is the MARS (MAintainable Real-time System) [Kopetz, Damm, Koza, Mulazzani, Schwabl, Senft, et al., 1989].

**Passive redundancy**

*Passive redundancy* (sometimes called *standby* or *cold* redundancy) refers to a redundancy organization that activates the redundant physical resources only after the primary source has failed. It is implicitly assumed that the primary resource contains error detection mechanisms to detect errors in its internal state or operation before an incorrect output is delivered to the user.

*Database transaction systems* are good examples of the application of passive time redundancy. At the beginning of a transaction a database record is locked and the old value is saved in a log file so that in case of a failure of an ongoing transaction the old consistent state of the database can be restored and the transaction restarted. Since the state of the database is periodically saved on an independent back-up device, the total database contents can be restored even after a failure of the primary storage device.

*Software exception handling* can be considered as a special type of standby redundancy. When the processor detects an exception during the execution of a program, then control is transferred to an exception handler that either terminates the operation of the program (termination model) or replaces the failed program by some other program (resume model). *Rollback recovery* is another example for standby redundancy using time redundancy. After an error is detected, control is transferred to a recovery point to restart the program from a previously stored checkpoint state.

In real-time systems the scope for the implementation of standby redundancy is limited. In most cases the time needed to restart another subsystem from a fault-free state after an error has been detected is not available. There are only a few hard real-time applications, where the deadlines are far enough in the future that all activities required for rollback recovery or exception handling can be executed before the deadline has expired.

**Active redundancy**

*Active redundancy* (sometimes called *hot* redundancy) refers to a redundancy organization that activates all redundant physical resources simultaneously. Depending on the failure characteristics of the redundant subsystems two (fail-silent failures), three (consistent failures masked by voting in a Triple Modular Redundancy configuration), or four (inconsistent or Byzantine failures) subsystems are

grouped into a fault-tolerant unit (FTU) to tolerate the failure of a single subsystem.

Active redundancy requires that the replicated subsystems visit the same states at about the same time. This property is called *replica determinism*. If replica determinism is not maintained, the ability to tolerate failures is lost.

Let us explain the concept of replica determinism on a simple example of a three-channel flight control system in an aeroplane. Immediately before take-off the system has to check if the take-off speed of the plane has reached a predetermined minimal speed limit. If not, the take-off has to be aborted. Consider the following scenario:

| | | | | |
|---|---|---|---|---|
| Channel 1 | speed limit | < | abort | decelerate engines |
| Channel 2 | speed limit | > | take-off | accelerate engines |
| Channel 3 | speed limit | > | take-off | decelerate engines (error) |
| Majority | | | take-off | decelerate (error) |

Although the decisions of channels 1 and 2 are both correct, they are not consistent, i.e., replica determinism is not maintained between channel 1 and channel 2. A single fault in channel 3 cannot be tolerated any more, since the majority voter will select the result of the incorrect channel. This problem cannot be avoided by providing five or seven channels.

There are a number of mechanisms that can destroy replica determinism [Poledna, 1995] such as:

(1) Inconsistent input from process sensors, both in the domains of value and time;
(2) Uncoordinated access to the local clocks (time-outs);
(3) Inconsistent order among messages;
(4) Non-deterministic language constructs (e.g., SELECT statement in ADA);
(5) Inconsistent view of membership;
(6) Dynamic pre-emptive scheduling decisions;
(7) Uncoordinated local information.

If there is a possibility of more than one correct decision at an n-ary decision point, then an agreement protocol must be executed among the replicas in order to agree on a consistent decision. However, the execution of such an agreement protocol takes time and communication bandwidth, both of which are limited in distributed real-time systems.

It is therefore expedient to try to limit the number of situations where the execution of agreement protocols is required. Whereas it is not possible to avoid the first reason for replica non-determinism—inconsistent input from process sensors in the domain of value and time—the other reasons can be avoided by a carefully designed architecture.

## *The markets for fault-tolerant systems*

In this section we analyse some of the important existing and emerging markets for fault-tolerant systems. We start by looking back on the historic developments and focus on two key markets, high availability systems and safety critical real-time systems.

### Historical perspectives

In June 1995 the 25th annual IEEE Symposium on Fault-Tolerant Computing, the premier international meeting on this topic, took place in Los Angeles (USA). At this meeting the historic developments and the present state-of-the-art in the field of fault-tolerant computing was critically reviewed. During the last 25 years a solid theoretical understanding of some of the key issues in the field of fault-tolerant computing has been gained and many prototype systems have been implemented that have proven the viability of the concepts. A number of companies, particularly in the field of high availability database systems, have been successful in the market. However, the wide industrial deployment of fault-tolerant computing has not been realized for the following reasons:

(1) The micro-electronics revolution has made it possible to integrate millions of transistor functions on a single VLSI chip. This integration has not only led to phenomenal performance increases and cost reductions, but also to impressive reliability improvements of non-redundant systems. Today it is possible to implement a complete system on a few chips with a resulting MTTF (Mean Time To Failure) of around a thousand years. The inherent reliability of such a highly integrated system is sufficient for many computer applications with benign failure modes.
(2) Up to now there exist only a limited number of computer applications with catastrophic failure modes [Mellor, 1994]. A most notable example is the aircraft industry with the "fly by wire" systems. In other industries, e.g., the nuclear power industry, the deployment of computers in safety critical applications is progressing slowly. For the relatively few safety critical computer applications a number of special proprietary fault-tolerant architectures have been developed that are not available on the open market.

We can expect that this situation will change over the next few years. The need for high availability database systems will grow as the computer systems become totally integrated in day-to-day business operations of most organizations. Generic solutions for fault-tolerant safety critical real-time systems will bring the cost of these systems down to a level that will open large new markets in the field of embedded computer and process control applications.

### High availability systems

The day-to-day operation of an increasing number of organizations depends on the continuous availability of many computer services. Consider as an example a travel agency that depends on the services of its own local computer system, on the services of a number of airline reservation systems and some credit card authorization systems. Even a short unavailability of any one of these database transaction systems will have a significant business impact. Since the intrinsic reliability of a standard database server that has to service thousands of terminals is not sufficient for many of these business-critical applications, fault-tolerant computer systems have in the past been successful in the field of database transactions. Companies such as Tandem and Stratus [Johnson, 1989] have taken advantage of these user demands and successfully marketed fault-tolerant transaction processing systems for many years.

Many database transactions that run on PC servers of small and medium-sized companies are becoming business critical. The loss of any data or the unavailability of the server for a prolonged period of time has a very negative effect on the business operation, making the installation of a fault-tolerant server an interesting alternative. A section of the $11 billion a year PC server market is thus a target for fault-tolerant system solutions.

Another class of systems where the application of fault-tolerance is the rule rather than the exception are large telephone switching systems. Whereas the infrequent loss of a single telephone connection between two end-users is tolerated, the probability of the total loss of a central switch must be extremely small. As the costs of fault-tolerant system solutions are going to decrease in the next

few years, the market for high availability telephone switching systems is going to expand to smaller telephone exchanges, offering new business opportunities.

**Safety critical systems**

In the past few years there has been a growing tendency to replace hydraulic, mechanical or electric control devices in many industrial products by real-time computer systems. A good example is the field of automotive electronics as an emerging mass market for distributed real-time computer systems. After the successful installation of computer networks in cars for non-safety critical body electronic functions, such as the control of lights or power-operated windows, there is a growing activity to control safety-critical core vehicle functions, such as the engine, transmission or the brakes, by real-time computer systems. The envisioned benefits of such computer applications are impressive: reduction of fuel consumption and pollution, increase in the comfort of the vehicle and, above all, reduction of production costs.

At present, computer safety in cars is approached at two levels. At the basic level a mechanical system provides the proven safety level that is considered sufficient to operate the car. The computer system provides optimized performance on top of the basic mechanical system. In case the computer system fails in a fail-silent mode, the mechanical system takes over. Consider, for example, an Antilock Braking System (ABS). If the computer fails, the "conventional" mechanical brake system is still operational. In the near future, this approach to safety may reach its limits for two reasons:

(1) If the performance of the computer-controlled system is further improved, the "distance" between the performance of the computer-controlled system and the performance of the basic mechanical system is further increased. A driver who gets used to the high performance of the computer-controlled system might consider the fall-back to the inferior performance of the mechanical system already a safety risk.
(2) The improved price/performance of the microelectronic devices will make the implementation of fault-tolerant computer systems cheaper than the implementation of mixed (computer/mechanical) systems. Thus, there will be a cost pressure to eliminate the redundant mechanical system and replace it by a redundant (active redundancy) computer system.

In safety critical applications without a mechanical backup, such as a flight control system or a train signalling system, no single point of failure is allowed to exist within the computer system. In these applications the deployment of fault-tolerant architectures is dictated by the certification authorities. Whereas in the past many companies tried to design their own proprietary fault-tolerant architecture, there is now a tendency towards generic fault-tolerant architectures that will fill the needs of many companies and industrial segments, e.g., process control systems, medical systems, etc. The availability of these architectures on the market will generate many new opportunities for the deployment of safety critical systems in a variety of applications.

## *Envisioned benefits of fault-tolerance*

**System cost**

In a market-driven economy every decision to invest in a new technology is driven by cost considerations. An end-user will invest in a particular computer system solution for one or more of the following reasons:

(1) Improved functionality or ease of use of the new computer system, or
(2) Improved performance, or
(3) Improved dependability.

The additional cost of a fault-tolerant computer system can only be justified by the improved dependability over a non-fault-tolerant solution, since there is no change in functionality or performance.

The cost of a computer system failure can be broken down into two terms: the indirect cost of the failure caused by the impact of the system outage on the business operation and the direct cost of repair and system reintegration. Since the latter is often covered by a maintenance contract from the system vendor, the main cost justification for the investment into a fault-tolerant solution must come from the indirect impact of the cost of failures on the business operation at hand.

In a non-safety critical application, such as a database transaction system, the cost argument has to consider the system availability and the data integrity as the critical measures. If the system is business critical, and the unavailability of the services is a substantial cost factor for the organization at hand, then the extra cost for fault tolerance can be justified.

In safety critical applications the arguments for a fault-tolerant solution are directly related to the potential cost of a catastrophic failure, i.e., to the system reliability. Either the certification agency requires a "no-single-point-of-failure architecture", in which case there is no alternative to a fault-tolerant architecture, or the cost of a catastrophic failure multiplied by the probability of failure exceeds the extra cost of a fault-tolerant solution.

From the previous discussion it follows that only the difference between the intrinsic dependability of the non-fault-tolerant solution and the improved dependability of the fault-tolerant solution enters into the considerations. Since most fault-tolerant architectures focus on the improvement of the hardware dependability, no significant impact on the system dependability can be expected if the main cause of system outages is related to software malfunctions. Hardware fault-tolerance is only justified if a very high level of software reliability has already been achieved.

**Maintenance**

A fault-tolerant architecture can lead to a significant reduction of the system maintenance costs. If the system detects and isolates the faulty subsystem autonomously, the cost for manual fault diagnosis, a main cost factor during system maintenance, disappears. Furthermore, since the system operation will not be disrupted by the hardware fault, the time-consuming restart and recovery procedures that have to be followed after a hardware failure are eliminated. Some fault-tolerant systems even notify the system vendor autonomously via a communication link about the failure of a redundant subsystem and continue the operation without redundancy until the faulty part is replaced by a spare unit without any disruption in the computer operation.

With fault-tolerant architectures it is possible to replace the expensive "on-call" maintenance by a lower-cost "preventive" maintenance. This can be of extraordinary significance in process control applications at remote sites, where the 24-hour maintenance contract is often very expensive.

On the other side it must be considered that a fault-tolerant system will contain more hardware than a non-fault-tolerant solution. This redundant hardware also has a probability of failure and must be maintained. But in general, this additional cost of maintaining the replicated hardware units is not a major cost factor.

**Opening of new markets**

For a system vendor, the introduction of a fault-tolerant architecture may open new market opportunities. As the computer systems penetrate into the core operation of more and more organizations, the software systems become more stable and mature, and the price for hardware fault-tolerance is reduced by the progress of the hardware industry, the number of organizations that opt for the installation of fault-tolerant systems will be on the rise. Vendor organizations that can meet this anticipated market demand at the right time can establish themselves as technology leaders in a market that is anticipated to grow in importance.

## Conclusion

Over the last 25 years, computers have become an indispensable part of everyday life. As a consequence, the failure of a computer system can have a severe impact on the operation of a business, or can even become the cause of a major catastrophe. Although the inherent reliability of computer products has been improved dramatically over the stated period, the dependability requirements of many applications cannot be satisfied any more by the inherent reliability of the computer technology. This is the reason why the field of fault-tolerant computing is gaining in importance and interest. Fault-tolerant computer architectures can provide a level of dependability that is far beyond the dependability of its subsystems.

In this short contribution, the basic concepts and techniques of fault-tolerant computing have been discussed and some of the major business opportunities for fault-tolerant systems that are expected to emerge in the near future have been highlighted.

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# B. NEWS AND EVENTS

### *Removing toxic substances from the soil using electrochemistry*

By conservative estimates, there are at least 4,000 hazardous waste sites in the United States alone. Many of these store toxic heavy metals or organic substances which may be washed into the rivers or gradually seep into the groundwater and ultimately pollute our drinking-water. Many other countries face similar problems. Current methods for cleaning up waste sites involve excavation or soil flushing, followed by chemical treatments or incineration. While these methods are often effective, they are very expensive.

A number of techniques are being studied that avoid digging up the soil and promise to be less expensive. Among these emerging *in situ* techniques is an electrochemical process which has the potential to work well with many contaminants and in a variety of soils, such as clays, where other techniques are less likely to succeed. Field tests are being conducted in a number of countries, applications have started in at least one and companies have formed alliances to explore the viability of the process.

The electrochemical process, variously called electroremediation (-reclamation, -restoration) or electrokinetic remediation, involves the application of a direct current voltage between electrodes placed in the soil at a suitable waste site. Most soils contain water to various extents in the pores between the soil particles and have an inherent electrical conductivity which results from salts leached from the soil minerals. Many contaminants present in waste sites dissolve in the soil water and, under the influence of the electric field, move to the electrodes where they can be removed.

From a technological point of view, electroremediation's chief advantages are its inherent ability to work in low-permeability soils, such as silts and clays, and its applicability to a wide range of metallic and organic impurities. On the other hand, in its present form, electroremediation is not applicable to the removal of most water-insoluble organics and it is economically unfeasible for the removal of trace metals at sub-ppm levels.

Laboratory experiments under controlled conditions, mathematical modelling and field tests have all contributed to better defining the process. It has become increasingly clear that success or failure of electroremediation in the field will largely depend on careful site selection and characterization. This includes detailed geotechnical and hydrological evaluation, soil analysis, contamination history, contaminant concentration and distribution, electrochemical laboratory experiments on actual soil samples as well as design and cost analysis, using mathematical modelling. A decision whether a certain site is amenable to electroremediation would be made on the basis of this evaluation.

From all that is known at this time, electroremediation is an emerging technology that offers certain unique advantages over other *in situ* technologies and deserves continued attention. A small number of field tests and applications have been performed already. Success or failure are highly site specific. A larger number of field tests is required to define better the range of applicability of the process and its economics. Commercialization of the process should be possible in the next few years when applied to situations that field tests have identified as amenable to electroremediation. (Extracted from *Chemistry & Industry*, 15 May 1995)

### *TCDC-INRES: at your fingertips!*

SU/TCDC has the unique responsibility—and opportunity—to foster international development cooperation by promoting maximum use of the TCDC modality. Among the most valuable resources made available by SU/TCDC for this purpose—yet still an under-appreciated and under-utilized UNDP service—is the Information Referral System for developing countries, known as TCDC-INRES.

INRES is the most comprehensive database exclusively dedicated to cataloguing and providing instant access—at the stroke of a computer—to training and expert services available in the developing world. Yet even after nearly two decades of continuous refinement and improvement and, most recently, its availability on desktop computers in over 130 countries throughout the world, INRES remains surprisingly underutilized by all but a select group of knowledgeable users.

The range of organizations targeted by INRES as potential beneficiaries of the system spans a wide spectrum:

- Businesses, non-profit organizations, individuals and government agencies in developing countries needing consultancy services or seeking training opportunities for their staff can easily take advantage of the massive information maintained in INRES.
- Government ministries, agencies or departments can use INRES to identify qualified contractors or facilities offering training for development projects. Indeed, INRES can also serve as an excellent source of information to developing countries on their own national institutions' capacities.
- Institutions and the private sector can use INRES to find potential partners for business ventures or joint research projects.
- Other agencies within the United Nations system can use INRES, alongside the databases they maintain themselves, to identify contractors to participate in technical cooperation projects. Although INRES at the moment does not contain the names of individual experts, it contains information on institutions where experts are available and the specific fields in which they work.

INRES was launched in 1977 with the publication of the "Directory of Services for Technical Cooperation among Developing Countries". Copies of this directory were distributed from United Nations Headquarters.

The opportunities provided by INRES have been made ever more attractive through a continuous process of upgrading and improvement. Hence, in response to mandates from the United Nations General Assembly, INRES was modernized in 1984 through automation on a mainframe computer. When this method, in turn, was found to be too centralized and inflexible, it was replaced by a PC-based system in 1989. INRES was re-thought and revamped yet again in 1993 through use of the Microsoft Access Data Base Management System—making the database both "user friendly" and suitable for mass dissemination.

**New software provides instant database**

Last year, SU/TCDC broke further new ground with the creation of "INRES-Lite". This new PC-based format was distributed in late 1994 to over 350 beneficiaries world-wide, making INRES data available literally at the fingertips of its users. INRES-Lite contains the full set of the data previously maintained in the main database, presented in the software known as "Folio Views". Attractive features of the new INRES-Lite include:

- A powerful on-line query capability;
- A multilingual thesaurus making it possible to cross-reference inquiries instantly in three languages: English, French and Spanish;
- Distribution in a nine-disk package available in two PC environments—DOS and Windows—and working both on stand-alone and local area networks.

In the spirit of TCDC itself, INRES is meant to be used by every national and international organization involved to any degree in the development field. To encourage the widest possible distribution of INRES-Lite, the SU/TCDC has ensured that the resource is free of limitations restricting the free and open transfer of intellectual property rights. In this spirit, all organizations receiving the new INRES-Lite are encouraged to copy and distribute the software at the sectoral and departmental level.

The next wave of the future? To provide world-wide and real-time access to INRES, preparations have already started to offer access to INRES on the Internet.

For those not yet convinced, inquiries about INRES are welcome at all times. Questions—or requests for the software—may be sent to on-site TCDC focal points, to UNDP country offices, or to SU/TCDC in New York. One final hint: the more specific the request, the more focused the response. In the spirit of INRES: the better the inputs, the better the results. (Extracted from *Cooperation South*, May 1995)

### *Video history of the semiconductor industry*

An oral history of the semiconductor industry, called the "Silicon Genesis Project", is being produced and funded in cooperation with Stanford University Libraries.

Extended videotaped interviews with semiconductor pioneers will be conducted, produced and donated to Stanford University, where they will serve as the repository for scholarly access to the materials.

The unedited videotaped interviews attempt to capture the history, motivation and vision of semiconductor pioneers.

The multi-year project started in early 1995. More than 25 contributors in semiconductor technology, venture capital and business among Silicon Valley pioneers have been identified as future interviewees. One of the project's goals is to eventually make all or portions of the broadcast-grade videotapes digitized and available over the Internet. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *What computers can tell us about evolution*

One clue is provided from computer program code evolution experiments known as "artificial life" (see *Bio/Technology*, **13**: 122-123, February). Rather than use computers to model three-dimensional shapes, the computer's RAM memory is used as a virtual universe to explore which types of evolutionary formats win out in response to artificially designed selective pressures. These experiments show that homologous recombination of the previously selected sequences is the primary generator of new structures. Point mutation was shown to be a background operator, assuring that crossover has a full range of alleles available. Recombination—with point mutation—and selection were shown to be sufficient for sequence evolution and the continuous accumulation of information content.

One can extend these results to the biological realm. In a sense, nature uses local, parallel processing as the organizational strategy for meeting any environmental challenge while maintaining homeostasis. Rather than being restricted by a single, global average set by a computer programmer, each protein determines its own folding based on its local environment. The collection of these mini-processor proteins that make up each cell cooperatively interact directly with both the internal and external environment to respond to change. This type of molecular parallel processing (so far, without evolution by recursive selection) has now been utilized for "molecular computing". This is a powerful computational method because no program that would average interactions could adequately simulate the many known and unknown low-affinity interactions that contribute to the complex interactions that produce protein folding and binding—in turn driving other interactions.

Viewed from this perspective, the complexity of these interactions suggests that it will always defy attempts at rationalization and manipulation. This, in fact, may be a strategic goal of nature in evolving such complex systems. The complexity itself may serve as a defence to exclude competitors such as pathogens or viruses. Modern encryption technology presently used to protect private on-line communication uses a similar strategy to ensure that outsiders cannot gain control of the system. (Source: *Bio/Technology*, Vol. 13, June 1995)

### *New networks*

One of the perennial problems of the information age is the lack of domestic bandwidth. There are already all sorts of data highways in the world; but from your home you cannot get onto them. The rate at which data can leave the home (the bandwidth) is mostly limited to 20,000 bits a second or so on a telephone line. Humdrum electric circuits may offer a way to get data in and out of houses quickly enough to let the residents interact with any sort of television that offers them the chance —and do much more besides.

Power companies have long tried to send signals down their lines, but they have usually been beaten back by the noise and interference caused by electric motors and practically anything else plugged into the mains. So messages have been limited to the occasional on-off signal for street lights and substation switches. Inside the house, the mains have been used for little more than carrying the reassuring noise of a baby's breathing to the parents in the sitting-room below.

In the age of data highways, however, the stakes are higher. Any method of moving data that does not require digging up streets or negotiating rights of way is being looked at anew. Here, electric power lines have the advantage of being already laid, and paid for - if only they can be tamed.

Norweb Communications, part of Norweb, one of Britain's regional electricity companies, thinks it may have found a way. By using a broad band of spectrum at frequencies above one megahertz, where it is easier to limit noise, it claims it can pump up to 20 million bits per

second through the mains. It is providing digital telephone services and Internet access to 20 homes in the Manchester area as a trial.

The system on trial offers each house 32,000 bits per second, but the capacity is constrained mostly by the off-the-shelf telecommunications equipment used with the trial—the wires themselves could carry much more, at least for the 250 metres (820 feet) between the average house and its substation. A substation serving 200 houses should, in principle, be able to offer them all 100,000 bits a second simultaneously. At the substation the messages could be put onto the fibre-optic lines that Norweb, like most electric companies, already uses to control its network.

A first drawback is cost. If the electronics necessary to coax such miracles from a simple power line are more expensive than laying fibre from scratch, few companies will bother—and Norweb will not yet reveal the costs. Then there is the question of the real world. It is always possible to fine-tune a system for one particular line; developing a technology that works on any line, anywhere, is more difficult. Norweb says that its system only works on British power networks at the moment, although it plans to try it soon in America—where almost everything is different, from voltages up.

About a dozen American electric utilities are now running trials of such electricity-management schemes, according to Parks Associates, a Dallas consultancy. Intellon, a company in Ocala, Florida, sells plug-in devices that send 10,000 bits per second along ordinary American home wiring, letting utilities control appliances, read meters and monitor usage. With this it hopes to lay the foundation for "smart homes" with networked appliances.

Over the next two years, boxes using the same technology and reaching data rates of 100,000 bits per second or more on ordinary wiring are expected to come to market. That could turn any household's wiring into a full-blown Local Area Network (LAN). (Extracted from *The Economist*, 24 June 1995)

### The multimedia challenge

Although numerous platforms for the delivery of multimedia are available, by far the most common is CD-ROM, to run either a PC or a MAC. Some information applications for multimedia operate on Philips CD-i, but this technology has not yet achieved the installation levels of CD-ROM drives. Figures vary, but it is safe to assume that between 70 and 80 per cent of the PCs shipped in the United States in 1994 contained built-in CD-ROM drives.

Telecommunication companies world-wide are investing heavily in optical fibre which will deliver multimedia, and the television cable companies are also aware of their ability to do so. With the development of the World Wide Web and the introduction of Netscape as the successor to the Mosaic interface, claims are being made that the Internet will become the obvious platform for the delivery of multimedia.

The question of platform is complex and changing, too quick for comfort, as technology develops. Potential customers may wonder whether sufficient appropriate applications exist or can be written for a particular platform; and given the history of the very rapid drop in the price of hardware often months after launching, they will be paying large sums for technology that will cost a fraction of the price 10 months later. The implications of this are that any organization, with a few exceptions, seeking to develop a multimedia title, whether for internal or external information, would be wise to use CD-ROM. (Source: *Information Management Report*, May 1995)

### IT outsourcing: maximize flexibility and control

Between 1991 and 1993 40 US and European companies were studied to see how they had grappled with the issue of outsourcing IT and it was concluded that in a majority of cases the strategic versus commodity approach led to disappointments and problems. A company's main objective should be to maximize flexibility and control so that different options can be pursued as it learns more or circumstances change. The way to maximize control and flexibility is to maximize competition. The explosive growth of the IT industry has allowed companies to create a competitive environment. The outsourcing decisions made by the 40 organizations studied showed that about half of them had taken a selective approach, outsourcing such services as data centre operations, telecommunications, applications development and applications support. A total of 150 interviews were conducted with business executives, chief information officers and IT staff. Individual best practices for sourcing IT were identified but no one company had combined all of them into a blueprint that others could use.

Energen is used to illustrate a case history of outsourcing covering choosing suppliers: continuous learning requirements; and the case for selective outsourcing. Questions asked when making a decision are: is the system truly strategic? Will IT requirements change? If a system is a commodity, can it be broken off? Could the internal IT department provide this system more efficiently than an outside provider could? Does the company have the knowledge to outsource an unfamiliar or emerging technology? What pitfalls should be considered when hammering out contract details? How can a contract be designed that minimizes risks and maximizes control and flexibility? What in-house staff are needed to negotiate strong contracts and to ensure that the company gets the most out of these contracts? What in-house staff are needed to allow change to be exploited? The processes that are used to manage IT will determine how effectively a company controls the IT services that it consumes. Companies that excel in developing such processes will end up not only with superior IT but will have a superior ability to recognize and exploit market change. (Source: *Harvard Business Review*, May/June 1995)

### JESSI sees bright future for optical lithography

Europeans involved in the JESSI programme expect optical lithography to have a more extended future than that anticipated by many US and Japanese workers.

At a European micro-electronics conference in Grenoble, Jean Paul Klein, head of JESSI's project for the development of sub-half micron processes, said the use of optical lithography will continue well into the next century. This will delay the high capital equipment and associated costs connected with e-beam and X-ray lithography.

At the 0.25 μm level, JESSI has produced two processes, one employing deep UV lithography with excimer lasers and the other i-line steppers with phase-shift masking. Deep UV with phase-shift techniques will be used for the 0.18 μm process that employs optical lithography by the end of 1996. The JESSI programme ends in that year and such an achievement could attract additional funding from the Governments of the European Union countries.

The first 0.35μm JESSI test structures will be produced this year, with commercial production scheduled

for 1997. A start has been made on the definitions for a 0.18 μm process. Plans for the successor 0.12 μm process specifications are scheduled for 1996, but the 4 Gbit DRAM level is unlikely to be commercially exploited before 2004. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### European Union assesses equipment

The European Union plans to fund some 5-10 projects in its new Equipment Assessment (EA) programme.

Equipment will be purchased from a European supplier and operated at a European institute, university or industrial laboratory site by staff from at least two users, together with the site staff. The work will take 12-18 months after which the equipment will often become the operating site's property.

Results assessing the equipment's suitability for industrial requirements will be disseminated world-wide. Total funding is expected to be approximately $19 million.

The programme offers a significant opportunity for semiconductor users to gain an in-depth assessment of an item of equipment without tying up valuable production line space or purchasing the equipment. It also offers equipment suppliers an opportunity to prove the value of their equipment to potential buyers.

EA projects may be performed at such centralized sites as IMEC (Belgium), LETI (France) and the industrially-orientated laboratories of the Fraunhofer Gesellschaft in Berlin and Erlangen. However, the United Kingdom has set up a Semiconductor Equipment Assessment Potential Sites group at the instigation of JEMI UK and the Department of Trade and Industry. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### "Virtual corporations"

Videoconferencing and Internet-supported facilities such as Email may finally make the "virtual company" a reality. On the simplest basis, employees can work from home rather than commuting to the office. When staff do visit the office, they may well share desks, rather than have their own personal space; Digital and Ernst & Young provide examples of companies operating on a "hot-desk" basis. At a somewhat higher level of complexity, inter-company project teams can be established.

Henley Management College in the United Kingdom is a virtual institution: two thirds of its 300 academic staff are not based on the campus at all, and are paid on a fee basis for their services, rather than being salaried. By the end of this year, eight colleges in the Scottish highlands and islands will be linked via Email and videoconferencing to form a virtual "university".

The founder of Atari established a virtual corporation, Vent, two years ago. This will launch a computer game, *Hyper Soccer*, in the autumn. The board of directors has never met in a single physical location, but commune over the Internet. Software design and manufacture are handled by remote contractors.

The concept requires a re-thinking of attitudes on the part of both employer and employee. Old notions of loyalty to the company are no longer appropriate: instead, employees become contractors paid for specific skills. At the same time, employees must take responsibility for their own careers. Fee-earning contractors must search out prospects, convert them into customers, and chase them for payment. They require skills in sales, invoicing and credit control in addition to their core professional expertise. (Source: *Computing*, 11 May 1995)

### World Wide Web

The premier means for information storage and retrieval on the Internet is currently the World Wide Web. This is a distributed multimedia hypertext system in which a large number of documents, located on computers throughout the world, may be accessed by clicking with a mouse, or some other pointing device, on key phrases or active graphics highlighted in the text of any of the documents. The main tool that allows such a system to be set up is the Web browser. This reads documents from distant computers into your local computer and displays them on screen. The documents displayed by a Web browser are written in HTML (Hypertext Markup Language).

A Web browser can equally be used to display documents stored on the Internet and on a local hard disk. If a computer is connected to a network that allows read access to network files, however that network is configured, then the document files may be placed centrally and accessed by all of the network users. For instance, if there is a Novell file server to which client computers attach, any logged-in PC will be able to access the HTML files held on the server drive. Such a system can meet the need to share information within an organization in a manner that is simple to use even for relatively untrained staff. Indeed, in an organization such as a local authority, there may well be a large measure of crossover between the internal and external needs for information provision. (Source: *Managing Information*, May 1995)

### Prospects for the information superhighway

Vendors in the entertainment, telecommunications and information technology markets have produced a torrent of promises regarding the brave new world of the "information superhighway". Facts have become obscured, and potential consumers bewildered.

The first point to make is that the Internet and the superhighway are not synonymous. The latter promises rapid delivery of graphics and full-motion video using broadband technologies such as asynchronous transfer mode (ATM), whereas the Internet (despite the rapid increase in the availability of commercial services) has been likened to an electronic car-boot sale. Bandwidth restrictions mean that the Internet is slow and limited. It is also anarchic.

The main driver of the new superhighway will be the domestic market, but at present this amounts to little more than a few small-scale trials. Some believe that large-scale take-up of the new services is a decade away.

In the meantime, however, considerable investment is under way or planned. In the United Kingdom, the main rivalry is between BT and the US and Canadian companies comprising much of the Cable Communications Association (CCA). CCA has already committed £3,000 million to build cable networks linking 4.5 million homes, and plans to spend a further £10,000 million to create a superhighway by the end of the century. Similar levels of investment are evident elsewhere in Europe, especially in France and Germany, but all are dwarfed by those in the United States. If payback is not rapid, some suppliers may encounter financial problems for the first few years. (Source: *Computing*, 11 May 1995)

### Electronic (journal) information: who pays?

Journal publishers are experimenting with electronic information, though there is little sign of the conventional serial being abandoned on the appearance of the electronic version. Subsequent development will turn on the take-up of the electronic version, and upon the revenue yielded by it. Initially the electronic versions are likely to be cheap, for they will duplicate the printed text, and be offered to subscribers for a small additional cost, provided that subscriptions to the printed journal are sustained.

It is important to continue with the journal format in the electronic world. Most journals are produced by learned or academic societies, either directly or via a publisher acting for the sponsoring society, and the most highly valued publications are those on which a great deal of editorial effort is expended. Although the authors of papers in learned journals are not paid, much of the screening of the pages goes on before publication. Customarily, each paper submitted to a journal of standing is studied by at least two referees and an editor, before any decision is taken over publication. The preservation of quality control is of utmost importance for publishers, for the reputation of the serial publication or journal, and provides a mark of customer approval that a miscellaneous collection of articles in a database can never attain.

Another reason for caution in embracing the electronic revolution is that library users remain content with the present system. There are other reasons for embracing caution. All too often electronic systems are regarded as having elastic, ever-expanding memories. But memory costs money, and the maintenance of large memory stores is expensive. Further, a backup system is needed in case the original store or compilation becomes faulty, damaged or destroyed. That doubles the amount of memory needed. (Source: *Taking Stock*, May 1995)

### Secret plans (encryption)

In the United States, computer programs and chips designed to put messages into an unbreakable secret code are classified for export purposes as munitions. In recent decades America's Department of Defense and the electronic eavesdroppers of the National Security Agency (NSA) have prevailed upon the State and Commerce Departments to seize almost every patent application for cryptographic inventions, and restrict their export. It is, however, no longer just armies who would like to be able to talk to one another in secret. For example, without cryptography, international bankers would have to return to paper notes in satchels for confidential money transfer. America's software makers say they are being hurt by the prohibition on selling this technology abroad, even though similar technology is readily available overseas.

This clash of interests will soon be tested in the courts. Daniel Bernstein, a student at the University of California, says the export licensing system is unconstitutional. In 1992 he wanted to put his cryptographic program *Snuffle* on the Internet but was denied a munitions export licence. Meanwhile the federal Government is prosecuting Phil Zimmerman who, in 1991, wrote a powerful encryption program called *PGP (Pretty Good Privacy)* which is widely distributed on the Internet and seen as a stinging affront to the Government's power to control the dissemination of cryptography. The courts will have to balance the contending claims of national security, free speech and the right to privacy. (Source: *The Economist*, 6 May 1995)

### How best to find and fulfil business information needs

In the next five years, communications will probably make less use of paper products and more of electronic services. By their nature, services entail greater interaction with users; and most service suppliers pay close heed to their communications with their users and feedback from them. To fulfil business information needs, we need a similar strategy but not just with users. We must give comparable attention to the links between our users and our funders and between our funders and the providers of our information services.

A business's funders and fund managers include: the shareholders and institutions, which provide fixed and fluid capital; the board of directors, including non-executives; the management team; outside suppliers, on whose capacities, skills and credit the business may draw; and those who place awards, grants and contracts. Together, they allot funds and allocate resources and they set evaluation criteria and constraints that will govern the agreed strategy. The funders and fund managers are also concerned with monitoring performance in the context of the business's strategic and financial objectives.

Users of our information services can include: those having line and staff functions; research managers and research teams; customers of the business and consumer groups; organizations and individuals with an academic or professional interest in the business; and the media. Our services may draw upon information and media specialists, and external suppliers of services and expertise. Among these suppliers may be publishers, database hosts, contractors, agents, consultants, technical advisers, and other libraries and information services. Our information strategy should reinforce the enthusiasm and support of our funders, and facilitate communication between our funders and our users. (Source: *Aslib Proceedings*, May 1995)

### Micro-electronics trends

Micro-electronics continues to be the key enabling technology for the present information age. But for the highly sophisticated and complex chips that are designed by the VLSI design community and subsequently fabricated at extremely sophisticated and capital-intensive plants, the increasing sophistication in system performance would not be possible. Out of the total world production of electronics of about US$ 600 billion in 1993, the micro-electronics content was about US$ 80 billion. In 1994 a strong semiconductor growth rate of 29 per cent was witnessed, primarily due to a world-wide boom in the PC market. Semiconductor sales are expected to be around US$ 90 billion this year and likely to cross the US$ 100 billion mark in 1996.

The cost of setting up wafer fabrication facilities continues to increase steadily due to the demands for ever-decreasing minimum line widths coupled with the spiralling equipment costs. The big players in the semiconductor industry, however, continue to plan major investments in this area; e.g. NEC is planning to boost its capital investments in semiconductors to US$ 1.25 billion for the year ending March 1995. Toshiba is planning to build a US$ 1 billion plant to make 64 Mb DRAMs. The capital equipment content of a new semiconductor plant is around 50 per cent to 75 per cent at present. It is understood that in the first five years of operation of a modern mega-size semiconductors plant, depreciation would add more to the wafer cost than all the other factors combined. The

fabrication costs are likely to cross US$ 2 billion with the line width going below 0.2 micron by the year 2000.

The main semiconductor technologies continue to be CMOS, Bipolar and BiCMOS with CMOS and its variants as the mainstay. Silicon is expected to continue as the leading semiconductor material with III-V compounds being used for high temperature, low noise, rad hard devices. A qualitative shift in device technologies is expected to occur with the advent of nano-electronics where devices would be made by structuring of atomic layers by selective epitaxial deposition. Decrease in feature size and increase in chip and wafer sizes; improvement and increase in the number of interconnection layers achieved with high yield, deposition and etch, chemical-mechanical polishing and other planarization processes and improved stress control; more extensive use of epitaxial and high energy ion implantation; improved and denser side-wall isolation techniques; thinner and more reliable gate and capacitor dielectrics; advancement of lithographic techniques; continued development of effective, low damage deposition etch, strip and clean processes; vertical integration with SOI, etc., would all contribute to the evolution of micro-electronics technologies. In the key area of lithography, optical lithography continues to defy all predictions about its limits as X-ray lithography continues to be beset with difficult problems. New innovations, such as the use of holography as against photography, may lead to major improvements in the feature size combined with lower equipment costs.

At present the cutting edge technology is around 0.35 micron. It is expected that 0.25 micron technology would be in use by 1996 and 0.18 micron technology in commercial production by the year 2000. Wafer sizes are likely to increase from the present eight to 12 inch by 1998 with corresponding chip areas of more than 600 $mm^2$. Deep UV lithography is likely to continue up to line widths of 0.18 micron by employing phase shift masks and off-axis illumination for improving the depth of focus of high numerical aperture steppers. X-ray lithography is likely to come into its own only around 0.15 micron line widths. The existing processes such as PECVD, TEOS, SOG, aluminium metallization, favoured due to their cost advantage, may eventually be replaced by such processes as plasma oxide gap fill, chemical-mechanical polishing and tungsten plugs. The high density plasma gas fill method is felt to be most promising for local and global planarization.

Wafer surface preparation and wafer cleaning amounts to about 20 per cent of the total cost of wafer processing. Many new techniques are being tried for wafer preparation, e.g. chemical recycling, vapour phase cleaning, etc., in place of the conventional wet cleaning. Point-of-use chemical generation in which ultra-pure chemicals are produced at the fabrication site is gaining in popularity as it eliminates the problems associated with transporting, storing and delivering the chemicals.

Ion implantation is expected to remain the main technology for the formation of ultra-shallow source drain junctions in CMOS devices. Cost of ownership, however, may be a major concern in the use of ion implantation. Failure analysis of future devices of around 0.1 to 0.2 micron feature size and junction depths below 50 nanometres will present major challenges. Computerized navigation based on design and layout databases will extend to a number of analytical tools, including wafer stage SEMs, SIMs, Auger, etc.

In the area of testing, advanced techniques such as electron beam and field ion beam probing are becoming popular for the probing of internal nodes of the chip for advanced characterization and performance enhancement studies of devices. Testing costs of integrated circuits are becoming a major factor of the total device cost as the device size, complexity and speeds increase. Design verification and testing issues are converging as designers find that DFT helps them in design verification and fault stimulation and the IC manufacturers want the testing task to be simple. Test synthesis tools combining scan-based test, ATPG and simulation technology are increasingly contributing to the creation of testable designs. Testing of MCMs offers further challenges because they contain high pin count chips connected into one circuit with high density interconnections.

One of the interesting developments recently in new device structures has been the multi emitter resonance tunnel hot electron transistor (MERHET). It is estimated that one MERHET may replace 18 conventional elements in a logical circuit. The Fujitsu Research Institute has stated that by improving the manufacturing process for thin films, it hopes to develop ICs with integration levels more than 1,000 times that of conventional ICs by the turn of the century. As the increasing demands on system performance translate into feature sizes significantly below 200 nm and the physics, technology and cost issues for silicon technology become increasingly intractable, molecular electronics may eventually provide the solution. Molecular electronics chips would use components with line widths in the range of 50 nm as compared to the current line widths of 350 nm for silicon chips. Molecular electronics-based chips are estimated to give a thousand to a million times more computing power than silicon chips of the same area. These devices could even be implanted in the human body to actuate prosthetic limbs, increase memory, enhance visual, hearing and other senses, or speed up responses to stimuli. Molecular devices would require a strong inter-disciplinary effort and may use synthetic materials, e.g. conducting polymers or self-assembling biological materials, such as DNA.

The advanced ICs fabrication techniques can also be used to micro-machine silicon into micro electro-mechanical systems (MEMS). There are already more than 300 companies and research organizations working on MEMS. MEMS include sensors such as pressure and acceleration sensors, actuators, light detectors, micro-pumps, flow control devices, simple structures, like probes, valves, membranes and micro systems, like micro motors, miniaturized chemical analysis systems, etc. MEMS have potential applications in air- and spacecraft, entertainment electronics and other consumer goods, medical electronics, automobiles, analytical and process technology. The current world market for MEMS is around US$ 2 billion and is estimated to grow to US$ 10 billion by the year 2000.

While the advances in device structures, silicon process technologies, and also new technologies such as molecular electronics, etc., would continue, it is interesting to note that one of the major challenges would continue to be that of education in the face of constantly changing technologies. (Extracted from the inaugural address to the 8th International Conference on VLSI Design '95 given by N. Vittal, Secretary, Department of Electronics, India, and reprinted in *Electronics Information & Planning*, February 1995)

# C. NEW DEVELOPMENTS

### X-ray 180 nm lithography with an economical laser plasma source

A new UK research consortium working in the field of X-ray lithography has demonstrated the use of an economical bench-top plasma soft X-ray source for the proximity printing of 180 nm features. The development of lithography at these dimensions is of special importance for future 180 nm gate length silicon FET circuits and 1 Gbit memory devices.

The consortium involves the Department of Electrical Engineering, University of Edinburgh, Scotland; the Central Laser Facility and the Central Microstructure Facility at the Rutherford Appleton Laboratory (RAL), Oxfordshire, England; the Department of Physics, King's College, London; and Leica Cambridge Ltd., Cambridge, England. The new laser plasma X-ray source was developed at RAL and the X-ray membrane masks used in the work were patterned using a state-of-the-art Leica Cambridge VB6HR electron beam lithography system.

The X-ray plasma source was based on KrF excimer lasers. A mode-locked YAG laser was used to generate 5 ps pulses at a wavelength of 746 nm with a 50 Hz repetition rate.

The group selected a novolak-based, positive tone, chemically amplified negative resist (Hoechst AZPF514) for this work, since it offers a relatively high sensitivity of 20 mJ/cm$^2$ at the 1 nm wavelength and a resolution of about 100 nm. The resist was spun on silicon wafers to 0.5 μm thickness and pre-exposure baked at 110°C for 60 seconds using a hot plate. Exposure times of four to five minutes gave the required 20 mJ/cm$^2$ dose. A post-exposure bake of the wafer was performed by hot plate at 60°C for 60 seconds. After development, this produced 180 nm lines in 0.5 μm thick photoresist.

The work demonstrated that laser-based X-ray lithography can be used for 180 nm patterning and that the resulting patterns are compatible with reactive ion etching requirements for future 180 nm silicon FET technology.

Details of this work were presented last autumn at the Micro- and Nano-Engineering Conference in Davos, Switzerland. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### TI develops 3 lb mainframe computer

Texas Instruments (TI) has completed the development of an ultra-high-performance, high-density parallel processor called Aladdin that outperforms a Cray X-MP in 2,700 times less space. The effort was cost-shared between the Advanced Research Project Agency (ARPA) Night Vision Electronic Sensors Directorate (NVESD) and TI.

The Cray X-MP mainframe computer was selected as a benchmark by TI in 1989 when the project began. The Cray X-MP weighs 2,000 lbs, consumes 75 ft$^3$ of space, and features processor performance of 30 MIPS/400 MFLOPS. By comparison, the completed Aladdin processor achieved 400 MIPS/1600 MFLOPS in 3 lbs of weight and 48 in$^3$ of volume. To achieve this goal, TI combined submicron BiCMOS custom integrated circuit designs; an advanced commercial RISC microprocessor; high-density silicon-on-silicon multichip packaging technology; a compressible interconnect; and three-dimensional memory packaging. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### Sony develops lithography for 0.18 μm process

Sony has developed a lithography technique capable of use with a 0.18 μm process. Digital and multimedia equipment in recent years has intensified the need for single-chipping of large-scale high-density devices and ASICs. This has caused lithography technology to shift towards shorter exposure source wavelengths, and sources are now making the transition from i-line to KrF excimer lasers. At the same time oblique mask illumination and halftone phase shift technology are being applied in an effort to improve microfabrication precision.

For multi-function devices such as ASICs, conventional lithography technology results in focal depth variation due to changes in pattern density, presenting yield problems.

To resolve these problems, Sony adjusted the position and angle of the optical devices in the illumination optics system of the stepper, developing a new exposure distribution by changing the incident angle. This distribution was combined with phase shift mask in the new lithography technique.

For low-density patterns the new approach makes it possible to prevent degradation in focal depth, which was the problem with oblique illumination in the past. For high-density patterns the new technique provides the same focal depth as oblique illumination, and is expected to be able to handle volume production of 1G DRAM with 0.18 μm process requirements. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### Joint European project for 8-in. SOI wafers

The JESSI project "Silicon on Insulator Wafers for VLSI Applications" aims at the production of 8-in. SIMOX (Separation by IMplanted OXygen) wafers for advanced CMOS applications.

The low-dose SIMOX process developed by SOITEC (Grenoble, France) will be applied to wafers from Wacker-Chemitronic. Electrical characterization and evaluation will be performed at the new 8-in. facility of the Grenoble Submicron Silicon Consortium (GRESSI).

The low-dose implantation achieves ultra-thin films of both silicon and oxide in the SOI structure. Thin 80 nm buried oxide layers can be produced with silicon films about 100 nm thick. The target at the end of the project is for a film thickness uniformity of better than 5 nm in ultra-thin 50 nm silicon films. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### PVD technique fills sub-0.5 μm contact holes and vias

A group at the Thornbury Laboratories of Electrotech near Bristol, U.K., has developed a plasma vapour deposition technique for filling sub-0.5 μm holes with aluminium. It is capable of filling >0.25 μm holes with aspect ratios exceeding 6:1 and is said to be the first plasma vapour

deposition system specifically designed for sub-0.5 μm geometries.

The wafer is pre-heated, via cleaned, and Ti/TiN is deposited. Aluminium is then deposited at a high rate to generate rapid grain growth in the plane of the film. All of the holes are thus sealed by aluminium, leaving a void beneath the metal. The wafer is then transferred to another chamber where high-pressure argon is isostatically applied, extruding the aluminium to give global hole-fill.

This process operates at wafer temperatures over 100°C lower than conventional aluminium hole filling processes. Thermal budgets are much reduced, putting less stress on the Ml diffusion barrier and minimizing the effect on junction doping profiles. Global filling of 0.25 μm holes can be effected with just 0.5 μm of metal, reducing capacitance between lines and allowing improved inter-layer dielectric planarization. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### Oki develops totally inorganic SOG material

Oki Electric Industry has developed a photosensitive SOG material offering 0.1 μm resolution and a totally inorganic composition.

Normally SOG materials require sintering at 700°C to 900°C to fully eliminate organics, which has limited their applications. In addition, it made it impossible to make totally inorganic SOG after the formation of Al wiring patterns, because of the 600°C melting point of aluminium.

It is possible to form an $SiO_2$ film on the newly-developed SOG material merely by irradiation with electron beams or infrared light, which eliminates the need for sintering and the accompanying bottleneck. Because regions that are not irradiated can be stripped off with solvent, $SiO_2$ films can be formed with conventional lithography process. in addition, totally inorganic films can be obtained at low temperatures of only 350°C to 400°C.

The new SOG material is coated directly on the metal film, and the pattern formed through lithography. This serves as the $SiO_2$ film mask, allowing immediate metal film etching. Overall, the number of processes is halved. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### 0.25 μm devices

IMEC (Leuven, Belgium) and Lam Research (Fremont, Calif.) are pursuing joint research to characterize Lam's Transformer Coupled Plasma (TCP) source technology for imaging of 0.25-μm and smaller geometries. The research is being conduced at IMEC's Leuven, Belgium facility using their expertise and technical personnel to develop top-surface-imaging silylated resist on Lam's advanced TCP 9400 plasma etch system. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### Blue electroluminescent material for FPD

A cerium-doped strontium sulphide blue electroluminescent (EL) emitting material enables full-colour EL displays to be built that can produce brightness levels two to three times higher than full-colour EL panels built by conventional processes.

The development of full-colour EL flat panel displays has been long delayed by the lack of any adequately strong blue emitter. The process to produce the new material has been developed by a German group at the Heinrich-Hertz Institut für Nachrichtentechnik GmbH, Berlin, with staff of the former East German Academy of Sciences.

In one method the group uses three active layers, one for each of the basic colours, to form a full-colour EL display. However, they see advantages in using an active white emitting layer under three layers which appropriately filter light of the three basic colours. This technique allows standard EL display production processes to be used, so full-colour production yields should match those currently achieved with other EL displays.

Displays using the new active white layer process have exhibited efficiencies of 1.6 lumen/watt. The group is confident that the stringent requirements of panels for workstations can now be met. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### BT demos multi-gigabit network

A fibre optic network transmitting multi-gigabit per second data using optical time division multiplexing has been demonstrated by researchers at British Telecom (BT) laboratories.

The BT network avoids the bottleneck associated with converting optical signals to an electrical form at switching centres. Instead, long distance transit traffic passes through switching centres in optical pulse form. By performing channel multiplexing and extraction processes at high speed using optical devices, much higher aggregate data rates can be attained, potentially as high as 100 Gbit/s. (Source: *Electronics Weekly*, 21 June 1995)

### US firm claims first high gain transistor at 500° C

Astralux of Boulder, Colorado, claims to have made the first transistor having a gain of more than 100 at 500° C.

The device combines two high-temperature semiconductor materials: gallium nitride and silicon carbide, to form a heterobipolar transistor.

The device has achieved a current density of 1800 A/cm$^2$ and a power density of 20 kW cm$^{-2}$. At room temperature the current gain is around 10 million, which only drops below 100 at 535° C. The normal upper operational limit of silicon transistors is between 150 and 200° C. Astralux cites electric vehicle motors and spacecraft as potential uses for the device. (Source: *Electronics Weekly*, 21 June 1995)

### National launches 100 MHz op-amp

National Semiconductor has released a 100 MHz voltage feedback op-amp with a selling price of $1.29. The chip, called the LM6171, is the first product of a two-year development programme to increase the performance of its existing vertical integrated PNP (VIP) technology. The LM6171 also features 2.5 mA consumption, a slew-rate of 3,600 V/μs and a common-mode rejection ratio of 110 dB. Target applications are ADC and DAC buffering and video processing in multimedia broadcase systems, scanners, copiers and faxes. (Source: *Electronics Weekly*, 28 June 1995)

### Sandia confirms electric motor at 300,000 rpm

Sandia National Laboratories of Albuquerque, New Mexico, has confirmed that their micromachined polysilicon electric motor rotates at 300,000 rpm.

Researchers knew that the tiny machine, first fabricated in late 1994, should be rotating at this speed, but could not eliminate the possibility that it was spinning at a sub-harmonic of the drive frequency.

The toothed wheel is 50 micron in diameter (a human hair is 75 micron) and is driven through linkages reminiscent of a steam engine.

Two electrostatic linear actuators are employed, mounted at right angles and driven 90 degrees out of phase which allows direction of rotation to be predetermined. (Source: *Electronics Weekly*, 12 July 1995)

### DINOR 16 M flash memory and circuit technology for 1G DRAM

Mitsubishi Electric and Hitachi have jointly developed a DINOR 16 M flash memory with a single 3.3 V supply voltage. Mitsubishi also developed a low-voltage, high-speed DRAM circuit technology suitable for 1G DRAM chips.

Conventional NOR flash memory uses CHE cell write, which makes it difficult to use a single supply voltage. NAND chips stack the cells vertically to reduce the chip footprint, slowing down the random access performance. The DINOR architecture combines the strong points of both methods to resolve the bottlenecks.

The DINOR 16 M flash memory, with a single 3.3 V supply, features innovations in the positioning of the transistors making up the blocks, offering 32 erase blocks, each 64 Kbyte in size. The chip size is 76.9 $mm^2$. In addition, the chip has a 256-byte page buffer and an internal voltage step-up circuit with about double the performance of the prior design, supporting a data transfer rate of 1 Mbyte/s. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### Single electron gets warmer

Hitachi's quest to build electronic circuits from structures that use a single electron has taken a significant step forward. Researchers at its Cambridge laboratory, with Cambridge University, demonstrated a single-electron transistor device working at 77 K rather than 4.2 K.

The 77 K device is a thin metal wire on a silicon-dioxide substrate. The gold-palladium islands are the so-called Coulomb blockades letting single electrons cross the gate. The islands have a "world record" diameter of 2 nm.

But to get room temperature operation the dots would have to be five times smaller, said Prof. H. Ahmed of Cambridge University. "The important thing is to reduce the capacitance of the Coulomb blockade by using different materials rather than making them much smaller."

The group has also demonstrated an inverter at 4.2 K and is striving to build more complex logic primitives. (Source: *Electronics Weekly*, 12 July 1995)

### Custom 32-bit designs in six months

SGS-Thomson Microelectronics claims to be able to produce a customized 32-bit embedded microcontroller design within six months with the launch of its ST20 micro core and design library.

SGS-Thomson has taken the 32-bit T425 Transputer core and coupled it with an arithmetic accelerator, instruction pre-processor and hardware micro-kernel on dual 200 Mbyte/s memory and peripheral buses. The progressive development of a library of VHDL-based macrocells will create a family of customized ST20 designs in embedded control applications from hard-disk drives to set top boxes.

The variable length instruction pre-processor supports 8, 16, 24 and 32-bit word lengths. The operation has been optimized for basic 8-bit instructions which has implications for the memory bus design.

The integrated micro-kernel creates no memory penalty in embedded designs. The hardware micro-kernel is optimized to perform reading, multiplexing and processing of high bandwidth data.

A family of four micro cores manufactured in the HCMOS5S 0.5-micron process supports operation at up to 50 MHz; by the end of the year this will be extended to 100 MHz using the company's HCMOS6 0.35-micron process technology. (Extracted from *Electronics Weekly*, 12 July 1995)

### Superminiature integrated optical head for magneto-optical recording

Matsushita Electric Industrial Co., Ltd. has developed a superminiature integrated optical head that is usable for the write-in and readout of magneto-optical (MO) disks and mini-disks (MD). The optical head was miniaturized by incorporating a small piece of glass with the functions of a prism and lens, through which the number of components was decreased. Actually, the head size was reduced to about one-fiftieth compared to conventional counterparts.

The optical head is a device that records and reads out information by irradiating a laser beam on the disk surface. The laser beam is bent or converged, so up till now as many as three prisms and five lenses were used. The new optical head has a construction in which a rectilinear laminated prism 3 mm long, 2 mm wide, and 3 mm tall is laminated with a crystal plate 44 $\mu$m thick and four parallel optical glass plates 0.5-0.9 mm thick, inside which are integrated an NA transformation hologram acting as a collimator lens, an astigmatism hologram serving as a cylindrical lens for a focal detection, two types of beam splitter films (beam splitter 1, beam splitter 2), a polarized beam splitter film for a magneto-optical signal detection, and several types of reflection films.

The magnetic disk and minidisk recording systems have optical systems which are much more complicated than those of compact discs (CDs), so miniaturization had been needed. Further details from Matsushita Electric Industrial Co., Ltd., 1-1-2, Shiba-Koen, Minato-ku, Tokyo 105. Tel.: +81-3-3578-1237, Fax: +81-3-3437-2776. (Source: *JETRO*, May 1995)

### Free-orientation integration by direct bonding

Hitachi, Ltd. has succeeded in direct bonding of two semiconductor materials with different crystallographic orientation of the wafer surface, providing a "hybrid crystal" in which the crystal lattices are slightly disturbed at the bonded interface but have a high overall quality. A semiconductor laser was fabricated experimentally by applying the new technique and the basic characteristics were confirmed. The new technique is anticipated to improve the performance of opto-electronic integrated circuits (OEICs), which mount optical devices and electronic circuits on the same chip.

The new technique was applied to the fabrication of an InP semiconductor laser on a GaAs wafer. Investigation of the laser characteristics such as the light-output dependence on current showed that they were almost the same as an ordinary laser. Up to now, materials with the same surface orientations have been bonded together, but the bonding of

materials of different surface orientations had been regarded as difficult. The new technique is also available for GaP, InAs, and Si wafers.

With the conventional crystal growth technique, defects are easily generated in the crystal lattices of the layers grown on wafers of different lattice dimensions, and it is impossible to change the surface orientations of the layers on one wafer. The direct bonding technique enables semiconductor structures to be obtained which are impossible to obtain by crystal growth, so the technique is expected to promote the development of integrated devices, especially photonic integrated circuits. Further details from Hitachi Ltd., Public Relations Secretary's Office, 4-6, Kanda-Surugadai, Chiyoda-ku, Tokyo 101. Tel.: +81-3-3258-1111, Fax: +81-3-3258-5480. (Source: *JETRO*, May 1995)

### First hyper-dynamic range CCD

Matsushita Electric Industrial Co., Ltd., has developed the first hyperdynamic range charge-coupled device (CCD). This key device for the multimedia era can produce 10,000 levels of halftone, compared with 500 levels of halftone for conventional CCDs. CCDs used in current camcorders can handle an illumination of up to 500 levels of halftones, so recording a composition which combines both bright and dark subjects appearing to the human eye, such as an individual standing with a sunset in the background or a subject on a sunny beach viewed from the shade of a tree, has been difficult.

The new CCD achieves a hyperdynamic range, approximately 20 times higher than that of conventional CCDs, using a new read-out structure with an electrode built into the centre of the photo diode, an eight-phase driving method that facilitates the hyperdynamic range, and various applications that utilize driving methods with a higher degree of versatility.

Potential applications for the new CCD include a pocket-sized camcorder with more advanced capabilities than current professional-use three-panel cameras, a camera for car navigation systems with resistance to vibration and high dynamic range through the elimination of mechanical iris control, a mobile videophone that features shock resistance and low power consumption based on a total electronic system, and sensors in the fields of medical and basic research that require high dynamic range. Further details from Matsushita Electric Industrial Co., Ltd., 1-1-2, Shibakoen, Minato-ku, Tokyo 105. Tel.: +81-3-3578-1237, Fax: +81-3-3437-2776. (Source: *JETRO*, May 1995)

### Easy nanoclusters

Chemists at Cornell University (Ithaca, NY) report a general method for making metal nanoclusters in polymers using solubilizing monomer ligands. The fabrication of polymer materials with metal nanoclusters is becoming a hot research topic, promising payoffs in such areas as catalysis. However, preventing phase separation and aggregation of the inorganic clusters has been a problem. The Cornell scientists use polymerizable ligands to keep the metals in solution. (Source: *Chemical Week*, 14 June 1995)

### Hard disk wafer made of glass ceramics

Ohara Inc., a leading domestic manufacturer of precision optical glass, has ventured into the mass production of a hard disk (HD) wafer (TS-10) made of a newly developed glass ceramics material.

Encouraged by the high evaluation on the US and other foreign markets, the company established a mass production setup for producing 2,000,000 blank wafers month (2.5-in equivalent). It primarily plans to manufacture blank wafers in the initial stage and, in response to the needs for ground and polished substrate wafers, plans to produce 2,000,000 units of both blank wafers and substrate wafers from the spring of 1996.

A distinct advantage of the new TS-10 hard disk substrate is the low density of 2.43 (10 per cent lower than the aluminium substrate), a great hardness of Hv 700 (40 per cent harder than aluminium substrate), large Young's modulus of 9,480 kg/mm$^2$ (30 per cent larger than aluminium substrate), excellent heat resistance and weatherability, and high flatness and smoothness, so the new hard disk substrate has the broad range of properties demanded of hard disk substrate.

A vital requirement for producing HDDs of large and high-density storage capacities is to minimize the gap (flying height) between the magnetic head and hard disk, which in turn demands improvement of the HD planar flatness. The 2.5-in TS-10 wafer has a gap of less than 5 $\mu$m, much less than other substrates. In addition, to prevent sticking between magnetic head and HD, the disk substrate surface receives a special treatment to provide a texture.

With the trend for increasing lightness, miniaturization, and ever larger storage capacities, the demand for glass-based wafers, featuring low density, high impact resistance and ever thinner configurations, is estimated to increase and to reverse the market share ratio of aluminium wafers by the year 2000. Further details from Ohara Inc., 1-15-30, Oyama, Sagamihara City, Kanagawa Pref. 229. Tel.: +81-427-72-2101, Fax: +81-427-74-2314. (Source: *JETRO*, June 1995)

### First dual focus optical pickup for SD DVD and CDs

Matsushita Electric Industrial Co. Ltd. of Osaka has developed the first dual focus optical pickup capable of playing back both SD format DVDs and current CDs with a single optical pickup.

The DVD is expected to be a key medium in the coming multimedia era, and all companies involved are currently working to develop related technologies. Matsushita has been researching an optical pickup capable of reading both DVDs and CDs which differ in substrate thickness and in pit size to permit playback of the current, widely available CDs on the SD format DVD player that will be marketed in the future.

The company has been successful in developing technologies enabling the formation of the two different optimum optical spots for DVDs and conventional CDs with a single laser beam, a dual focus optical pickup method that utilizes a hologram, and a precision engineering method for the hologram-integrated aspherical moulded glass lens.

After carrying out a feasibility study for mass production, Matsushita has incorporated this dual focus optical pickup in SD format DVD players. Further details from Matsushita Electric Industrial Co. Ltd., 1-1-2, Shibakoen, Minato-ku, Tokyo 105. Tel.: +81-3-3578-1237, Fax: +81-3-3437-2776. (Source: *JETRO*, June 1995)

### Carbon nanotubes

Carbon nanotubes, discovered by Sumio Iijima of the NEC Corporation, consist of up to 50 cylinders nestled inside each other with hemispherical caps like geodesic domes at the ends. Dr. Iijima and others found that they

have exotic electrical properties; they can act either like metals or like semiconductors, depending on their geometry, something that might conceivably prove useful in making computer circuits a hundred times smaller than today's. But making circuits requires controlled manipulation, and that is not something nanotubes lend themselves to.

One of the problems is the difficult of attaching other molecules to the tubes' unreactive surfaces. Pulickel Ajayan of the Université Paris-Sud has now found an intriguing solution to this. When nanotubes are mixed with molten vanadium oxide their endcaps burn off; capillary action then draws the hot liquid into the interior. And since the surface tension of liquid vanadium oxide is low, it also wets the outside of the tubes. Both inner and outer surfaces end up covered with thin films of the oxide. The carbon skeleton can then be dismantled through further chemistry, leaving only its imprinted shape.

The promise of vanadium oxide lies in its catalytic power—its ability to speed up chemical reactions and to lower the temperature at which they take place. A vanadium-oxide nanotube inserted into a bath of the right chemicals would quickly be covered with the products made when the chemicals react together. Such techniques might enable scientists to build almost unimaginably tiny structures: capacitors, wires and resistors a few atoms thick. Furthermore, vanadium oxides have a property called electrochromism—they change colour when put in an electric field. A vanadium-oxide nanotube hooked up to a few tiny wires might become an optical switch. This could enable computers to transmit signals through light rather than electric current—making them faster, cooler, and more efficient. (Extracted from *The Economist*, 17 June 1995)

### *Copper lasers offer high cutting speed*

Oxford Lasers Ltd., (Abingdon Science Park, Oxfordshire, UK) has developed new techniques for drilling and cutting silicon and other semiconductor materials.

Copper lasers provide a unique combination of a visible wavelength (511 nm), short pulse duration (40 ns), high peak powers (50-500 kW), and high pulse repetition frequencies (2-20 kHz) that permit high-quality cutting and drilling.

The visible wavelength is strongly absorbed by silicon in contrast to the infrared wavelengths available from other lasers. The short duration, high peak power, copper laser pulses allow efficient removal of material with little or not heat affected zone. The high pulse frequency produces high drilling and cutting speeds. For example, 250 $\mu$m thick silicon can be cut at 22 mm/sec using a 250 kW peak power (50 W average power) copper laser. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### *New type of high-performance illumination material*

Ohno Research and Development Laboratories Co., Ltd. has developed a new type of illumination material, Crystal Light, that is produced by forming a micro-joint layer on the surface of a transparent plastic material.

This new illumination material features excellent light conductance and provides illumination more than three times brighter than conventional types of coated illumination devices such as neon lamps. In addition, the shape can be designed flexibly and large-area displays can be fabricated at low cost.

The micro-joint layer has excellent light conductance and is produced by coating a transparent acrylic resin on the surface of a plastic material, followed by special machining and treatment. The optical characteristics at the interface between the plastic material and micro-joint layer are utilized to reflect the light generated by light sources placed at both terminals of the illumination material to guide the light efficiently over a long distance.

The new illumination device has a broad range of applications, including mood illumination, light objects, interior illumination, sign display, and backlighting for office automation equipment. Further details from Ohno Research and Development Laboratories Co., Ltd., 11-24, Miyamae-cho, Kawasaki City, Kanagawa Pref. 210. Tel.: +81-44-244-4800. Fax: +81-44-244-4806. (Source: *JETRO*, June 1995)

### *Manufacture of high-purity indium phosphide semiconductor single crystals*

Japan Energy Corp. has succeeded in manufacturing indium phosphide (InP) semiconductor single crystals with an impurity content as low as 0.05 ppm.

Indium phosphorus semiconductor single crystals are used as materials for producing optoelectronic devices such as the semiconductor lasers and photodetectors used for optical fibre communications.

However, with the conventional manufacturing method, impurities such as iron are required to be added at over 0.05 ppm, which results in iron diffusion occurring in the epitaxial process when manufacturing devices, deteriorating the performances of these devices. There is also the problem that the impurities are precipitated to generate stress inside the crystals, making the use of this single crystal material impractical.

The company developed a new manufacturing process that eliminates iron addition. Single crystal wafers are sealed inside a quartz ampoule in vacuum, then inserted in a high-pressure vessel with a maximum pressure vessel of 80 Pa, followed by high-temperature heat treatment under a phosphorus environment at a temperature of over 900° C, through which phosphorus vacancies inside the crystals, detrimental to semiconductor properties, are removed successfully.

The company has already established a setup for mass production. The attainment of the high level of purity now enables the manufacture of high electron mobility transistors (HEMTs) for operating in the millimetre wave region of 60 GHz and heterojunction bipolar transistors (HBTs), for which demand is certain to increase with the introduction of multimedia. The company plans to distribute samples of the new indium-phosphorus semiconductor to device manufacturers soon. Further details from Japan Energy Corporation, Public Relations Dept., 2-10-1, Toranomon, Minato-ku, Tokyo 105. Tel.: +81-3-5573-6100, Fax: +81-3-5573-6784. (Source: *JETRO*, June 1995)

### *120 MB 3.5-in floppy disk and drive*

Matsushita-Kotobuki Electronics Industries, Ltd., Compaq Computer Corp., and 3M Corp. (both of the USA) have jointly developed a 3.5-in floppy disk (FD) of 120 MB capacity and its drive system (FDD). The capacity is 83 times that of existing FDs. Samples of the FD and FDD are to be distributed from September 1995, and the sales targets will be computer manufacturers.

The FD recording density has been increased by using a metal-coated medium and by introducing a technique for accurate position detection with an optical head. A 120-MB magnetic head and an ordinary magnetic head are incorporated, so the FD system features complete compatibility with lower hierarchy systems, or enables existing FDs to be used intact. The incorporation of the drive system with two types of heads makes the system compatible with 2DD (0.72 MB) and 2HD (1.44 MB) floppy disks, so it is fully compatible and enables reading and writing of conventional types of disks.

Since the capacities of personal computer hard disks are increasing steadily, there had been a need to expand the storage capacities of the FDs used for backup.

Matsushita-Kotobuki Electronics Industry plans to manufacture roughly 30,000 FD systems monthly and to supply these FD systems to computer manufacturers on the original equipment manufacturing (OEM) basis, and to sell the system as an external storage system. Further details from Matsushita-Kotobuki Electronics Industry Ltd., 2123, Hachiman-mori, Minamikata, Kawauchi-cho, Onsen-gun, Ehime Pref. 791-03, Tel.: +81-899-66-2111, Fax: +81-899-66-3602. (Source: *JETRO*, June 1995)

### *IBM, Siemens, Toshiba report breakthrough on DRAM chip development*

IBM, Siemens AG, and Toshiba have announced a major achievement in their joint DRAM chip development project. They reported the smallest and fastest fully functional 256-megabit Dynamic Random Access memory (DRAM) chip ever developed.

With a size of 286 $mm^2$ and a memory access time of just 26 ns, the revolutionary new chip is at least 13 per cent smaller and has an access time that is nearly twice as fast as any chip.

The innovative device, featuring 0.25 micron CMOS process technology, is designed to support any proposed Joint Electron Device Engineering Council standard for 256 Mb DRAMs.

Researchers from the three companies have been working on the project since January 1993 at IBM's Advanced Semiconductor Research and Development Centre in Fishkill, N.Y. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### *Memory trio ripens 256 Mbit*

The alliance of IBM, Siemens and Toshiba on DRAM design and manufacturing says it has produced working samples of the world's fastest and smallest 256 Mbit DRAM. The alliance joins the NEC/Samsung joint venture in announcing working samples of this generation DRAM.

The prototypes, to be manufactured in a 0.25-micron CMOS process, have a die size of 286 $mm^2$ and an access time of 26 ns—13 per cent smaller and twice as fast as other reported 256 Mbit DRAM samples. Siemens says it is making engineering prototypes for internal evaluation. The Dresden fab will eventually manufacture the chip.

The second revision of the 64 Mbit DRAM was a collaboration between IBM, Siemens and Toshiba after IBM and Siemens began the initial design. The firms have already made samples of the B design.

The 256 Mbit DRAM is likely to be made in three versions: EDO (including burst-EDO variant), synchronous and multibanked DRAM—a DRAM technology developed by US firm MoSys. (Source: *Electronics Weekly*, 7 June 1995)

### *Multiprocessing on DSPs*

Determining the nature of a multiprocessing system is far from trivial. DSP-based multiprocessor systems are generally used when signals are required to be processed within a given time and the computational load is greater than can be handled by a single device.

Examples where real time signal processing is used include antenna steering, signal classification and system control.

Signal processing devices offer several key advantages when compared to Risc devices. The architectures are tuned to perform multiply/accumulates—the fundamental operation of signal processing arithmetic. They are also designed to handle high interrupts rates, and have predictable bus access and data transfer rates.

The most commonly chosen DSPs for multiprocessing applications are the Texas Instruments TMS320C40 and Analog Devices ADSP-21060.

Choosing a particular DSP device for multiprocessing involves a number of considerations, of which the dominant factor is a processor's performance.

Another issue is that of communication between devices. Transferring data introduces latencies. Ideally the time involved in transferring data occurs in parallel with the computation, and is not an explicit part of the algorithm. These issues have been catered for in the TMS320C40 and the ADSP-21060. Both offer sophisticated DMA controllers that enable data to be moved in the background, as well as six point-to-point communication links in addition to the standard bus interfaces.

Even when one device has a clear technical advantage, other issues that need to be considered include device familiarity, associated software tool support, and device availability given the project's timescale. (Extracted from *Electronics Weekly*, 12 July 1995)

### *New inspection technique based on "T-rays"*

A new technique using "T-rays"—teraherz electromagnetic pulses—has been developed at AT&T Bell Laboratories (Holmdel, NJ) by researchers Binbin Hu and Martin Nuss. It is said to be the first imaging system based on optoelectronic teraherz time-domain spectroscopy (THz-TDS), a powerful technique that operates in the far-infrared spectral region.

The technique generates and detects terahertz radiation using optically gated transmitters and receivers and offers a signal-to-noise ratio of up to 10,000:1. It does not require cooled detectors, can be built into a compact system, and has transmitter and detector technology that is compatible with integrated circuit technology.

Most chemical compounds show very strong and highly specific frequency-dependent adsorption and dispersion in the THz range. The DSP can pick up the characteristic shapes of the transmitted THz waveforms to determine the material at the spot illuminated by the THz beam.

Among many other applications, AT&T sees uses for the new technique in profiling of doping and defects in semiconductors and for packaging inspection. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA.)

### *Philips gets a passion for plastic circuits*

Philips has made simple electronic circuits out of plastic, ushering in an age of throw-away electronics. A five-stage ring oscillator has been made by the integration of polymeric transistors. The main problem in fabricating

such a circuit is the low mobility of charge carriers. Although charge transport along the semiconductive chains in the polymers is easy, hopping between chains—with a typical hop length of 1 nm—is difficult.

To overcome the problem, the research team have increased inter-chain hopping probability by concentrating on precursor molecules with appropriate solubilizing sidechains. After deposition from solution they can be converted in situ by elimination of the sidechains into the desired unsubstituted semiconductive polymers.

The resulting closer packing of the molecules leads to an enhanced interchain overlap and, hence, to an increased mobility of the charge carriers.

Philips reckons that it will be possible to build circuits operating at up to 100 kHz.

Applications are in large-area electronics like active matrix TFT flat panels, in low-end high volume circuits such as FRID tags, mass logic and low-density data storage, and it is an ideal technology for chip cards. (Source: *Electronics Weekly*, 28 June 1995)

### In-circuit programmable memories

Atmel has released what are believed to be the first in-circuit programmable EEPROM-based memories for booting RAM-based FPGAs. Known as FPGA configuration memories, they are available in 64 kbit and 128 kbit capacities, with a 256 kbit version following soon. Unlike previous reprogrammable FPGA boot PROMs, which had to be removed from the PCB to be modified, the Atmel EEPROMs can be modified *in situ* through a serial bus. (Source: *Electronics Weekly*, 28 June 1995)

### FPGA coprocessor

A family of SRAM-based FPGA devices has been unveiled by Xilinx, targeted at embedded applications. The devices are designed to work alongside the host processor for the acceleration of computationally intensive tasks.

Xilinx is one of several programmable logic companies that believe that the advent of reconfigurable logic will propel programmable logic into mainstream computation. However, according to Xilinx, it is likely to take three to five years for the technology to fully develop.

Reconfigurable logic couples the advantage of hardware acceleration with adaptation, enabling algorithms to be imprinted on logic "on the fly".

Xilinx is targeting the XC6200 at embedded control applications such as laser printing, image processing and DSP, and real-time video processing.

The XC6200 devices comprise a large array of 4 x 4 configurable cells in a fine-grained architecture. As an example, a device with 16,384 cells can implement up to 32 kbytes of memory, or a logic device with up to a 100,000 gate capacity. With reconfigurability, this memory/logic mix can be changed dynamically as demanded by the application. (Extracted from *Electronics Weekly*, 28 June 1995)

### Superconducting magnet using compact helium refrigerator

Toshiba Corp. has developed a superconducting magnet whose superconducting coils are directly cooled to the temperature of liquid helium (absolute temperature 4.2 K, -269° C) with a compact helium refrigerator, without using liquid helium, and succeeded in generating an intense magnetic field of 10 T (100,000 G) in a room temperature space of 10 cm diameter.

The niobium-titanium alloy is generally used for producing the superconducting magnets in wide use today, but transforming these alloy superconducting materials into the superconducting state requires immersion in liquid helium for cooling. However, liquid helium is expensive and volatizes easily, so has to be constantly supplemented.

The company used a compact helium refrigerator and has already developed a superconducting magnet of 6 T whose niobium-titanium superconducting coils are directly cooled to the temperature of liquid helium without using liquid helium.

Cooling without using liquid helium eliminates the need for installing a liquid helium storage tank and ancillary supply pipes, the size of the vacuum container for accommodating the magnet is as compact as a 25-in. TV set with a width of 65 mm, depth of 50 cm and height of 49 cm, and compared with a superconducting magnet of same performance cooled with liquid helium, the size of the vacuum container has been reduced to about one third.

Using the new cryocooler cooled superconducting magnet will facilitate physics and chemical reaction experiments conducted by universities and research organizations, and enable virtually all industrial magnets for semiconductor application as well as research magnets with magnetic field intensities of 20 T (200,000 G) level, which are cooled with liquid helium, to be completely replaced with those cryocooler magnets, so the new type of superconducting magnet using compact helium refrigerator is certain to come into wide use in various fields.

Further details from Toshiba Corporation, Public Relations Office, 1-1-1, Shibaura, Minato-ku, Tokyo 105. Tel.: +81-3-3457-2105; Fax: +81-3-3456-4776. (Source: *JETRO*, June 1995)

### Artificial sight

An image recognition system that uses artificial retina chips has been developed by Mitsubishi Electric's semiconductor research laboratory. The system mimics human stereoscopic observation by exploiting the parallax associated with two points of observation. Using data from two point sources, the system can compute an object's shape, position and speed of motion in less than 1 ms.

The artificial retina device produces electrical outputs from numerous horizontally and vertically photosensitive elements. Mitsubishi has embedded the device within a video camera, and uses two cameras in the image system to produce the separate views. The camera outputs are fed to an optical "neurochip", which performs correlation analysis on the data to identify the displacement between images.

Envisaged applications for the system include factory inspection systems. Mitsubishi is looking to use the technology to develop a robotic system for operation in hazardous environments. It also plans to make generally available its artificial retina and optical neurochip devices. (Source: *Electronics Weekly*, 14 June 1995)

### Super photodiode detector

Ortel, a Washington-based optoelectronics device specialist, claims to have developed a photodiode detector that will accept seven times the optical input power of existing diodes without overloading.

Ortel claims that the significance of its photodiode, which is being aimed at local access fibreoptic communications systems, is that it accepts these high-power inputs without degrading frequency performance. The device does not achieve its power handling capability through averaging

the input light over a larger photosensitive area, which inherently degrades the frequency response. Instead Ortel has used process technology to raise the power thresholds of the photodiodes.

The company claims that the diode will support input powers up to 15 mW at operating frequencies of 18 GHz. (Source: *Electronics Weekly*, 14 June 1995)

### *Single electron transistor with asymmetric tunnel barriers*

Professors T. Sugano and T. Toyabe, T. Hanajiri and their co-workers at Toyo University have conceived a single electron transistor (SET) with asymmetric tunnel barriers (ATBs). Computer simulation has shown that the new configuration will overcome the shortcomings of conventional SETs.

The predicted advantages are: the operation speed will be at least up to five times as fast as previous types; the probability of co-tunnelling will be reduced; and tunnelling of electrons will be more likely in one direction than in the other. The research team is going to confirm the predictions by experiments.

A SET is made up of two tunnel junctions and a capacitor between them. The major problems of conventional SETs are that there is no preferred direction of tunnelling current and current leakage caused by the co-tunnelling effect. These problems are preventing application of the device. With the conventional structure, the SET has tunnel resistances correlated with the capacitance. In the high-frequency range, therefore, conventional SETs have increased time constant, a product of the resistance and capacitance.

The new SET has been a subject of the two-year-old Nanoelectronics Research Project of the University's Faculty of Engineering.

Further details from Toyo University, Faculty of Engineering, 2100, Kujirai-Nakanodai, Kawagoe City, Saitama Pref. 350. Tel.: +81-492-31-1131; Fax: +81-492-31-1855. (Source: *JETRO, June 1995)*

### *Photosensitive copper conductive paste*

Toray Industries, Inc. has developed a new range of a photosensitive copper conductive paste that enables the line widths of printed circuit wirings on ceramic substrate, which have the smallest line width of 80 $\mu$m using the conventional copper paste, to be narrowed to a wiring line width of 30 $\mu$m.

Reducing the line width enables printed circuits of the same scale to be engraved in an area that is less than 15 per cent compared with before to permit the chip sizes of multichip modules (MCMs), for which demand is increasing rapidly for use in portable telephone sets, to be reduced substantially. The circuit engraving cost is also suppressed to about the same level as that of conventional photosensitive conductive pastes.

To respond to current demands for high-frequency, high-speed signal processing as well as miniaturization of computers and communications equipment, it will be necessary to use conductor lines of finer dimensions and lower resistivities. The copper paste can replace the silver-based paste as a conductive material due to the low electric resistivity, excellent migration resistance, and soldering ease.

The new photosensitive copper paste was developed by using the company's original photosensitive resin, glass frit, and photopolymerization agent, proprietary conductive paste manufacturing technology, and a superfine patter-forming technology based on photolithography developed through the manufacture of colour filters.

Up till now, when forming patterns by the screen printing method, the pattern cross-sectional area became serrated and lacked uniformity. The cross-sectional areas of the patterns formed by this photosensitive copper paste have a sharp rectangular shape characteristic of photo-lithography, so that the pattern reliability and migration resistance are improved substantially. In addition, the rectangular shape of the pattern sectional area enables electric circuits with CADs and CAMs to be designed with ease.

The new photosensitive copper paste consists of an easily decomposed acrylic resin, copper powder, glass frits, polymerization agent, plasticizing agent, various kinds of additives, and a solvent. In the pattern-forming process, the photosensitive copper paste is applied to the ceramic substrate or green sheet by the screen printing technique, then dried and exposed via the mask, followed by aqueous developing to acquire the prescribed superfine pattern. Heating is with a belt furnace in which the film subsequent to pattern forming is controlled in an oxygen atmosphere. Excellent characteristics are displayed in both pattern resolution and sharp rectangular shape of the sectional area.

By capitalizing on the basic technology of this photosensitive copper conductive paste, the company plans further research to develop photosensitive silver, silver-palladium, tungsten and insulating pastes.

Further details from Toray Industries, Inc., Public Relations Section, 2-2-1, Nihonbashi-Muro-cho, Chuo-ku, Tokyo 103. Tel.: +81-3-3245-5178; Fax: +81-3-3245-5459. (Source: *JETRO*, June 1995)

### *Intelligent porous polymer film produced by ion irradiation*

The Takasaki Radiation Chemistry Research Establishment-Japan Atomic Energy Research Institute (TRCRE-JAERI) and the Gesellschaft für Schwerionen-forschung (GSI) have jointly conducted a heavy ion irradiation research project and succeeded in synthesizing a new type of intelligent porous polymer film with a temperature control function.

The two research institutes had been advancing joint research from 1991 to produce new materials by ion irradiation, with TRCRE-JAERI synthesizing an environmentally responsive material and GSI creating superfine holes by heavy ion irradiation.

The new functional film is produced by irradiating $^{197}$Au ions with an energy of 11.6 MeV/n on a poly (ethylene terephthalate) (PET) foil with a diameter of 3 cm and 19 $\mu$m thick, followed by etching in aqueous 5 M NaOH for three hours at 40° C. which forms a PET film with cylinder-shaped pores of 2.9 $\mu$m diameter. The superfine hole containing films are then irradiated with 10 kGy $\gamma$-rays and bonded with poly (N-isopropylacryl-amide), to change the sizes of the holes reversibly between 1-1.5 $\mu$m within a range of 30-32° C.

The research team observes that the new film can be applied to the transfer and separation of substances as well as to the development of new intelligent materials.

Further details from Takasaki Radiation Chemistry Research Establishment, Japan Atomic Energy Research Institute, 1233, Watanuki-machi, Takasai City, Gunma Pref. 370-12. Tel.: +81-273-46-9413; Fax: +81-273-46-9687. (Source: *JETRO*, June 1995)

# D. MARKET TRENDS AND COMPANY NEWS

## Company News

### NEC and AT&T to co-develop 0.25 μm CMOS

NEC Corp. and AT&T Microelectronics have signed an agreement to jointly develop a common manufacturing process for 0.25 μm. The agreement extends an earlier arrangement under which the two companies began developing manufacturing processes together. The companies hope to complete the development effort by the end of 1996.

As in the previous agreement, the joint development work will be broken into modules, with responsibility for each module shared among development teams from each company. The development teams will work independently, sharing results at each stage of the work. Development work will be carried out at NEC's facilities in Tokyo and AT&T Microelectronics and Bell Laboratories facilities in the United States. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### MCM-D consortium

Multichip module manufacturing technology will get a boost from a $40 million technology development agreement between the US Defense Department's Advanced Research Projects Agency (ARPA) and the newly formed MCM-D consortium. The cost-shared project will focus on large-format deposited multichip module (MCM-D) manufacturing technology. The contract will be implemented by ARPA through the Technology Reinvestment Project (TRP), which is funded by matching contributions from government and industry.

The ultimate goal of the consortium is to perform a coordinated research and development programme to develop low-cost MCM-D manufacturing technology, by working with equipment manufacturers to develop high throughput, reliable and low-cost equipment. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### SEMATECH launches 300 mm group

SEMATECH has launched an effort to create a new international group to address the transition to 300 mm wafers. The total industry cost of converting from 200 mm to 300 mm manufacturing is estimated to be in the range of $10 billion to $16 billion. The purpose of the new international group would be to share the costs and minimize the risks by gathering the global companies most likely to move into 300 mm manufacturing. It is believed that international cooperation could allow the work to be completed as early as 1998.

The new group would be a separate entity, but foreign firms will not be offered membership in SEMATECH and SEMATECH intellectual property will not be shared with the new legal entity.

The name and goals of the new group are as yet unclear, other than that it will focus on qualifying and characterizing materials and tools for 300 mm manufacturing on a world-wide basis, and share the results of that research with members of the organization. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### European alliance will develop 12 in. wafers

The challenges offered by 12 in. wafer processing will be tackled by an alliance known as Integrated Fab Systems (Infab). It has been formed by Empak, Meissner and Wurst, Jenoptik and Praxis.

The change to this new wafer size requires intensive collaboration by device manufacturers, materials suppliers and equipment companies. The collaboration involves the cleanroom expertise of Meissner and Wurst, the specialist cleanroom automation and microfabrication experience of Jenoptik, the expertise in wafer shipping and isolation of Empak and the software and systems experience of Praxis. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### Collaboration on 0.18 μm optical lithography

Texas Instruments (TI, Dallas) and IMEC (Leuven, Belgium) are collaborating on research for an advanced 0.18 μm photolithography process that will enable migration to gigabit-class chips. The research is being done at IMEC's facilities in Belgium by both TI and IMEC researchers.

This work is expected to enhance future digital applications, such as high definition television, video on demand and desktop video conferencing.

The initial phase of the joint research effort concentrates on developing a method of combining advanced optical illumination techniques, phase shift masks and photoresists to enable optical steppers to achieve 0.18 μm linewidths. These developments will allow for a cost-effective process and will delay for another generation a technology change to more expensive alternative techniques, such as X-ray lithography. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### SOITEC, JESSI to develop SOI wafers

SOITEC (Grenoble, France), a manufacturer of silicon-on-insulator (SOI) wafers, is working on a joint research project with JESSI aimed at the development of standard 200 mm wafers for advanced CMOS applications. In this project, focused on SIMOX (Separation by IMplanted OXygen), SOITEC is working with Wacker-Chemitronic, a leading producer of silicon wafers. GRESSI, the Grenoble Submicron Silicon consortium, will perform electrical characterization and evaluation. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### Gate array rethink

All the best ideas are simple. And US EDA firm Silicon Architects, acquired by Synopsys earlier this year, has taken the ASIC industry by storm with a seemingly obvious evolution of the gate array.

The company has redefined the logic cells on a gate array's base wafer to better suit the needs of today's complex ASIC designs. The result is its cell-based array (CBA) methodology which combines the metal-only customization advantages of gate arrays with the density of cell-based ASICs.

Silicon Architects has a place and route, and synthesis library which offers a 30 to 60 per cent greater density than traditional gate arrays, depending on circuit type Fujitsu, NEC and Toshiba, three of the world's largest ASIC suppliers, are to support the CBA technology.

The basic building block on a CBA comprises a group of four cells: one drive cell and three compute cells. The group is replicated across the gate array in a channel-less architecture. This 3:1 drive-to-compute cell ratio is a patented feature of the CBA.

A drive cell features two buffers and a compute cell contains eight transistors, four p-type and four n-type, in three sizes. A compute cell has a fan-out of 2 and a drive cell can be ganged up to provide higher fan-outs. The p- and n-type transistors are carefully ratioed with the drive from two p-types equalling one n-type.

The input to a macrofunction is connected to the smallest transistor in a compute cell to reduce loading, and the output is programmable by using combinations of the available transistors.

The physical layout of both cell types is as compact as possible and a compute cell has a number of alternative physical inputs around its periphery and within the body of the cell. This alleviates the difficulties of wiring routing and reduces the number of vias needed, increasing the chip's yield.

The CBA technology is targeted at complex ICs with multiple memories, datapaths and random logic.

Silicon Architects has developed a library of datapath and memory-block compilers and rapidly-configurable application-specific blocks for use with CBA.(Source: *Electronics Weekly*, 28 June 1995)

### *Electronic cash firms forge Internet links*

UK electronic purse company Mondex is believed to be squaring up to its European rival Europay to provide secure, chip-based financial transactions over the Internet.

Europay has joined forces with technology giant IBM to develop a smart card-based payment system for commercial transactions over the Internet. This mirrors the plans of Mondex, led by NatWest Bank, Midland Bank and British Telecom which, according to one industry source, wants to provide its own electronic funds transfer services over the Internet.

Europay, which is backed by credit card firms Mastercard and Visa, is making the running and IBM has already devised an open payment protocol, named Internet Keyed Payment Protocol (iKP) that is fully compatible with leading operating systems, such as Windows, OS/2, Macintosh and others.

It has proposed this protocol to the World Wide Web organization and the Financial Services Technology Consortium in an effort to make it an industry standard.

Another contending protocol is the Visa and Microsoft STT protocol, which will need proprietary system to run.

In order to allow electronic commerce over the Internet, specially designed card-readers, that can be fitted onto PCs or multimedia boxes, are already in development. (Source: *Electronics Weekly*, 21 June 1995)

## Market Trends

### *Sensor market on an upswing*

According to a new research report from Forst & Sullivan (Mountain View, CA), the sensor market is on the upswing, driven by legislation to protect the environment and address occupational and home safety concerns. Also, automobile safety mandates and demand for optional features have increased the demand for accelerometers, Hall effect sensors and other sensors used in on-board automotive systems.

The report, titled "Sensor Market Sourcebook", also says that improvements in sensor design are also driving the market, including the emergence of silicon micromachined sensors with enhanced performance and durability, fibre-optic sensing devices, increasing prevalence of "smart" microprocessor-based sensors that allow greater facilities integration, and the development of thin-film technology that improves quality and lowers sensor manufacturing cost.

Silicon sensors have greatly expanded the application of industrial sensors, and their micromachining allows for batch manufacture of millions of sensors that can be cost-effectively deployed in cars, consumer electronics and other applications, requiring large numbers of sensors. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *DRAM market to grow 40 per cent*

The DRAM market is expected to grow 40 per cent this year as suppliers try to keep up with demand spurred by the requirements of new operating systems, principally Windows 95, and memory-hungry applications.

Market research firm Dataquest predicts that the world-wide memory market will reach $45 billion this year, up from $32 billion in 1994. Dataquest says that demand is being driven by the needs of PC users, which account for two thirds of the memory market.

By the end of this century, Dataquest estimates that world-wide PC shipments will be 100 million units per year and DRAM revenues will reach $60 billion with total memory revenues including SRAM, ROM, EPROM, EEPROM and flash memory sales reaching $78 billion. (Source: *Electronics Weekly*, 14 June 1995)

### *Dataquest blames DRAM makers for chip shortage*

If DRAM manufacturers had geared up to make the right product, there would not be a shortage, says US analyst Dataquest.

According to Dataquest, the reason for the DRAM shortage is because "manufacturers do not know how to make the part everyone wants. At 16 Mbit the bulk of the demand is for x16 parts and only three manufacturers can make it."

These parts are in demand because they are more cost-effective for PC main memory than traditional x4 chips.

Dataquest says that DRAM manufacturers are using their 16 Mbit lines to make 4 Mbit DRAMs, which means the plants are only operating at a half to one third of their capacity. If they were operating at full capacity there would be no shortage.

Dataquest projects a rise in DRAM average selling price (ASP) until late 1996 or early 1997 when prices could start to drop.

Apparently, the only three suppliers of x16s are Toshiba, NEC and Samsung. The problem in making x16s is the extra I/O pins, which cause ground bounce noise problems. (Extracted from *Electronics Weekly*, 12 July 1995)

### *EDO wins Pentium L2 caches*

Extended data out (EDO) high-speed DRAMs will soon replace SRAM-based level 2 cache in some Pentium PCs as system manufacturers struggle with continuing shortages of asynchronous SRAMs.

Developers are designing low-end Pentium motherboards without high-speed SRAM cache where main memory based on EDO and even higher speed burst-EDO DRAM can provide the necessary access speeds. Opinions differ on whether this is a short-term measure to plug the SRAM shortage gap or a permanent change.

Intel, by far the largest manufacturer of Pentium motherboards, continues to recommend SRAM cache and views the use of EDO DRAM as a short-term measure. But some suppliers say EDO DRAM will ultimately replace asynchronous SRAM cache.

Current shortages of asynchronous SRAM traditionally used in cache memory may not be cleared until 1996 as suppliers turn their attention to new higher speed synchronous SRAM which has a definite speed advantage over all flavours of EDO DRAM. (Source: *Electronics Weekly*, 12 July 1995)

### *ICE market analysts up chip forecast—warn of over-capacity*

Market analysts at Integrated Circuit Engineering (ICE, Scottsdale, AZ) have dramatically changed their 1995 forecast for the world-wide semiconductor market. The initial forecast, developed in October 1994, saw a 10 per cent increase in 1995. Now, ICE sees the potential for a 19 per cent increase. The change is based on faster evolution of the assumptions used. For 1995, ICE analysts now see:

- A 3 per cent US GDP growth;
- A 15 per cent increase in computer sales;
- Strong foreign currencies;
- Inexpensive Pentium chips; and
- Windows 95 software.

The revised ICE forecast is not without caveats: the critical factors are the health of the US economy, rising interest rates, the economic collapse of Mexico, and erratic exchange rates. Plus, the better outlook for 1995 has robbed 1996, lowering expectations there from 20 per cent to a still healthy 15 per cent.

ICE's report said that in 1994 capital spending represented about 21 per cent of world-wide semiconductor sales. This will jump to 23 per cent for 1995, significantly above the 20 per cent figure that ICE estimated is needed to keep up with demand.

A survey by ICE in early March revealed that DRAM manufacturers are planning a collective capacity to produce about 420 million 16 Mb DRAMs in 1995. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *Semiconductor equipment shipments increased in 1994*

World-wide semiconductor equipment shipments increased to $14.5 billion in 1994, up from a 1993 value of $10.4 billion, according to Semiconductor Equipment and Materials International (SEMI).

Based on the combined SEMI-SEAJ (Semiconductor Equipment Association of Japan) world-wide database, total equipment (including wafer processing, assembly and packaging and test) sales in North America reached a value of $4.6 billion in 1994, up 27 per cent from a 1993 figure of $3.6 billion.

Total equipment shipments to Europe in 1994 increased 28 per cent from $1.4 billion in 1993 to $1.8 billion. The Japanese market's total equipment shipments for 1994 grew 46 per cent in dollars, from $3.2 billion in 1993 to $4.7 billion. Equipment shipments into Korea/Rest of World (ROW) led all regions, growing 60 per cent from $2.2 billion in 1993 to $3.4 billion in 1994.

Producers of wafer process equipment enjoyed a 1994 sales growth rate of 46 per cent, with sales to Korea/ROW leading all regions with a 70 per cent annual growth rate. The Japanese market also posted significant growth in the wafer process equipment category, increasing 51 per cent in 1994. The North American market for wafer process equipment grew 36 per cent in 1994, although bookings did better, with 51 per cent growth and almost a billion dollars more orders than shipments. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *Where do all those silicon wafers go?*

A recent *Icecap Report* from Integrated Circuit Engineering (ICE, Scottsdale, AZ) sizes up the world-wide status of silicon wafer usage.

Last year 200-mm wafers moved into mainstream production. As of late 1994, there were just under 30 merchant 200-mm wafer fabrications in operation. Of those almost two thirds came on line in 1994. However, 200-mm wafers still represent the smallest portion of the world's IC wafer capacity; within the IC industry's per month capacity of 7.8 million wafers, only 7 per cent belongs to 200-mm wafers.

By world region, North America is the largest consumer of 200-mm wafers. Japan is second, followed by Europe, and "the rest of the world" (primarily Korea).

Today, 150-mm wafers are the dominant size, and their usage is still rising; 150-mm wafer usage is not expected to peak until 1997.

Smaller 100-mm and 125-mm wafers have already seen their days of peak usage. But, world-wide, many wafer fabrication facilities are outfitted for these sizes. The report says that many of these facilities may never be upgraded. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *Fast growth in digital wireless communications*

World-wide consumption of semiconductor components installed in digital wireless communication (DWC) terminals and rf base station equipment is expected to increase from $2.8 billion in 1994 to $12.2 billion by the year 2000, according to a new study by Kenneth W. Taylor & Associates (Los Altos, CA).

The DWC market includes: digital cellular radio, digital cordless telephones, paging systems, wireless PBX, personal communication networks (PCNs), specialized

mobile radio and dispatch, digital wireless wide area networks, wireless local area networks, wireless modems, wireless terminals (PDAs), global positioning systems and satellite-enabled telephones, among others. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *64 Mb DRAM technologies "in the wings"*

An analysis by Integrated Circuit Engineering's microelectronics laboratory (ICE, Scottsdale, AZ) shows that the major early generations of 64 Mb DRAMs are based on ~0.35 μm wafer processing technology. However, ICE engineers believe that when these semiconductor manufacturers begin to make more than 500,000 units a month by 1998, they will move to advanced 0.25 μm processing.

Commenting on emerging technology for 64 Mb DRAMs, ICE technologists said, "If the IC industry moves quickly to sub-0.35 μm feature size devices, the 3.3 V power supply standard will be fairly short-lived, stepping down to 2.2 V for internal circuitry." In addition, a process like Hitachi-TI has revealed it will be increasingly difficult to manufacture. High-volume production using such a leading-edge process will not be an easy task.

It is ICE's view that early in its life cycle, the complex, expensive characteristics of the 64 Mb DRAM will limit its use to high-performance workstations, servers and mainframe computers. However, by 1998, they expect 64 Mb DRAMs will be used by the majority of PC vendors. ICE forecasts that 205 million 64 Mb DRAMs will be shipped in 1998, to the tune of roughly $75 each.

The lowest selling price now expected for the 64 Mb DRAM is about $25, but this price is not expected until 2003.

ICE has published an extensive analysis of 64 Mb DRAM—"Ready or Not, Here Come the 64 Mb DRAMs"—in a recent issue of its *Icecap Report*. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *Flash memory far from fool's gold*

Is flash memory just a flash in the pan? Based on its slowly increasing popularity, the answer is no.

Just over half a decade ago, flash memory was conspicuously absent from electronic designs. One sign of flash's wider acceptance comes from the World Semiconductor Trade Statistics (WSTS), that just started tracking flash data as a separate category last year. Flash memory is gaining momentum among designers. Groups such as InStat, predict flash, especially high-density devices, will enjoy remarkable market-share growth over the next several years.

According to WSTS, world-wide flash sales reached $864.8 million in 1994. The North American market alone consumed nearly half of this total ($428.2 million). Data from the first two months of 1995 provide an initial clue to the pace of growth. World-wide flash sales for January and February of 1995 expanded 62.2 per cent from the same period in 1994. At the same time, sales to North America climbed 57.2 per cent. World-wide unit sales over the year expanded at the blistering rate of 87.8 per cent. For the 12 months ending February 1995, unit sales totalled 123.6 million.

High density flash (16 Mbits and above) shows up in digital answering machines, cameras, fax machines and PCM CIA cards. Because flash is non-volatile, it can take the place of disk drives in small hand-held computers, taking up less space and using less power.

Flash does have its faults. Two market forces impeding flash proliferation are high price and low availability—two factors that often go hand-in-hand. But flash prices are trailing off, and have already dropped below total MOS DRAM average selling prices (ASPs). Between February 1994 and February 1995, the flash ASP fell 12.3 per cent to stand at $7.69 per unit.

In addition, more manufacturers are entering the flash fray. Close to a dozen chip makers offer high-density flash devices and second sources are evolving, producing a more highly-charged, competitive environment. (Extracted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *EIAJ says design-ins are increasing*

The Electronic Industries Association of Japan (EIAJ) said the number of foreign chips being designed into Japanese products is on the increase. According to a recent EIAJ report, design-in activities, in which semiconductor users and suppliers work together to develop specific large-scale integrated circuits (LSIs), have increased sevenfold between 1986 and 1993.

EIAJ claims part of the increase in design-ins is due to the efforts of its User's Committee of Foreign Semiconductor (UCOM), which held a design-in campaign known as "Chip-in" from May to July 1994. A second campaign, called "Chip-in II", began earlier this year and was jointly sponsored by UCOM and the US Semiconductor Industry Association (SIA).

Industrial surveys conducted by EIAJ show that more than half of the Japanese users point to suppliers' technological capabilities as the most important factor for a successful design-in. Other important considerations among Japanese buyers include continuous design-in efforts and the ease of design-ins. User expectations, however, vary by product. For example, more than half of the users point to technology as the key to a successful design-in for analog, logic and microprocessor devices, whereas technology is regarded as less important for other products that are easier to design in. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

# E. APPLICATIONS

### Low-cost FEDs

It is difficult to produce cold cathode microtips for field emission displays (FEDs) that will emit electrons at relatively low voltages. Layers of n-doped diamond-like amorphous carbon developed at Cambridge University can be used at much lower voltages than existing cathodes without the use of microtips.

The Cambridge workers employ a carbon arc to deposit and dope the diamond-like carbon layer with nitrogen and phosphorus. The carbon rods that form the arc contain the phosphorus dopant, while the nitrogen comes from the gas plasma. These dopants reduce the energy band gap so that emission occurs at lower field strengths.

According to team leader Gehan Amaratunga, the diamond-like material emits at a field strength of 25 V/$\mu$m, but the group hopes to attain values of about 5 V/$\mu$m. The material may considerably reduce the cost of producing FEDs. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### On-site portable information processing terminal

Nippon LSI Card Co. Ltd. has developed an on-site portable information processing terminal that enables image information taken with a compact digital camera to be transmitted by fax.

The new "handy DIGICAME" is 38 cm long, 10 cm wide and 3.5 cm thick, and incorporates components such as a charge-coupled device (CCD) and a central processing unit (CPU). A colour still-picture camera is fitted at the tip of the body, and image data are collected by an LSI card (8 Mb), a contactless memory card, instead of a film. The photographed image data are stored directly in a so-called intelligent terminal connected to a portable telephone set, then transmitted by fax. The data can also be transmitted to a Windows personal computer with the portable telephone set.

Further details from Nippon LSI Card Co. Ltd., Sales Division, 2-9-16, Nihonbashi, Higashi, Naniwa-ku, Osaka 556. Tel.: +81-6-647-1677; Fax: +81-6-647-6216. (Source: *JETRO*, May 1995)

### Clinical dentistry instruction using virtual reality system

Prof. S. Tsutsumi and his research team of the Research Centre for Biomedical Engineering, Kyoto University, have developed an educational simulation system for clinical dentistry that is based on virtual reality (VR). This simulation system can be used for conducting studies on emergency situations where training cannot be offered with training systems using manikins, and enables playback of recorded stereoscopic treatment processes.

Central to the new educational system is a British virtual reality workstation (PROvision 100 VRX) which uses a special-purpose virtual reality software on a UNIX computer. The output system uses a helmet-type display, by which the patient's teeth can be seen with both eyes while listening to stereophonic sounds. Position information is transmitted with a three-dimensional mouse with five pushbuttons, while the three-dimensional position information is sensed with three coils in a magnetic environment.

The application of virtual reality provides the advantages of (1) supplementing intermediate and manikin-based training in the process of practical education, (2) enabling training in abnormal cases, and (3) enabling three-dimensional recording of the process of tooth cutting, which can be played back later for review.

The virtual reality technique is being applied to flight training simulators, but application to dentistry had previously remained only a concept.

Further details from Research Centre for Biomedical Engineering, Kyoto University, 53, Kawahara-cho, Shogoin, Sakyo-ku, Kyoto City, Kyoto 606-01. Tel.: +81-75-751-4130; Fax: +81-75-751-4144. (Source: *JETRO*, May 1995)

### On demand information

On Demand Information (ODI) surpasses the limitations of text-based electronic publishing systems by offering images as well as text with video a possibility in the future. So a reference library on the construction industry contains diagrams, drawings and colour photographs. The images are fully integrated and cross-referenced with the text so a user can switch from one to the other. ODI's offering also surpasses the limitation of reference books by updating this information on the fly.

At the customer end, information is scanned, manipulated and retrieved through a basic access ISDN2 line linked to a 486 PC equipped with a customized graphics card. The core user system has been designed so that time and therefore charge for ISDN use is kept to the minimum. The user searches and selects information on the PC front end before a request is put over the line and the data is retrieved. A 12-page document takes about 45 seconds to retrieve from the host.

ODI's image management software is a combination of the industry standard, the custom built and the exclusively licensed. For example, at the PC end it has a Windows face but ODI has also signed contracts with Eidos for technology compressing video onto a digital signal as well as with US company Excalibur Technologies for fuzzy logic knowledge searching software enabling unstructured requests. ODI's first application of this platform is in the construction industry. Working in partnership with the Building Centre in London, the company developed a CD-ROM-based product before moving to its network in mid-1994. (Source: *Connexion*, 3 May 1995)

### Dynamic drum system for noiseless variable-speed playback, and potential for high-density recording

Victor Company of Japan, Ltd. (JVC) has introduced new VHS core technologies, such as the first Dynamic Drum, which further increase the versatility of the VHS format. Special-effects playback such as forward or reverse variable-speed search are virtually noiseless. Recording in the reverse direction will also be possible in the future. And these technologies represent a big step towards the introduction of long-time and high-density recording.

As the width of a recorded pattern is measured in microns, the lower drum supporting the rotary head has to be firmly attached to the base to prevent movement of any

kind. However, in order to introduce features that satisfy the various needs stemming from new applications and lifestyles, the Dynamic Drum System has been developed. The lower drum is separated from the base, allowing precisely-controlled dynamic movement.

The main feature of the DD System is a "Noiseless variable-speed playback" system, and its future possibilities are as follows: smooth slow-motion playback (improvement over current frame advanced slow-motion pictures), automatic compensation is applied to recording patterns to combat effects of environmental changes, such as temperature, and mechanical errors, track-unit frame recording in the pause mode, endless recording (once tape reaches its end, recording automatically continues in reverse direction), and narrower recording tracks which are necessary for long-time and high-density recording.

Further details from Victor Company of Japan, Ltd., Public Relations Office, 3-12, Moriya-cho, Kanagawa-ku, Yokohama City, Kanagawa Pref. 221. Tel.: +81-45-450-1489; Fax: +81-45-450-1498. (Source: *JETRO*, June 1995)

### New electronic printing system commercialized

Mitsubishi Heavy Industries, Ltd. has commercialized Japan's first electronic printing system that prints monochromic or colour characters and graphic information prepared by computers directly on paper without using a film or plate. The electronic printing system enables on-demand printing of small lots of 1,000 sheets that are unsuitable for conventional offset printing and, if necessary, printing one document at a time.

The new electronic printing system uses size A-4 lateral-width rolled paper and enables four-colour printing on one face and two-colour printing on the front and rear faces. The introduction of a long service-life photosensitive drum makes the printing system durable and capable of printing a maximum of 1 million sheets of superprecision images of 800 dots per inch (DPI).

The system also incorporates a large-capacity memory of 8 Gb capable of storing more than 800 pages of characters and over 180 pages of colour images, and the printing speed is 72 sheets/min of size A4 paper. The printing size is maximum 306 x 430 mm, and A3 paper with a register symbol can also be printed. The system software is available in both Japanese and English, and the plan is to prepare a broader range of software in response to overseas market demands.

Further information from Mitsubishi Heavy Industries, Ltd., Public Relations Section, 2-5-1, Marunouchi, Chiyoda-ku, Tokyo 100. Tel.: +81-3-3213-3111; Fax: +81-3-3212-9860. (Source: *JETRO*, June 1995)

### VLSI chip brings DECT to local wireless loop

VLSI Technology's latest baseband processor for the DECT European digital cordless telephone standard will provide multiple line access in wireless local loop basestations and wireless PBXs.

The VP23030 is VLSI's third DECT baseband chip, but the first aimed directly at promoting DECT's use in the wireless local loop.

The device incorporates the DECT baseband processor core, a programmable radio interface, data recovery circuitry and received signal strength indication (RSSI). The main change on its predecessor, the VP23000, is that the VP23020 G.721 transcoder has been moved off-chip.

The DECT processor incorporates a 64-slot ADPCM interface which supports connection not only to VLSI's own (VP23020) G.721 transcoder, but also industry standard devices such as ISDN chips from Oki and Siemens. The device supports the full 12 DECT speech channels, and the ADPCM interface allows chips to be connected in parallel for basestation designs.

VLSI Technology also intends to introduce a programmable baseband processor next year which will support multi-protocol mobile phones.

The attractions of dual-mode handsets is that GSM mobile phone operators will be able to overlay a DCS1800 network, utilizing the 1800 MHz frequency band, to increase the number of radio channels in high usage city areas. The biggest modification is designing an RF front end which will support 900 and 1800 MHz radio links. (Extracted from *Electronics Weekly*, 28 June 1995 and 12 July 1995)

### Multiprocessing

The latest generation of 64-bit microprocessors are going to extend the performance of PCs. In addition, designers are stringing processors together to increase performance to high-end workstation and server class system levels.

Multiprocessing, once the preserve of the supercomputer, is filtering into the PC architecture which is resulting in new high bandwidth system buses. But how far can multiprocessing go in the PC architecture given the practical limitations of bus bandwidth and DRAM access times?

Today's high-speed processors do not have to rely on main system DRAM memory for all data retrievals. Indeed it is necessary that they do not since DRAM and external buses are not fast enough. Processors have fast SRAM-based cache memory containing the present task's most frequently used data, which has been copied from main memory. The latest generation of 64-bit processors which support multiprocessor designs, incorporate two levels of associated cache, L1 and L2. Cache systems make assumptions of which data to hold, usually based on temporal and spatial synchronicity in the processor's addresses to main memory. The efficiency of cache data selection is vital for overall system performance.

Memory bandwidth can be increased by interleaving data access from more than one DRAM, or more commonly in multiprocessor systems, by using a multiple memory system which can be accessed from the one bus. Even with a split-transaction bus, which allows memory use while the memory controller is accessing DRAM, processor contention and inherent latency can result in transaction delays before read requests are received at the DRAM.

Latency can be reduced with distributed memory architecture which places some DRAM memory closer to processors.

A key feature of the split-transaction bus is that slow devices or long latency periods do not prevent other bus transactions.

Bus bandwidth can be a limiting factor in any multiprocessor architecture. One option is widening the bus from 32- and 64-bit up to 256-bit wide. The other way is to create multiple data paths within the bus, with crossbar switching logic which dynamically routes the data transactions.

As the number of data paths within the crossbar switch is a squared function of the number of processor connections, the approach is limited to small multiprocessor systems.

In general, multiprocessing system design is easiest when the designer can rely upon a unified memory model, where each memory location has its unique address. This is achievable with distributed memory and even crosspoint bus switching, but it requires careful system design. Coherency is also a problem in multi-cache systems, but here each data cache constantly monitors traffic on the bus. (Extracted from *Electronics Weekly*, 28 June 1995)

### Teachers and the world of CD-ROMs

CD-ROMs provide an interactive multimedia tool to integrate information and ideas in a web woven by the learner. A CD-ROM (Compact Disk-Read Only Memory) stores 650 megabytes of information on a plastic disk. The information is read using a laser and can be translated by computer into sounds and images. The CD-ROM has been around in the form of music CDs for 15 years.

While the tool is old, the ability to cheaply and quickly make your own CD is a new and growing cottage industry. Teachers can now consider converting their home-built curricula to CD. This format can be smart, since the information is not only stored but also catalogued and linked. This is the key because the index connects ideas. CDs can also disseminate information: publishing a CD is becoming a feasible way for a teacher to share materials and insights.

Using a CD player and a computer, the learner drives the CD and determines the order in which the information is displayed. CD format is important because it permits a return to the tutorial, question and answer mindset of learning in which the learner helps drive the direction of the teaching—it is in the heritage of one-on-one pedagogy.

CD records information in a long, spiral line. The advantages are that all information can be indexed and linked and the information is quickly accessible because of the platter format. Furthermore, since the information is digital, CDs can be multimedia.

While CDs are most familiar for music recordings, their power as a learning tool lies in their ability to record text and images as well as sounds. These can be integrated so that the learner can read, see and hear about a topic. Thus, CDs can accommodate the learner's preferred mode of presentation. The information can be linked or webbed so that the learner determines the line of inquiry.

Students know that video games can keep track of their names and their score. CDs can be designed to work with computers so that the performance and preferences of all the students in a classroom are recorded on the computer hard drive. These records can assist in the measurement of not only how much a student has learned but it can also analyse how the student learns. Again, this emulates the classical tutor-student relationship possible when teaching is one-on-one.

It has been said that media are additive—new ones do not replace old ones. Blackboards are not becoming extinct. But it appears that teachers and students will soon be able not just to use a new tool, but to routinely make their own versions of the tool. (Extracted from *Genetic Engineering News*, 1 June 1995)

### New failure analysis techniques developed by Sandia

Sandia National Laboratories (Albuquerque, NM) have developed a technique for finding defects in integrated circuits. The technique uses low-energy charge-induced voltage alteration (LECIVA) to locate open conductors without damaging the chip. Open conductors have become more difficult to detect and localize as linewidths shrink and complexity increases.

Sandia describes LECIVA as an improved imaging technique using charge-induced voltage alteration developed two years ago by researcher Edward Cole in Sandia's Electronic Quality and Reliability Center (ECRC).

The technique uses a scanning electron microscope to inject a small amount of electric charge at a precise microscopic spot on an interconnection. Cole determined that this small charge would cause no effect on a normal circuit but, if injected into an interconnection line near an open conductor, it would cause a voltage change at the spot of the defect. Images, detectable with the scanning electron microscope, are produced from the voltage fluctuations of a constant-current power supply as an electron beam is scanned over the integrated circuit surface. The brightness at a particular spot is proportional to the voltage required to keep the current constant. (Extracted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### Non-contact clean plate conveyance using acoustic levitation

Kaijo Corp., a maker of semiconductor manufacturing systems, and the Precision Engineering Research Laboratory of Tokyo Institute of Technology, have jointly developed a non-contact clean plate conveyance system. Objects weighing several kilograms, about a thousand times heavier than those conveyable with conventional non-contact technologies, are levitated by ultrasonic vibration.

With this new technology, a duralumin plate is first vibrated to generate ultrasonic waves, and the energy used to levitate printed circuit wafers by 50 μm to 2 mm for conveyance at a fixed speed. Levitation of objects weighing as much as about 5 kg has been confirmed, although this will differ with the specific system.

Non-contact levitation techniques such as those using magnets have been available, but objects weighing only up to a few milligrams could be levitated, so commercialization was not possible. The new technology is capable of conveying clean plate made of all kinds of materials by levitation as long as the wafer has a fixed area. Since no special technology such as superconductivity is used, the system cost is quite low.

The new technology can be commercialized for conveying 12-in. wafers which are the next generation of semiconductor wafers, and large glass wafers for liquid crystal devices (LCDs), by which contamination by foreign substances due to contact in the circuit-forming processes as well as the generation of defective products can be decreased substantially.

Further details from Kaijo Corporation, Head Office, No. 3-1-5, Sakaecho, Hamura City, Tokyo 190. Tel.: +81-425-55-2244; Fax: +81-425-55-7176. Overseas Marketing & Sales Div., 9th Floor, Kandabashi Park Bldg., 1-19, Kanda-nishiki-cho, Chiyoda-ku, Tokyo 101. Tel.: +81-3-3294-7611; Fax: +81-3-3294-7663. (Source: *JETRO*, June 1995)

# F. SOFTWARE

## *Software 2000: a view of the future*

(Edited by Brian Randell, Gill Ringland and Bill Wulf)

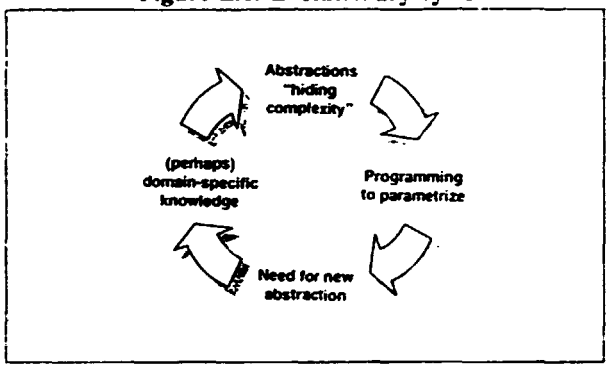
### Programmers and programming

There is a spectrum of types of programmer—from people who are very much professional programmers and know it, and who are paid by people who know it, through to people who do not regard themselves, and are usually not regarded by anyone else, as programmers.

In considering the programming task in general, several workshop discussions centred on a phenomenon related to the development of programming, namely the notion of cycle and progression. We start from a system which is rigid in what it can do. Very often flexibility is then provided by allowing parameterization or customization, leading to a more complex system that is eventually recognized as needing new abstractions. A new abstraction is found, perhaps incorporating domain-specific knowledge. Sooner or later, this is extended in its turn, and the evolutionary process goes on.

As each discipline develops special techniques and tools, what people in each domain term as programming—whether the COBOL world or in-car intelligence—has become more different. Intellectually it is the same type of activity, but technically it is different. This causes a fragmentation and spreading of the activities performed by programmers.

**Figure E.1. Evolutionary cycle**




Academics, in considering education and training needs, differentiate between software professionals (those who build underlying systems) and the professionals in some other domain who use basic software components to solve problems in their area, be it choreography or architecture. The number of people who design programs that will be used by someone else is much smaller than the number of people who are involved in programming at some stage.

Professional programmers work increasingly outside the IT industry and IT departments. For instance, increasing processing and storage capability within small-size and low-power requirements are revolutionizing the use of embedded software. Sewing machines are now optionally provided with ports for downloading programs to control their stitching. And in HDTV, the software may become effectively unbundled. The number of people involved in writing software for these embedded environments is growing amazingly fast—for instance, the amount of code in consumer products is doubling every year. The question was asked as to whether these programmers were facing the complexity problems of the 1968 software engineering world all over again.

The evidence seems to be that on the whole, the lessons of OS/360 have been learned. It may well be that a large number of domain-specific software frameworks emerge for embedded environments: communications, entertainment creation (authoring), visualization and information retrieval. These would consist of applications programming interfaces, languages, tools, and so on. They would evolve and adapt very quickly, and each give rise to a software industry.

Software prices have fallen, ever since unbundling. The trend has been accelerated by the switch into desktops (and games), away from mainframes. New styles of distribution and support operate for this software. There are knock-on changes in IT departments, instrumentation, defence and consumer device companies, and the services industries, where the decreasing price of software components puts bespoke prices under pressure.

The effect on systems integration businesses based on projects to deliver new systems has also been significant. Some of the US majors have had to lay people off because of the trend to use large numbers of software components and the effect of that on project price. The comparison of a custom system and a customized system based on existing components, in price and risk, has completely changed.

The lower cost of software components is also a problem in the software component industry itself. It must lower the capability for research and development. And it is hurting startups, who find that the cost of marketing, even existing components they have on the shelf, is too high to be worth it.

At the workshop, the term "intermittent programmer" was introduced to describe the relationship of "other professionals" to IT systems, applications, software and information. The term is meant to suggest that their use of a given set of software components is likely to be intermittent. Clearly they need to deliver high quality output in their domain as much as software professionals in theirs, so that they need a far higher standard of usability, predictability, on-line training, and resilience for tools and components intended for their use.

It was attempted to quantify the sizes and growth trends of the four types of "programmer":

- Software professionals (in software companies);
- Software professionals (in IT departments);
- Software processionals (in other industries, producing embedded software);
- Intermittent programmers.

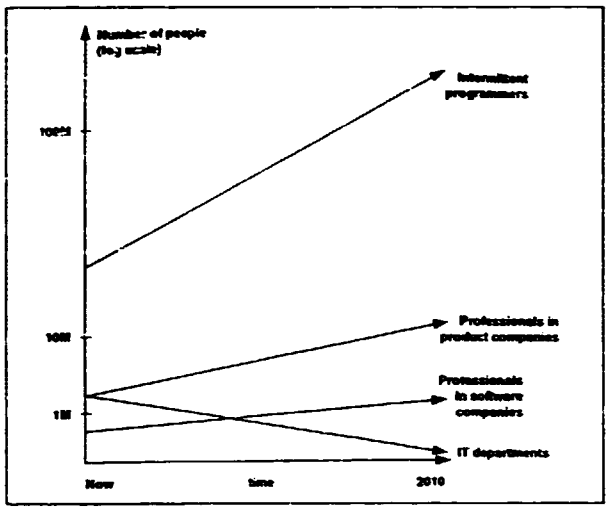
A model that may suggest the thought behind this theory is mathematics. There are few professional mathematicians in the world, yet each of us uses mathematics every day and usually without thinking "now I'm doing maths". In the future, professional people in most fields will use programming as a tool, but they will not call themselves programmers or think of themselves as spending their time programming. They will think they are doing architecture, or traffic planning or film making.

This provides a model of the trend point for programming skills in the twenty-first century. In the same

way that mathematics is ubiquitous, software is rapidly becoming so.

And, it also suggests that, although for the next few years the trends for professionals may be as shown, the effect of improved technology and re-use may start to limit the growth in the number of professionals needed within the next decade.

**Figure E.2. Who programs when?**




The workshop also discussed the size of effort—in terms of man-hours—spent working in the four domains. The large number of intermittent programmers, even if they only currently use IT for 10 per cent of their working time, represent more usage than the software professionals in IT departments and software companies combined. The effect of increasing their productivity is therefore very significant. In assessing the needs of these intermittent programmers, the view was expressed that users from the humanities provided interesting paradigms for "everyman". (Source: *Software 2000: a view of the future*. The output of a forum sponsored by ICL (Hedson House, UK) and the Commission of the European Communities, April 1994)

### *Clear multiple video images on personal computer displays*

NEC Corp. has developed a new technology that enables various kinds of animated video images to be displayed clearly on a personal computer display. With existing technologies, the image resolution is impaired when displaying multiple animated images on the display, but the new technology enables clear display by the format of aligning a maximum of 10 different kinds of video images vertically on the same display.

The company developed a new type of large-scale integrated circuit (LSI) that incorporates an ordinary graphics function and a video processing function, with eight video random access memories (VRAMs) of 4-Mbit for image storing and a digital/analog conversion chip on a single board for driving the personal computer.

The prototype system is capable of simultaneously displaying three types of video images. Changing the LSI design will allow the chip to display more than a dozen images without having to increase the number of VRAMs.

The new technologies allow (1) display of more than three video images simultaneously, (2) complete flicker-free display with a fixed video exposure performance, and (3) high-performance, high-definition (1,280 x 1,024 pixels) video display at a rate of 30 frames/s, or high-performance video processing at a low cost.

Commercializing a personal computer incorporating these new technologies will enable software houses to develop new softwares, making it possible for personal computer users in general to fully enjoy the multiple display of sophisticated animated images. The company envisages the new display technology will be applied to video editing systems for editing with numerous displays, electronic presentation systems and multi-point video conference systems, and plans to commercialize the new technology by the latter half of 1995.

Further information available from NEC Corporation, Public Relations Office, 5-7-1, Shiba, Minato-ku, Tokyo 108-01. Tel.: +81-3-3454-1111; Fax: +81-3-3457-7249. (Source: *JETRO*, June 1995)

### *Operation history used to generate computer model of human judgement operations*

OMRON Corporation has developed software to interpret expert human operations and judgements for machine control from only small data samples. This knowledge can then be used with ease from a personal computer. The system was expected to be marketed within 1995.

Data relating to each operation are coordinated with a main algorithm and then associated with the purpose of operation, to allow automation of machinery where fluctuating factors had previously forced the intervention of human operators. The system eliminates the need for incorporating unique programs based simply on plant site inputs, so productivity is expected to be improved considerably.

OMRON coordinated data relating to each operation under a set rule, on the premise that an operator performs operations and judgements only on the basis of results, and that the operator acts for the same purpose whatever the variable factors. During automated control, data are examined to clarify to which set of rules they belong, as judged from the lapse of time and target values, in order to judge the next operation.

Taking a chemical plant example, rise-up control maintains temperature at a fixed level, and has three targets: "rise-up", "overshoot prevention" and "retention of a set level". Thus the target values and time are set, and the data which change with each operation or judgement made by the operator are coordinated under set rules to establish operational know-how. Nearly 60 per cent of the rules are drafted from the results of one operation, and abilities of a skilled operator can be compiled into rules simply by repeating the operation several times to generate controls conforming to judgement made. Correctional software is incorporated to allow for seasonal variation.

The company plans to commercialize a programmable controller with approximately 32 input/output functions to cope with the rise-up at chemical plants, which largely rely on human intervention, and also for draw-forming and winding controls. By using this controller in factory automation (FA), substantial labour saving will become possible, as will uniform quality, while all operations can be programmed by extracting operational know-how automatically. The immediate plan is to further improve the system by adding a know-how self-evaluation function and a self-growth function.

Further information available from OMRON Corporation, Public Relations & Advertising Group, 3-4-10, Toranomon, Minato-ku, Tokyo 105. Tel.: +81-3-3436-7139; Fax: +81-3-3436-7215. (Source: *JETRO*, June 1995)

### Interactive tactile display system

The Electrotechnical Laboratory of the Agency of Industrial Science and Technology has developed an interactive tactile display for visually handicapped people to actively understand three-dimensional objects or environments.

This tactile display displays visual patterns by tactile pins arranged in a two-dimensional format. The pin height can be set to several levels to increase the touch information, for example, to display a three-dimensional surface shape. Also, it has three pushbutton keys for selecting the display mode.

Since conventional tactile display systems can adjust the pin height only to two or three levels, it is difficult to display more complex patterns than characters. The new display system can adjust the pin height between 0-6 mm in 1 mm units. The size of display is 175 x 175 mm, and the 16 x 16 pins are arranged both horizontally and vertically. The system knows the position of the pin touched by the user by means of a push switch at the bottom of each pin. The three-dimensional shape of objects is input by a stereo camera system and the pins raised appropriately to reproduce the pattern on the display. Visually handicapped people can recognize the object by scanning their fingertips over the raised pins, while other information, for example, size and colour, which is not suitable for tactile sense, can be represented by auditory information.

When showing an object, for example, a cup, with this tactile display, there are three modes to display: (1) the position, (2) the boundary shape, and (3) the surface shape of the object. In the first mode, by indicating the object position with a single pin, the user can recognize the relative position of each object. When the user wants to know the object name, depressing the pin provides an auditory explanation indicating that it is a "cup". If the user wants to know its shape, the user depresses the information selection key. The boundary mode or surface shape is displayed, and the object size and colour explained by voice. In boundary mode, the user can know the wire-frame shape, and in surface mode, scan the convex or concave shape. The user can recognize objects by repeating these processes.

The research team anticipates that this new tactile display system has general uses such as for offering education on three-dimensional shapes in schools.

Further details available from Electrotechnical Laboratory, 1-1-4, Umezono, Tsukuba, Ibaraki Pref. 305. Tel.: +81-298-58-5312; Fax: +81-298-58-5349. (Source: *JETRO*, June 1995)

### More natural computer graphics image processing

Prof. Y. Nakagawa of the International Christian University has devised a technique for processing computer graphics (CG) images more naturally by utilizing the 1/f fluctuation characteristic that provides a natural rhythm offering more comfortable human vision.

Most natural phenomena consist of a fluctuation that slightly varies from a fixed rhythm. The 1/f fluctuation is a good example. Phenomena conforming to the 1/f fluctuation rule are the human heartbeat, brain wave changes, music and soft winds which are pleasant to hear. Images also have intrinsic fluctuations, and studying the volumes of spatial frequencies obtained by processing image data mathematically enables the characteristics of fluctuations to be analysed. Artificial images such as animated images also contain intrinsic 1/f fluctuation, but scenic photographs or painted pictures are known to feature a $1/f^2$ fluctuation of much more irregularity.

Computer graphics achieve realistic image forming by rendering, so the contrast changes do not occur at random, but rather abruptly, especially at the boundary between an object and its background, and the manner of this change is the factor that makes computer graphics images appear unnatural.

The professor developed a signal processing technique for adding 1/f fluctuation signal components to CG images produced artificially and applied this technique to image processing at nearer the $1/f^2$ fluctuation. For example, when depicting a white teapot with monochromic CG, a sharp contrast is formed at the boundary of the teapot and the background, and the surface will be represented too smoothly to give a natural impression. Adding the 1/f fluctuation the monochromic contras. at the boundary will be changed smoothly to enable display of pictorial images with contrasts closer to those of the actual object.

Further details from International Christian University, Division of Natural Sciences, 3-10-2, Osawa, Mitaka City, Tokyo 181. Tel.: +81-422-33-3286; Fax: +81-422-33-1449. (Source: *JETRO, June 1995*)

### Programme predicts protein patterns

Biophysicists in the United States have written a computer program that can predict the shape of a protein from its sequence of amino acids: a challenge that has foxed scientists for over 40 years. The results could be a godsend to molecular biologists and pharmacologists designing targeted drugs.

It is not difficult to find which amino acids make up a protein's primary structure, but this does not give any information on how the protein works. That is determined by how the string of amino acids twists and folds itself. In enzymes, for example, the amino acid chain forms pockets which bind other molecules and catalyse reactions. However, these folded structures result from a complicated multitude of tiny interactions between the functional groups on the amino acids' side-chains. Until now they have proved near impossible for scientists to predict.

George Rose and Rajgopal Srinivasan, from Johns Hopkins University in Baltimore, named their program LINUS, after the late Linus Pauling. They claim it is the first method of predicting the entire structure of a protein just from its primary structure.

LINUS makes three assumptions about the structure. The amino acid side-chains will adopt the conformations most commonly seen in proteins; the chain will twist so that most of the fat-soluble side-chains are in the middle of the structure and the water-soluble ones are on the outside; two atoms cannot be in the same place at the same time.

The program divides the protein into overlapping pieces, each six amino acids long. It twists them into 5,000 conformations, looking particularly for sections that could form helices, sheets or turns. It measures the energy of each trial conformation and "freezes" the lowest energy ones in place.

This process repeats with ever-larger pieces, until the test sections are 50 amino acids long. It then produces a final shape based on the lowest-energy conformations of the largest sections.

The information which comes out is not perfect, Rose stresses. He fed LINUS six proteins with known shapes and it got the overall structure of five of them correct.

Even such approximate results might be enough to classify proteins which are involved in genetic disorders, or to tailor the shape of a prospective drug to target a particular active site. Moreover, it provides this information in hours, whereas detailed X-ray structures can take months or even years to obtain.

The team is trying to allow LINUS to cope with bigger pieces of the protein, which will lead to more detailed structures. Rose also wants to modify the program so it can cope with "special features"—such as disulphide bridges that can form between some amino acids, or the reactions between charged side-chains—as well as hydrogen-bonding interactions. (Source: *Chemistry & Industry*, 19 June 1995)

### *Intelligent control for autonomous systems*

Intelligent control is the discipline in which control algorithms are developed by emulating certain characteristics of intelligent biological systems. It is quickly emerging as a technology that may open avenues for significant advances in many areas. In fact, fuelled by advancements in computing technology, it has already achieved some very exciting and promising results.

Fuzzy systems, for example, despite emulating human cognition in only a simplistic manner, have dealt successfully with vibration damping in flexible-link robots and have also solved challenging problems in process control. Another type of intelligent system, the knowledge-based controller (which is based, for example, on expert or planning systems), has been employed for the management and coordination of the activities of autonomous robots. Crude circuit or computer emulations of biological neural networks have served as controllers that can learn how to control highly non-linear systems. And genetic algorithms, based on principles of biological evolution, have been used for the computer-aided design of control systems and to automate the on-line tuning of a cargo ship autopilot control algorithm.

Unfortunately, along with these genuine achievements in intelligent control, there have also been exaggerations and inflated claims. In particular, some proponents of intelligent control systems like to say (and write) that conventional control technologies are incapable of handling non-linear systems and system uncertainties. The fact is that "conventional" techniques have evolved substantially over the past several decades. Proportional-integral-derivative (PID) control and state-space and frequency-domain methods, optimal control and robust control, the Kalman filter, adaptive control, and Lyapunov techniques, to name a few, have been highly successful in solving problems in many areas. Among the areas: vehicular control, weapon systems, robotics, manufacturing, power systems, spacecraft, aircraft control and process control.

Another problem with intelligent control is that some engineers get so excited about the very idea of emulating intelligent behaviour (whatever that means) that they tend to lose their objectivity about it. Clearly, it is necessary to ask of this technology, as for any other innovation, three important questions: for which problems, if any, can it outperform tried-and-true conventional techniques? Can its behaviour be verified by modelling, simulation, non-linear analysis, and experimentation -- as is done for conventional control systems? And, will it stand up to objective cost-benefit analyses and the test of time?

Regardless of the successes of intelligent control, there is a second closely related, but more important, trend in the field of control today—the effort to integrate the functions of isolated subsystems to form highly autonomous systems that can perform complex control tasks without human help. This trend is gaining momentum as control engineers, having solved many problems, are seeking control challenges in which broader issues must be taken into consideration.

For instance, in military aviation, engineers are moving on from traditional terrain-following, terrain-avoidance control systems to a "pilot's associate" computer program that integrates the functions of mission and tactical planning into a single system, much as a human co-pilot does. In the emerging area of intelligent vehicle highway systems, to take another example, engineers are designing vehicles and highways that can fully automate the human's responsibilities in steering, braking, throttle control and route selection to reduce congestion and improve safety.

Although it is clear that conventional control will play a large role in the development of such highly automated systems, it is also possible that highly autonomous behaviour may be more easily achieved with intelligent controls. Even more likely, a combination of the two approaches may prove to be the best solution.

To determine the best overall engineering methodology for the development and deployment of autonomous systems—especially when safety issues are of concern—it is helpful to have a framework, or architecture, for the incorporation of intelligent control techniques into autonomous systems. Before getting into that area, however, it is best to review the techniques of intelligent control and to highlight those of their characteristics that have proven to be especially useful in particular applications.

The fields of intelligent and autonomous control are in their infancy. We are only beginning to find some answers to the questions posed in the opening remarks of this paper. While some "autonomous" robots and vehicles have been implemented, there is still much room for improvement.

Current intelligent systems can only roughly model their biological counterparts, and hence, from one perspective, they can achieve relatively little. What will we be able to do if we succeed in emulating their functions much more completely? Achieve full autonomy through the correct orchestration of intelligent controls implemented with new computing technologies like neural networks? Could we achieve the same goals with conventional methods and conventional computing technology? Regardless of how we proceed, the goal of achieving autonomy is exciting and challenging, and is likely to produce many technological benefits along the way. (Extracted from *IEEE Spectrum*, June 1995)

### *Glossary of Internet terms*

**56K Line**
A digital telephone-line connection (leased line) capable of carrying 56,000 bits per second. At this speed, a *Megabyte* will take about three minutes to transfer. This is four times as fast as a 14,400 bps modem.

**ADN**
(Advanced Digital Network) -- Usually refers to a 56K/bps *leased-line*.

**Anonymous FTP**
See **FTP**.

**Archie**

A tool (software) for finding files stored on *anonymous FTP* sites. You need to know the exact file name or a sub-string of it.

**ARPANet**

(Advanced Research Projects Administration Network)—The precursor to the *Internet*. Developed in the late 1960s and early 1970s by the US Department of Defense as an experiment in wide-area networking that would survive a nuclear war.

See also: **Internet (uppercase I)**

**ASCII**

(American Standard Code for Information Interchange)—This is the de facto world-wide standard for the code numbers used by computers to represent all the upper- and lower-case Latin letters, numbers, punctuation, etc. There are 128 standard ASCII codes, each of which can be represented by a seven-digit binary number: 0000000 through 1111111.

**Backbone**

A high-speed line or series of connections that forms a major pathway within a network. The term is relative as a backbone in a small *network* will likely be much smaller than many non-backbone lines in a large network.

**Bandwidth**

How much "stuff" you can send through a connection. Usually measured in bits per second. A full page of English text is about 16,000 bits. A fast modem can move about 15,000 bits in one second. Full-motion full-screen video would require roughly 10,000,000 bits per second, depending on compression.

See also: **56K Line**, **Bit**, **T-1**.

**BBS**

(Bulletin Board System)—A computerized meeting and announcement system that allows people to carry on discussions, upload and download files, and make announcements without the people being connected to the computer at the same time. There are many thousands (millions?) of BBSs around the world, most are very small, running on a single IBM clone PC with one or two telephone lines. Some are very large and the line between a BBS and a system like CompuServe gets crossed at some point, but it not clearly drawn.

**Binhex**

(BINary HEXadecimal)—A method for converting non-text files (non-ASCII) into *ASCII*. This is needed because Internet e-mail can only handle ASCII.

See also: **ASCII**.

**Bit**

(Binary DigIT)—A single digit number in base-2, in other words, either a one or a zero. The smallest unit of computerized data. *Bandwidth* is usually measured in bits per second.

See also **Bandwidth**, **Byte**, **Kilobyte** and **Megabyte**.

**BITNET**

(Because It's Time Network)—A *network* of educational sites separate from the Internet, but e-mail is freely exchanged between BITNET and the Internet. *Listservs*, the most popular form of e-mail discussion groups, originated on *BITNET*. *BITNET* machines are IBM VMS machines, and the *network* is probably the only international *network* that is shrinking.

**Browser**

A *client* program (software) that is used to look at various kinds of Internet resources.

See also: **Client**, **URL**, **WWW**.

**Byte**

A set of Bits that represent a single character. Usually there are eight or 10 bits in a Byte, depending on how the measurement is being made.

**Client**

A software program that is used to contact and obtain data from a *Server* software program on another computer, often across a great distance. Each *Client* program is designed to work with one or more specific kinds of *Server* programs, and each *Server* requires a specific kind of *Client*.

See also: **Server**.

**Cyberspace**

Term originated by author William Gibson in his novel "Neuromancer", the word Cyberspace is currently used to describe the whole range of information resources available through computer networks.

**Domain Name**

The unique name that identifies an Internet site. Domain Names always have two or more parts, separated by dots. The part on the left is the most specific and the part on the right is the most general. A given machine may have more than one Domain Name but a given Domain Name points to only one machine. Usually, all of the machines on a given *network* will have the same thing as the right-hand portion of their Domain Names, e.g.

gateway.gbnetwork.com
mail.gbnetwork.com
www.gbnetwork.com

and so on. It is also possible for a Domain Name to exist but not be connected to an actual machine. This is often done so that a group or business can have an Internet e-mail address without having to establish a real Internet site. In these cases, some real Internet machine must handle the mail on behalf of the listed Domain Name.

See also: **IP Number**.

**E-mail**

(Electronic Mail)—Messages, usually text, sent from one person to another via computer. E-mail can also be sent automatically to a large number of addresses (*Mailing List*).

See also: **Listserv**, **Maillist**.

**Ethernet**

A very common method of networking computers in a *LAN*. Ethernet will handle about 10,000,000 bits per second and can be used with almost any kind of computer.

See also: **Bandwidth**, **LAN**.

**FAQ**

(Frequently Asked Questions)—FAQs are documents that list and answer the most common questions on a particular subject. There are hundreds of FAQs on subjects as diverse as Pet Grooming and Cryptography. FAQs are usually written by people who have tired of answering the same question over and over.

**FDDI**

(Fibre Distributed Data Interface)—A standard for transmitting data on optical fibre cables at a rate of around 100,000,000 bits per second (10 times as fast as *Ethernet*, about twice as fast as *T-3*).

See also: **Bandwidth**, **Ethernet**, **T-1**, **T-3**.

**Finger**

An Internet software tool for locating people on other Internet sites. Finger is also sometimes used to give access to non-personal information, but the most common use is to see if a person has an account at a particular Internet site. Many sites do not allow incoming Finger requests, but many do.

**FTP**

(File Transfer Protocol)—A very common method of moving files between two Internet sites. FTP is a special way to *login* to another Internet site for the purposes of retrieving and/or sending files. There are many Internet sites that have established publicly accessible repositories of material that can be obtained using FTP, by logging in using the account name "anonymous", thus these sites are called "anonymous ftp servers".

**Gopher**

A widely successful method of making menus of material available over the Internet. Gopher is a *Client* and *Server* style program, which requires that the user have a Gopher *Client* program. Although Gopher spread rapidly across the globe in only a couple of years, it is being largely supplanted by *Hypertext*, also known as *WWW* (*World Wide Web*). There are still thousands of Gopher *Servers* on the Internet and we can expect they will remain for a while.

See also: **Client, Server, WWW, Hypertext**.

**Host**

Any computer on a *network* that is a repository for services available to other computers on the *network*. It is quite common to have one host machine provide several services, such as *WWW* and *USENET*.

See also: **Node, Network**.

**HTML**

(HyperText Markup Language)—The coding language used create to *Hypertext* documents for use on the *World Wide Web*. HTML looks a lot like old-fashioned typesetting code, where you surround a block of text with codes that indicate how it should appear. additionally, in HTML you can specify that a block of text, or a word, is "linked" to another file on the Internet. HTML files are meant to be viewed using a *World Wide Web Client* program, such as *Mosaic*.

See also: **HTTP, Hypertext, Mosaic, WWW**.

**HTTP**

(HyperText Transport Protocol)—The protocol for moving *Hypertext* files across the *Internet*. Requires an HTTP *Client* program on one end, and an HTTP *server* program on the other end. HTTP is the most important protocol used in the *World Wide Web (WWW)*.

See also: **Client, Server, WWW**.

**Hypertext**

Generally, any text that contains "links" to other documents—words or phrases in the document that can be chosen by a reader and which cause another document to be retrieved and displayed.

**IMHO**

(In My Humble Opinion)—A shorthand appended to a comment written in an on-line forum, IMHO indicates that the writer is aware that they are expressing a debatable view, probably on a subject already under discussion. One of many such shorthands in common use on line, especially in discussion forums.

**Internet (upper case I)**

The vast collection of interconnected networks that all use the TCP/IP protocols and that evolved from the *ARPANET* of the late 1960s and early 1970s. The Internet in November 1994 connected roughly 30,000 independent networks into a vast global *internet*.

See also: **internet (lower case i)**.

**internet (lower case i)**

Any time you connect two or more *networks* together, you have an internet—as in inter-national or inter-state.

**IP Number**

Sometimes called a "dotted quad". A unique number consisting of four parts separated by dots, e.g. 165.113.[illegible].2

Every machine that is on the Internet has a unique IP number—if a machine does not have an IP number, it is not really on the Internet. Most machines also have one or more *Domain Names* that are easier for people to remember.

See also: **Domain Name, Internet**.

**IRC**

(Internet Relay Chat)—Basically a huge multi-user live chat facility. There are a number of major IRC *servers* around the world which are linked to each other. Anyone can create a "channel" and anything that anyone types in a given channel is seen by all others in the channel. Private channels can (and are) created for multi-person "conference calls".

a name="ISDN">

**ISDN**

(Integrated Services Digital Network)—Basically a way to move more data over existing regular telephone lines. ISDN is only slowly becoming available in the USA, but where it is available it can provide speeds of 64,000 bits per second over a regular telephone line at almost the same cost as a normal telephone call.

**Kilobyte**

A thousand bytes. Actually, usually, 1,024(2^10) bytes.

See also: **Byte, Bit**.

**LAN**

(Local Area Network)—A computer network limited to the immediate area, usually the same building or floor of the building.

**Leased-line**

Refers to a telephone line that is rented for exclusive 24-hour, seven-days-a-week use from your location to another location. The highest speed data connections require a leased line.

See also: **56K, T-1, T-3**.

**Listserv**

The most common kind of *maillist*, Listservs originated on *BITNET* but they are now common on the *Internet*.

See also: **BITNET, E-mail, Maillist**.

**Login**

Noun or a verb.

Noun: The account name used to gain access to a computer system. Not a secret (contrast with *Password*).

Verb: The act of entering into a computer system, e.g. "Login to the WELL and then go to the GBN conference."

See also: **Password**.

**Maillist (or Mailing List)**
A (usually automated) system that allows people to send *e-mail* to one address, whereupon their message is copied and sent to all of the other subscribers to the maillist. In this way, people who have many different kinds of e-mail access can participate in discussions together.

**Megabyte**
A million *bytes*. A thousand *kilobytes*.
See also: **Byte, Bit, Kilobyte.**

**Modem**
(MOdulator, DEModulator)—A device that you connect to your computer and to a telephone line, that allows the computer to talk to other computers through the telephone system. Basically, modems do for computers what a telephone does for humans.

**MOO**
(Mud, Object Oriented)—One of several kinds of multi-user role-playing environments, so far only text based. See also: **MUD, MUSE.**

**Mosaic**
The best known and most widespread *WWW browser or client* software. The source-code to Mosaic has been licensed by several companies and there are several other pieces of software as good as or better than Mosaic. See also: **Browser, Client, WWW.**

**MUD**
(Multi-User Dungeon or Dimension)—A (usually text-based) multi-user simulation environment. Some are purely for fun and flirting, others are used for serious software development, or education purposes and all that lies in between. A significant feature of most MUDs is that users can create things that stay after they leave and which other users can interact with in their absence, thus allowing a "world" to be built gradually and collectively.
See also: **MOO, MUSE.**

**MUSE**
One kind of MUD—usually with little or no violence.
See also **MOO, MUD**

**Network**
Any time you connect two or more computers together so that they can share resources you have a computer network. Connect two or more networks together and you have an *internet*. See also: **Internet, internet.**

**Newsgroups**
The name for discussion groups on *Usenet*.
See also: **Usenet.**

**NIC**
(Network Information Center)—Generally, any office that handles information for a network. The most famous of these on the Internet is the InterNIC, which is where new domain names are registered.

**Node**
Any single computer connected to a *network*.
See also: **Network, Internet, internet.**

**Packet Switching**
The method used to move data around on the *Internet*. In packet switching, all the data coming out of a machine is broken up into chunks; each chunk has the address of where it came from and where it is going. This enables chunks of data from many different sources to co-mingle on the same lines, and be sorted and directed to different routes by special machines along the way. This way many people can use the same lines at the same time.

**Password**
A code used to gain access to a locked system. Good passwords contain letters and non-letters and are not simple combinations such as "virtue7". A good password might be:
Hot$1-6
See also: **Login.**

**POP**
Two commonly used meanings: "Point of Presence" and "Post Office Protocol".
A "Point of Presence" usually means a city or location where a network can be connected to, often with dialup telephone lines, so if an Internet company says they will soon have a POP in Belgrade, it means that they will soon have a local telephone number in Belgrade, and/or a place where *leased-lines* can connect to their network. A second meaning, "Post Office Protocol" refers to the way e-mail software such as Eudora gets mail from a mail server. When you obtain a *SLIP*, *PPP* or *shell* account you almost always get a POP account with it, and it is this POP account that you tell your e-mail software to use to get your mail.
See also: **PPP, SLIP.**

**PPP**
(Point to Point Protocol)—Most well known as a protocol that allows a computer to use a regular telephone line and a *modem* to make a *TCP/IP* connection and thus be really and truly on the *Internet*. PPP is gradually replacing *SLIP* for this purpose.
See also: **IP number, Internet, SLIP, TCP/IP.**

**RFC**
(Request for Comments)—The name of the result and the process for creating a standard on the *Internet*. New standards are proposed and published on line, as a "Request for Comments". The Internet Engineering Task Force is a consensus-building body that facilitates discussion, and eventually a new standard is established, but the reference number/name for the standard retains the acronym "RFC", e.g. the official standard for *e-mail* is RFC 822.

**Router**
A special-purpose computer (or software package) that handles the connection between two or more *networks*. Routers spend all their time looking at the destination addresses of the *packets* passing through them and deciding which route to send them on.
See also: **Network, Packet Switching.**

**Server** (see Client)
A computer, or a software package, that provides a specific kind of service to *client* software running on other computers. The term can refer to a particular piece of software, such as a *WWW* server, or to the machine on which the software is running, e.g. "Our mail server is down today, that's why e-mail isn't getting out." A single server machine could have several different server software packages running on it, thus providing many different services to *clients* on the *network*.
See also: **Client, Network.**

**SLIP**
(Serial Line Internet Protocol)—A standard for using a regular telephone line (a "serial line") and a *modem* to connect a computer as a real *Internet* site. SLIP is gradually being replaced by *PPP*.
See also: **Internet, PPP.**

**SMDS**
(Switched Multimegabit Data Service)—A new standard for very high-speed data transfer.

**T-1**
A *leased-line* connection capable of carrying data at 1,544,000 *bits* per second. At maximum theoretical capacity, a T-1 line could move a *megabyte* in less than 10 seconds. That is still not fast enough for full-screen, full-motion video, for which you need at least 10,000,000 bits per second. T-1 is the fastest speed commonly used to connect *networks* to the *Internet*.
See also: **56K**, **Bandwidth**, **Bit**, **Byte**, **Ethernet**, **T-3**.

**T-3**
A *leased-line* connection capable of carrying data at 45,000,000 bits per second. This is more than enough to do full-screen, full-motion video.
See also: **56K**, **Bandwidth**, **Bit**, **Byte**, **Ethernet**, **T-1**.

**TCP/IP**
(Transmission Control Protocol/Internet Protocol)—This is the suite of protocols that defines the *Internet*. Originally designed for the *UNIX* operating system, TCP/IP software is now available for every major kind of computer operating system. To be truly on the *Internet*, your computer must have TCP/IP software.
See also: **IP number**, **Internet**, **UNIX**.

**Telnet**
The command and program used to *login* from one *Internet* site to another. The telnet command/program gets you to the "login:" prompt of another *host*.

**Terminal**
A device that allows you to send commands to a computer somewhere else. At a minimum, this usually means a keyboard and a display screen and some simple circuitry. Usually you will use terminal software in a personal computer—the software pretends to be ("emulates") a physical terminal and allows you to type commands to a computer somewhere else.

**Terminal Server**
A special-purpose computer that has places to plug in many *modems* on one side, and a connection to a *LAN* or *host* machine on the other side. Thus the terminal server does the work of answering the calls and passes the connections on to the appropriate *node*. Most terminal servers can provide *PPP* or *SLIP* services if connected to the *Internet*.
See also: **LAN**, **Modem**, **Host**, **Node**, **PPP**, **SLIP**.

**UNIX**
A computer operating system (the basic software running on a computer, underneath things like word processors and spreadsheets). UNIX is designed to be used by many people at the same time (it is "multi-user") and has *TCP/IP* built in. It is the most common operating system for *servers* on the *Internet*.

**URL**
(Uniform Resource Locator)—The standard way to give the address of any resource on the Internet that is part of the World Wide Web (WWW). A URL looks like this:
http://www.matisse.net/seminars.html
or telnet://well.sf.ca.us
or news:new.newusers.questions
etc.
The most common way to use a URL is to enter into a WWW browser program, such as Netscape, or Lynx.
See also: **Browser**, **WWW**.

**Usenet**
A world-wide system of discussion groups, with comments passed among hundreds of thousands of machines. Not all Usenet machines are on the *Internet*, maybe half. Usenet is completely decentralized, with over 10,000 discussion areas, called *newsgroups*.

**Veronica**
(Very Easy Rodent Oriented Net-wide Index to Computerized Archives)—Developed at the University of Nevada, Veronica is a constantly updated database of the names of almost every menu item on thousands of *gopher* servers. The Veronica database can be searched from most major *gopher* menus.
See also: **Gopher**.

**WAIS**
(Wide Area Information Servers)—A commercial software package that allows the indexing of huge quantities of information, and then making those indices searchable across *networks* such as the *Internet*. A prominent feature of WAIS is that the search results are ranked according to how relevant the "hits" are, and that subsequent searches can find "more stuff like that last batch" and thus refine the search process.

**WAN**
(Wide Area Network)—Any *internet* or *network* that covers an area larger than a single building or campus.
See also: **Internet**, **internet**, **LAN**, **Network**.

**WWW** (World Wide Web)
Two meanings—First, loosely used: The whole constellation of resources that can be accessed using *Gopher*, *FTP*, *HTTP*, *telnet*, *Usenet*, *WAIS* and some other tools. Second, the universe of Hypertext servers (*HTTP servers*) which are the *servers* that allow text, graphics, sound files etc. to be mixed together.
See also: **Browsers**, **FTP**, **Gopher**, **HTTP**, **Telnet**, **URL**, **WAIS**.

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## *The role of the State in developing a software industry* (by Dr. Richard Heeks, University of Manchester, UK, reprinted from *Electronics Information & Planning*, February 1995)

**Summary**

India's software industry is developing fast, and the State must look for a role in this development process. Should it opt for a structuralist model of strong government intervention? Should it opt for a market-oriented model? Or should it look for some alternative path?

Naturally, the role adopted by the Indian State will depend to a large extent on local political considerations. However, it can also be guided by evidence from around the world.

Some countries have followed a structuralist, regulatory model of state intervention, but over the past 15 years this has been strongly criticized and a more market-oriented neo-liberal model has been promoted as the "correct" path, leaving only a minimal role for the State.

In the past year or so, however, it has become clear that the pendulum swinging from structuralism to neo-liberalism has slowed, possibly stopped, and may even be swinging back very slightly in some places, beginning in the former high citadels of the market.

At the moment, pronouncements in the United States and the United Kingdom indicate more a change of mood and attitude rather than action, but they mean that it is time to re-evaluate the State's role. This is particularly true for countries like India, where external neo-liberal pressures remain strong and where political time-lags meaning the down-side of Reaganomics, Thatcherism and the like may not be clearly recognized.

A review of successful state policy on software industry development and exports from around the world indicates that intervention is still essential to this industry. However, the form of state intervention is changing. Promotional measures rather than regulation are the order of the day, and such measures are complex and multi-faceted compared to the relative simplicity of earlier intervention.

**Introduction**

For India, the market will fail to be the best guide and state intervention will be needed in areas that include:

- Finance. States have intervened successfully to stimulate the supply of working and venture capital.
- Education and training. Although it needs to work alongside other provisioners, the State remains the prime source of fundamental skills relevant to software industry development.
- Research and development. R&D scale economies, particularly seen in basic software research and in customization to local needs, mean that the Government must invest, not least to combat a growing concentration of innovation with multi-nationals.
- Marketing and market information. The State can reap the benefits of scale economies in both these areas, being of particular assistance to small and medium software enterprises, which are seen as the driving-force of software industries in many developing countries.
- Intellectual property rights. Piracy has more to recommend it as a strategy for developing countries than is often admitted. However, the maturation of a software industry goes hand-in-hand with a legal framework only the State can provide.
- Infrastructure. From Singapore's intelligent island concept to the US data highways, the State is seen to have a vital part to play in the creation of a telecommunications infrastructure. Software exports in particular benefit both quantitatively and qualitatively from such government investment.
- Procurement. Because of its large purchasing power, the State can be the most important consumer for emerging software industries and can use its power to significantly influence the direction of industrial development.
- Spread of best practice. Even in a mature software industry, the State can use its purchasing power to lead in requiring best practice from its software suppliers. Acting as a communication link and business adviser, the State can also help best practice to spread within an industry.
- State-run organizations. The fashion for privatization has cast a shadow over public sector software firms in many countries, but this is not justified. Although software industries can grow through private ownership, experience in many countries shows that publicly-owned firms can be profitable and play a lead role in early industrial development.

Examples for these promotional areas will be cited from various developing countries, including Brazil, China, Mexico, Singapore and India itself. Where appropriate, supporting evidence from Western nations will be provided to indicate the changing but vital role of the State in software industry development.

All of this has implications for the nature of both the Indian State and also its representatives. The structure of state organizations must be such that they can respond quickly to industrial needs and to changes in both markets and technology. Joint industry-state structures are required but must be carefully planned so that the State can fulfil a role that is more than being merely the servant of industry or market.

Perhaps more far-reaching are the implications for state representatives. No longer bureaucrats, they must now be technocrats with a set of professional skills in economics; human resource development; marketing; the law; and so forth. There also need to be career paths that allow movement from industry to State and vice versa.

## I. SOFTWARE INDUSTRIES AND GOVERNMENT POLICY[1]

"*Computer software has become the 'lifeblood' of business, industry, and government*" (World Bank, 1993).

As a result of its crucial role in all areas of the economy, the global market for software and related services has grown rapidly. Typical growth rates have been 15-20 per cent per year and market size is predicted to reach US$ 300-400 billion by 1995 (Schware, 1992).

The software industry[2] has been dominated by the United States, but other countries are also becoming important players—including the developing countries.[3] Not only have the developing countries been producing large amounts of software for local consumption, but exports have also grown rapidly to more than US$ 500 million annually during the early 1990s (Heeks, 1993).[4]

Because of the importance of software for local use and for exports,

"*Software production is nowadays an industry essential for the growth of the economies of the developing countries; and the launching of programmes to promote strong and indigenous software industries is a priority task*" (Fialkowski, 1990).

Many other commentators—UNIDO (1983), Kopetz (1984), Narasimhan (1984), Schware (1987), Gaio (1989), Mody (1989)—agree that the creation and implementation of a government software policy is an essential element in software industry development.

"*The point of departure if a country regards software as an area of growth is the Government's commitment to nurture and create the necessary conditions*" (Borrego, 1992).

These comments are borne out by the experiences of individual countries.[5] Where government policy has been absent—as, for example, in most Arab countries, in Paraguay, or in Turkey—piracy and imports dominate, there are few software firms, and development of the industry is severely constrained. The conclusion drawn is that

"*Specific measures within a coherent policy framework will be required to accelerate the development of the software industry*" (World Bank, 1993).

On the other hand, where Governments introduce the right kind of policy, successful development has ensued. The software industry in Ireland is largely the creation of the Irish Government's Industrial Development Authority.

In China, "... the Chinese software industry has achieved a substantial expansion under a period of increasing official support in the 1980s" (Baark, 1990). In Taiwan, Province of China, "... government efforts to promote an indigenous hardware and software industry resulted in 100 software houses ..." (Fialkowski, 1990).[5]

So, government policy for the software industry is essential, but what constitutes "the right kind of policy"?

In the 1970s and early 1980s, very few countries had a software industry policy. One of the few that did was India, which has the third world's longest-standing software industry policy and largest export industry. Policy at that time was framed largely in structuralist terms[6]—with laws, rules, tariffs, licences and other physical bureaucratic mechanisms as the main policy instruments, all of which form elements of "state regulation".

In those countries with structuralist software policies, initial protection and regulation often played a vital role in nurturing early development of companies and capabilities. Unfortunately, regulation was also associated with tolerance of inefficiency and encouragement of rent-seeking behaviour. These negative aspects have been the focus of attention much more often than the beneficial effects of regulation, and have led to a reaction against regulation in software industry development.

Such a reaction mirrors wider changes, there having been a pronounced crisis of faith in the structuralist policy model for the past 15 or more years. This model—which dominated much political thinking on economic affairs since the 1930s—came under intense pressure on a number of fronts:

- Pressure from multinationals and international institutions, all of which favoured market-led rather than state-led solutions to economic problems;
- Pressure of self-interest within local political economies from those who now saw more to be gained from market than from state;
- Pressure from supposed failures of state regulation such as recession in Western nations, declining growth rates in some developing countries, and the political demise of state socialism in Eastern Europe;
- Pressure from supposed successes of the market in countries where the State had been "rolled back";
- Pressure from technological changes which placed an increasing part of economic activity outside the control of state regulatory measures.

As a result, the ideological pendulum has swung away from prescriptions based around state regulation and towards prescriptions based on market mechanisms. Swings in software policy from State to market have therefore been visible in many developing countries, such as China, India, Brazil and Singapore. The new market model has been held to provide the much-desired "answer" to development but its glitter has blinded many from the evidence of the problems thrown up by market forces.

Such problems are painfully evident in software industry development with even the World Bank (1993), normally a staunch supporter of market-oriented, neo-liberal policy, declaring:

> *"Free-rider problems, externalities and market imperfections are rampant in the software industry ... [Some] market-based responses only provide partial solutions to the underlying economic problems, and may even be counter-productive with respect to generation of externalities for the economy as a whole."*

Others go further. Correa (1990a) states that market barriers hamper the software industry, while Fialkowski (1990) identifies market imperfections as the main constraint to software industry growth in developing countries. Both conclude that state intervention is required in order to overcome these problems.

However, in many developing countries, external neo-liberal pressures remain strong and political time-lags mean that evidence about the shortcomings of market-oriented strategies has yet to be widely recognized. Developing countries, then, are still in danger of "throwing the baby out with the bath water" and abandoning almost all forms of state intervention in their bid to emulate the neo-liberal model.

This is ironic, given signs in the past year or so that the ideological pendulum has slowed, possibly stopped, and may even be swinging back very slightly in some places, beginning in the former high citadels of the market. In the United States, the Clinton Administration—despite the reversals of the mid-term elections—is pledged to spend more on a more active government role in industrial development, and even in the United Kingdom, the Minister for Trade and industry can promise, without blushing, in his inaugural speech to intervene in British industrial development. At the moment, such pronouncements indicate more a change of mood and attitude rather than action, but they mean that it is timely to re-evaluate the State's role.

Evidence on policy directions for software industry development remains confused, with trends in different directions and evidence both for and against particular standpoints. Adding to the confusion is the fact that many of the countries which seem to be moving from state to market in general terms are simultaneously increasing the extent of state intervention. As well as in the United States, this trend is particularly seen in Asia and to a lesser degree in Latin America. State interventions are addressing an increasing number of areas, including finance, education, marketing and improving the nature of the software production process.

In an effort to sort through these confusions and contradictions, and to answer the question "What is the right kind of policy?", the next section reviews why and how States have intervened in a number of areas to assist the development of local software industries.

## II. STATE INTERVENTION IN SOFTWARE INDUSTRY DEVELOPMENT

### Finance/investment

In some ways, software firms are not like other industrial enterprises. Their main product is intangible and of highly variable value depending on context. Partly because of the hit-and-miss nature of package sales, all software development has come to be viewed as risky and, given the conservatism of finance markets in developing countries, there has been a significant shortage of both investment and working capital.[8]

States have reacted to this problem in different ways. Some have focused on attracting funds from multinationals rather than mobilizing local capital. This is particularly so for smaller countries without a major domestic market to attract the foreign companies. For example, IBM investment was attracted to Taiwan, Province of China, through a government-supported local institution; the Irish Government has worked hard to attract foreign

investment, which has created more than 7,000 software jobs; and Hungary provides tax holidays for software joint ventures.[9]

Concerned that such investment may create little long-term benefit for the local economy, other States have focused more on local capital markets. In Brazil, the nationalized banks pushed ahead with substantial investments in software, despite its intangibility, and this has reaped rewards in terms of skills and products created. Similarly, India has used nationalized financial institutions to channel millions of dollars provided on lines of credit from overseas. The money has been used for venture and working capital funding to smaller companies that would otherwise have had to rely on self-financing. Ireland, too, has recognized these finance elements by providing working and venture capital grants and loans. Others, such as Israel and Taiwan, Province of China, have used tax breaks on software company investment.

These and a number of other States have acted successfully to stimulate the supply of foreign investment and local capital into the software industry, overcoming the reluctance of chief executives and financiers alike. Where Governments have not acted, as in Turkey, lack of access to capital remains a major developmental barrier.

**Education and training**

There has been widespread agreement that the single most important input to the software production process is skilled labour, but equally that the relative lack of such skilled labour is the most serious constraint to software industry development in many countries (Kopetz, 1984; Schware, 1990; Platz, 1992).

As was the case with financing and investment, the State often finds itself working alongside private provision which has many shortcomings. While the private sector may appear very active in training, "there is little control over the quality standards of these institutions, and a good proportion of the students receive little hands-on experience in the use of computers" (Schware, 1987).

In India and Singapore, Governments have acted on this problem with a programme to establish skills standards through examination and certification. Singapore's Government has gone further in creating three training institutes in collaboration with multinationals from different countries. Thanks to these institutes and other government measures described here, Singapore's software skills base grew more than tenfold during the 1980s.

Governments also need to stimulate in-house, on-the-job training, which forms a substantial route for skills formation. Many software companies have taken short-term views and shied away from investment in training, partly because of the dangers of staff turnover. Because they can take a more macroeconomic perspective, Governments can more readily justify this type of investment. In Japan and Ireland, the State has provided grants or tax reductions for in-house training, and in Singapore 70 per cent of the cost of continuing education for software developers has been met from public funds.

Although it needs to work alongside other provisioners, which may focus on specific skills, the State remains the prime source of core informatics skills relevant to software industry development. State education in computer science and related subjects has therefore long been recognized as an essential prerequisite for software industry growth (UNIDO, 1993).

In Latin America, universities have played a major part in the development of software industry capabilities, while in Ireland an integral part of the Government's software development plan was the strengthening of university computer science programmes. Complementing this, States can also seek—as did Singapore—to infuse new ideas and skills by funding training and education overseas.

Two final successful measures can be seen from Singapore. As in many countries, the State has realized the importance of general computer literacy and has pushed this into as many school and college courses as possible. Like India, it has also funded a number of very public information technology (IT) projects that have raised IT awareness. Lastly, Governments can efficiently monitor labour market trends in the software industry (such as the trend away from programmers towards analyst-designers) and disseminate this information to universities, private training institutes and software firms.

**Research and development (R&D)**

Director public investment in software R&D can be justified in two main areas. Firstly, in areas such as basic software research where there are considerable economies of scale. Secondly, in areas such as software development to meet local needs, where the market has failed to produce the required products. In either case, government funding of R&D becomes more rather than less critical during periods of liberalization—particularly in order to combat the growing impact of multinationals and the increasing concentration of innovation within their hands.

Only a few of the richer developing countries—Brazil, India, Republic of Korea and Taiwan, Province of China—have the resources to fund basic software research.[10] The Brazilian Government has been particularly active, helping to focus R&D activities on areas such as Unix and software development methodology, with rich potential spin-offs for the software industry. Many more countries invest to meet local needs. In China, for example, the Government has invested heavily in the development of Chinese language software, with the added advantage that this can be used for export as well as for meeting domestic market needs.

Naturally, R&D work alone is not sufficient for industrial development—government must ensure that there are adequate channels for the dissemination and commercialization of the innovations produced. One method has been for government to pay for the work to be done in existing private sector firms. However, where these lack the requisite skills or where the returns on investment need to be more widely accessible, the work can be done by public sector bodies. Overall, then, R&D programmes will need to follow the Republic of Korea's model, with the Government directing research and development work in a mix of government, industrial and academic institutions.

The work of successful software producers is highly R&D-intensive. Without a sufficient level of R&D, software firms will miss opportunities to develop local technological capabilities or new software products, and will be consigned to services work of a low skill intensity. Yet, just as they have tended to skimp on training, software firms in developing countries also tend to cut corners on research and development. This arises partly from short-term managerial strategies and low profitability. For example, Indian software firms spend only 3 per cent of sales on R&D, compared to a figure of 15 per cent in the United States. Apart from directly funding software company R&D, the State can mitigate this situation by providing tax relief on R&D spending.

**Marketing and provision of market information**

Even the largest of developing country software producers—firms like Tata Consultancy Services in India and the Stone Corporation in China—are small by comparison with players in the West. For these (and even more for the smaller producers), market-related costs, especially in relation to foreign markets, represent a considerable barrier to growth. The costs of marketing packages and services are high, sometimes forming the major part of total costs for a package. So too are the costs of obtaining market information on potential partners, sales channels, regulations, customer needs and competitors.

States can reap the benefits of scale economies in both these areas, being of particular assistance to small and medium software enterprises, which are seen by some as the driving force of software industries in developing countries.

With regard to marketing, Governments cannot directly create buyer-seller relationships, so their role is to raise general awareness and create the environment in which such relationships may begin. The Indian Government has done this by organizing subsidized trade exhibitions and workshops overseas, and by coordinating visits of foreign buyers or government bodies to India.

Market information can be provided on a continuous basis from government offices overseas. The Irish Government has specifically opened offices around the world with information-gathering as part of their remit. Information also comes on a more in-depth basis by government commissioning of market research reports, which are then disseminated to software producers.

Some Governments—such as those in Brazil and China—have felt it useful to set up a register of software in an effort to disseminate information, which then fosters collaboration and avoids duplication of effort. However, the evidence is that many producers avoid registration because they see no benefit, and so the registers have had little impact.

**Intellectual property rights (IPRs)**

Software piracy has more to recommend it as a strategy for developing countries than is often admitted. It has been an important, probably essential, part of the initial development of informatics in most developing countries. Piracy greatly increases the accessibility of software and so speeds the diffusion of a hardware base and the diffusion of up-to-date software. It also saves huge amounts of foreign exchange. In a related manner, weak laws on intellectual property rights allow local producers to increase growth and skills by creating versions of popular packages for the local market through "reverse functional engineering" (Heeks, 1995).

Almost all commentators and all large software package producers claim that a mature local software industry requires a legal framework which only the State can provide. The framework must not only criminalize common distributional piracy, but also protect producers against the theft of their original ideas by competitors. It is said that without such legislation local producers will not invest in software package production and that the growth of the software industry will be stunted (Borrego, 1992; Gwynne, 1993).

Even those who posit an initial role for piracy feel that during the development of a software industry, a crossover point will be reached when the costs of lax legislation start to outweigh the benefits. Yet there has been little attempt to critically question these claims and to explain, for example, the fact that many software firms have invested in and produced packages in situations of little legislation and high piracy.

However, such questioning may be of only theoretical interest since the US Government has pressurized developing countries to act on piracy long before even the hypothetical crossover point is reached. Countries threatened with retaliation—usually under the punitive section 301 of the US Trade and Tariff Act—and pushed into enacting new or tougher anti-piracy legislation during the 1980s and 1990s, include the Republic of Korea, China, Taiwan, Province of China, Mexico, India and Brazil. In accordance with US Government pressure, most countries have taken to extending copyright law to software rather than treating software as a special case. The laws enacted are by no means the optimum legislative route, and they are more likely to benefit foreign firms rather than local ones (Correa, 1990b).[11]

The orthodox view of intellectual property rights has therefore been too readily accepted and too little investigated in developing countries. There may well be only a marginal link between software industry growth and IPR legislation. Having said this, even in a marginal situation and especially in a situation of US pressure, the Government retains a promotional role that cannot otherwise be fulfilled.[12]

**Infrastructure**

Software producers rely on many basic items of infrastructure in order to conduct their business, such as electricity, water and roads. Although these are provided by the private sector in a few Western nations, it is still generally accepted that they are provided by the State in developing countries.

There is more debate over the provision of telecommunications infrastructure. This forms a fundamental part of any strategy to move software exports away from on-site "body shopping" (with its political, financial and "brain drain" costs) since overseas clients demand good telephone, fax and e-mail links before they will contract work to be done offshore (Heeks, 1991b). Western companies and Governments are pushing for more private sector provision of telecommunications, but autonomous state organizations in several countries have proven themselves adept at meeting software industry needs.

The Irish Government's telecommunications agency has invested US$ 2.5 billion in telecommunications infrastructure to help build the software industry; the Republic of Korea's Korean Telecommunications Authority has kept revenue above expenditure whilst massively expanding international links; and in Singapore, the State has laid the foundations for it to become the "intelligent island". Even India's notorious telecommunications system now boasts good international access, used by all the top exporters and provided largely by the semi-autonomous public sector enterprise Videsh Sanchar Nigam Ltd.

Yet to be proven is the investment by some Governments, such as India and Taiwan, Province of China, in "software parks". These are specially designated locations—created and sometimes administered by the State—in which several software firms are brought together. The initial aim is to reap the benefits of scale economies in infrastructural provision and of operational gains from clustering similar small firms. More ambitiously, some hope to add in government-funded training, consultancy, validation and market research facilities.

There is yet to be any clear evidence of gains made from software parks. Given the problems of software technology parks in India, the absence of clear benefits for software firms working in export processing zones, and the possibly misguided nature of the spatial concept behind industrial parks, such promotional measures should obviously be approached with great caution (Wahi, 1993; Heeks, 1995).

Finally, some Governments have attempted to alleviate the problem of low technology intensity of software production found in many developing countries. One method has been for the State to invest in an infrastructure of hardware (especially large IBM-compatible machines) to which small software firms are given access. In both India and China such investment has had a bad record of failing to meet other than narrow academic software production needs. Such an infrastructure is also becoming outdated given falling price:power ratios, increasing portability of software development environments across hardware platforms, and increasing access to overseas computers through wide area networks.

The alternative method—used in India, Hungary, Mexico and the Philippines—has been to provide import tariff reductions on hardware used by software developers. While this has undoubtedly helped software firms, there has been a lot of "overspill" with computing power imported for software firms finding its way to other users.

Infrastructural provision has therefore been like the curate's egg: "good in parts", especially in telecommunications, but less successful in other measures.

**Procurement**

There is general agreement that a healthy domestic market is a precursor to long-term success in exports, and that the small size of domestic software markets in most developing countries is a severe constraint to industrial growth (Schware, 1987; Fialkowski, 1990; Press, 1991; Platz, 1992; Heeks, 1992b). Because of its large purchasing power, the State is the most important domestic consumer for emerging software industries and is therefore in a strong position to influence the local software industry's development through its procurement policies.[13]

The first stages in this process are to ensure that, throughout the public sector, software specifications are sufficiently detailed and sufficiently unbundled from hardware to allow local software firms a chance of tendering. Governments can also act to ensure that staff are sufficiently well trained to consider factors such as support and reliability as well as price in choosing software (World Bank, 1993). Without these changes, contracts will often go to foreign hardware and software package suppliers. Once these changes are in place, Governments can act—as in Brazil and Singapore—by prioritizing local firms in their procurement procedures.

Such actions have been an important contributor to software industry growth in developing countries, and have also expanded the base of software project skills (Heeks, 1992c; Schware, 1992). The main benefit has come where this process includes large-scale informatics projects. The main danger is these actions lead to US trade pressures like those which forced Brazil to open up its procurement.

**Spread of best practice**

The nature of software production in developing countries is epitomized by Mandurah's (1990) description of it in the Arab world—"very basic". While there are pockets of excellence, most software production cannot genuinely be described as a production process and bears no resemblance to the much-touted idea of the "software factory". Instead, it rather resembles a school art room—full of creative individuals using basic, outdated tools to their full capacity but involved in a "seat-of-the pants" exercise which is barely managed at all.[14]

As a result, overseas buyers are less willing to accept the products or services of developing country producers, so exports remain limited. Entry barriers remain low, allowing small, cheap, bad firms to enter and survive in the market. These firms often have marginal overheads and can substantially undercut their larger competitors. With many customers poorly attuned to notions of software quality but very well attuned to the "bottom line", this makes software production overly competitive, forcing prices down below economic levels on some contracts and reducing returns (and, hence, capital for reinvestment) for all software firms.

The practice of software development therefore needs strengthening by the State in three key areas:

(i) More use of new technology, such as CASE (computer-aided software engineering) tools which automate aspects of the software development process. Because they replace labour with capital, these tools pose a significant danger to software exports from developing countries, substantially reliant, as they are, on low labour costs. However, the greater danger will be in failing to adopt this new technology and increasingly lagging behind other producers who take advantage of the productivity and quality gains that the new technology can bring (Heeks, 1990).

(ii) More use of new techniques. At its most basic, this involves the use of simple project management techniques to gain greater control over the development process and so help to bring more work in on time on budget. Over and above this, techniques such as formal methods can be adopted. These will be required for software producers to remain locally and globally competitive.

(iii) Adoption of international quality standards. These form a subset of the new techniques to be adopted, but are of such significance as to be worthy of separate mention. There are many flaws in the conception of quality as a management issue, and it has been seized on far too uncritically as a panacea for improved organizational performance. However, while it remains "flavour of the month" it will become increasingly desirable and soon increasingly necessary for software firms—particularly exporters—to adopt quality standards. More and more Western clients will demand that their software suppliers have undergone certification procedures, normally under the ISO 9000 quality standard (*Dataquest*, 1993a).

Through procurement, the State can act in all three areas, though few in developing countries have yet followed the lead of Governments in the West. Government contracts stipulate, for example, that tenders can only be accepted from ISO-certified firms and that certain tools or methods (e.g., Structured Systems Analysis and Design Methodology) be used. There is also considerable indirect pressure to adopt other management techniques in order to meet time and cost deadlines.

The State can also act, as in Singapore, through best practice centres. These can have several functions:

- To evaluate the condition of software development in the country and target areas of greatest need;

- To inform by translating textbooks and international standards; by holding seminars at which those who have adopted best practice techniques talk to others; and by setting up demonstrator centres and projects where the various tools and techniques can be assessed. These centres can also inform local software purchasers of the need to demand certain minimum standards from local suppliers;
- To certify by acting as international standards certification centres, or by helping other organizations to become certifiers;
- To transfer by providing packs with "try-out" versions of new tools; by training university students and existing developers in new tools and techniques; and by subsidizing training and acquisition of new tools;
- If necessary, to establish a set of local standards. By demanding certification in such local standards for all government procurement, supposedly open tenders can favour local firms.[15]

Finally, the State may provide finance. In Singapore and Ireland, for example, the State will provide a proportion (70 per cent and 50 per cent respectively) of a quality consultant's fee.

Of course, such "wish lists" can only be implemented when the importance of best practice is recognized within the State and when the requisite implementation skills are present. As discussed later, such requirements have significant implications for the structure and staffing of government.

**Other intervention areas**

*State-owned enterprises (SOEs)*

As Evans (1992) points out, the State can have three roles—as well as being a regulator and promoter, it can also be a producer. The fashion for privatization has cast a shadow over public sector software firms in many countries, but this is not entirely justified. Although software industries mainly grow through private ownership, experience shows that publicly-owned firms can be profitable and play a lead role, especially in early industrial development. Thus, both Brazil's Cobra and India's CMC have built up a formidable base of innovatory skills. In the case of CMC, this has been successfully commercialized and even turned into export earnings.

However, the record of SOEs in other countries has been more mixed. In China, state firms have technological resources but it is the non-state ones that have the entrepreneurial perspective and talent. As such, it is clear that for software SOEs to work well, a particular set of conditions must hold, such as avoidance of over-diversification, exposure to competition, appointment of entrepreneurial senior managers, and so on.

*Sectoral development*

The State can act to develop valuable software specialisms through the promotion of non-software sectors. For example, both Brazil and Uruguay have created financial software exports through development of an investment in their banking and financial services sectors. In these cases, the exports have been created by private firms and have been a fortunate spin-off from the promotion of the sectors rather than a deliberate objective.

*Trade*

There has been a proven value in trade protectionism for young industries to allow time for import substitution and the growth of related capabilities, as seen in Brazil, where import controls allowed substantial operating system-related capabilities to be created. Where this protectionism is absent, countries remain largely dependent on imports (Correa, 1985).

Having said this, import policies—whether bans, quotas or tariffs—are of limited use given the intangibility of software which allows any policy to be circumvented with increasing ease [Heeks, 1995]. There is also a lot of "natural" local market protection based on language, regulations and knowledge of local needs. It is therefore hard to advocate a state regulatory approach to software trade.

*Multinationals (MNCs)*

As with trade protection, there are clear gains from regulating the activities of multinationals or—more accurately—clear losses from allowing them to act unfettered. However, regulation of multinationals has been fraught with problems in practice for two reasons. Firstly, by their nature, MNCs can act globally while States can only act nationally. Secondly, States are often caught in the weak and contradictory position of trying to encourage MNCs while trying to control them.

If regulation is to be attempted, then it needs to be targeted at certain times and sectors. If the gap between domestic and foreign skills and technology is very large, then one might try to encourage multinationals to infuse new skills and technology. If the gap is very small, then local firms should be competitive and regulation can again be minimized. Control is only worth while to protect local firms when there is a medium-sized "catch-upable" gap (Mody, 1989). Unfortunately, defining gap size is not an exact science.

*Industrial licensing*

Few Governments have attempted to regulate companies' entry into or exit from software production. Evidence from India—where licensing was widespread during the 1970s and 1980s—suggests that it is often counter-productive, removing the incentive and route for firms to become competitive.

*Export subsidies*

In almost all developing countries, the software export market provides greater returns on investment than production for the domestic market. As such, there is little justification for export subsidies to be paid by the State to software firms.

## III. CONCLUSIONS

A global review of the "right kind" of state policy for software industry development and exports in developing countries indicates that wide-ranging state intervention is still essential to this industry. The common element guiding all the interventions has been the failure of the market to provide the quality or quantity of inputs which are critical to software industry success. As well as addressing the obvious inputs, such as capital and labour, intervention has been needed to cover inputs such as market information and new development techniques.

While state intervention has been required most where market imperfections are greatest, it has also been found beneficial where, thanks to economies of scale, the State can be the most efficient provider. Examples include provision of core software skills and some items of marketing assistance and infrastructure. Finally, intervention may also be needed where market mechanisms produce outcomes

that are not deemed to be in the best long-term interests of the country, as seen in the emergence of overly-competitive industries in the absence of best practice action and, perhaps, in the need for legislation on IPRs. A full summary of areas for state intervention is presented in Appendix I.

Clearly, the form of state intervention has changed over the past 20 or so years. Regulatory measures—some of which will still be of value in countries initially creating a software industry—are now giving way to measures which promote the growing industry and promote its access to inputs. Such measures are complex and multifaceted compared to the relative simplicity of earlier intervention. In most countries, too, the State is now working alongside the private sector and public enterprises aiming for cooperative development rather than close control.

Of course, the list of interventic , should not be taken as meaning that government intervention is a guarantee of software industry development, nor that state intervention—even promotional intervention—is perfect. In practice, there have often been problems with intervention.

In general terms, there have been delays, misunderstandings, inter-agency disagreements and—as seen in the case of software registers and hardware provision—interventions which have not had the desired effect. There have been other specific, common problems such as poor commercialization of academic innovations and weak links between business and academia for training (Baark and Heeks, 1993; World Bank, 1993).

However, a shortcoming, even a failure, of government intervention is not a logical argument for recourse to the market. It should, instead, be an argument for improved intervention next time.

Interventionist measures are not always right first time, and any given measure may become outdated by changing events. Therefore, just as important as the particular input addressed by promotional intervention is the strategy of intervention in general. Successful intervention strategies are those which are responsive to the industry's needs, and which are flexible and iterative—always trying to improve in the light of past experience and changing circumstances.

Because of this, one cannot universally prescribe a particular set of interventions which will bring success. Each country will have to choose the policy measures that suit its software industry best, based on a continuous survey of the quantitative and qualitative nature of that industry.

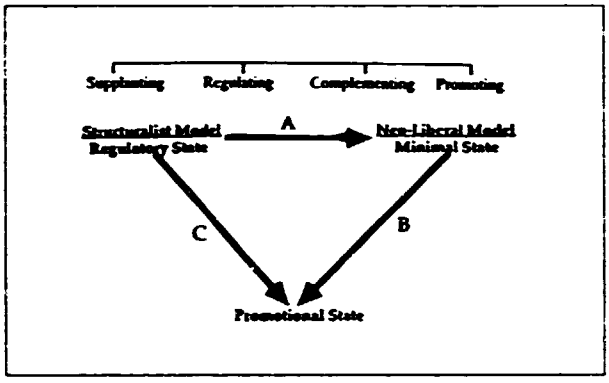
This is also true because of the constraints placed on the process of making software industry policy. Policy outcomes will finally be determined not by some objective, technocratic choice of the "best path", but by a mixture of this "best path" intention with the balance of power and interests of the various elements in a country's political economy (Heeks, 1992a). The outcome will also be determined partly by external factors, especially the actions of the US Government and US companies, which may try to block certain state interventions while encouraging others.[16]

One may conclude that the argument should no longer be one of "State vs. Market", but a question of how to achieve the most from State and market working together. The continuum of importance here is not that which runs from "All State" to "All Market", but that which runs through a spectrum of different state responses to private industry (and autonomous public enterprises):

Neither a completely state-owned nor a completely market-led approach to the software industry will create the conditions required for long-term industrial development. Yet, with alternatives to the market being too rarely presented, many countries are being pushed under pressure of structural adjustment along a path from the regulatory State to the minimal State (path A in figure 1).

This seems most likely to occur in countries where policy has been guided more by ideology than pragmatism; where politicians, business people and the public are accustomed to seek simple solutions; where an inferiority complex predisposes the Government towards external policy models; and where there is a continuing belief in the autonomous power of the State. In these circumstances, policy may flip from one ideology to another—from overactive embracing of State to overactive embracing of market.[17] There is likely to be a long and wasteful process before these States recognize the need to change once again and move along path B.

**Figure 1. State rules and developmental paths**




Such countries sit in marked contrast to those who have recognized that, instead, the push should be along path C from the regulatory State to the promotional State. These nations, such as those of South-East and East Asia, have been successful because—due to their particular political economies—they have been able to forge a co-operative alliance between State and industry, rather than ending up in a situation in which one or the other is ideologically dominant. The State's role is seen as one that promotes industry and development rather than promoting ideology.

**Implications of the State's promotional role**

Three further implications are worthy of note.

Firstly, the structure of state organizations must be such that they can respond quickly to industrial needs and to changes in both markets and technology. Giving such organizations a measure of autonomy does seem to have been associated with greater responsiveness and more effective performance.

Joint industry-state consultative structure is also required but must be carefully planned so that the State can fulfil a role that is more than being merely the servant of industry or market. Examples include Taiwan, Province of China's Industrial Development Bureau or the Republic of Korea's Council of Software Industry Promotion.

There may be some mileage in centralization and coordination. This could take place at the level of policy-making, for example in the creation of, as the World Bank (1993) suggests, a Ministry for Informatics. It could also take place at the level of implementation, with a public sector centre undertaking activities such as those described for the Singapore best practice centre and for what Borrego

(1992) terms an "IT observatory". This could include monitoring local and international markets and changing technologies; acting as the focus for dissemination of information and the spread of best practice; and undertaking research and development work.

Secondly, there may be far-reaching implications for state representatives and human resource development. No longer bureaucrats, the staff must now be technocrats with a set of professional skills in economics; human resource development; marketing; the law; and so forth. They will need training and will be assisted by career paths that allow movement from industry to State and vice versa.[18]

Finally, one would never seek to deny the importance of sound financial management and, to some extent, markets in the development of software production and software exports, but there are more than enough organizations and consultants around the world reminding everyone about this. What this paper has reinforced in the much less fanfared message—that the State continues to play an essential role in the process of industrial development.

This should be the basis for a renewal of confidence in the role of the State. Such a renewal is much needed within the State but also within industries such as the software industry. Too often, industrialists react to liberalization and the lifting of what they see as the "shackles of state interference" by seeking a future devoid of state intervention. Until they recognize that some forms of state intervention are indispensable, such industrialists will be constraining the long-term development of their own industries.

## Notes

1. The findings presented here form part of an ongoing research project, initiated in 1987, into the development of software industries in developing countries. They are drawn from fieldwork in China, India and Singapore, and from the references listed at the end of the paper.
2. In this paper, the term "software industry" is used to describe those companies or company divisions which earn the majority of their revenue from sales of software consultancy services or software packages. Other sources of software, such as in-house production, will not be the focus, although Governments can also act to promote this type of production—for example, through policy on research and development, training and spread of best practice.
3. Share of world software revenue outside the United States, Western Europe and Japan is likely to grow from less than 10 per cent to roughly 16 per cent between 1985 and 1995 (World Bank, 1993).
4. Wagstyl (1993) rather optimistically estimates the export figure to be just under US$ 2 billion.
5. To avoid unnecessary repetition, all references to individual countries are cited in a separate section of the references at the end of this paper.
6. Such State action is not restricted to developing countries: "To a significant extent the US, Japanese and French Governments have strengthened their software industries by a variety of measures" (Schware, 1989).
7. Structuralism is a political ideology which favours state regulation and ownership, trade protection and other measures to contain what it regards as the shortcomings of existing global economic structures, including markets.
8. Typical developing country software firms require US$ 1,000-10,000 per capita start-up investment and US$ 500-5,000 per capita per year working capital (Heeks, 1995).
9. Even in the United Kingdom—that fount of market ideology—state institutions have intervened hard to attract software companies to Wales and Scotland (*Computing*, 1993).
10. The Governments of Europe, Japan and the United States have all invested billions of US dollars in this area in what they see as a necessary effort to assist their domestic industries by developing skills and technological innovations.
11. Indonesia has been an exception, enacting its own protection law which largely ignores software not translated into Bahasa Indonesia, or which is not published for the first time in Indonesia.
12. Just as it does in creating the legislative framework for many business-related areas where "free market" behaviour is held to have a negative impact on long-term development.
13. The public sector can make up more than half the domestic market, as in India. Even in Western, market-oriented economies, the State is still normally the single largest domestic customer. In the United States, for example, government forms around 20 per cent of the market (Coopers and Lybrand/IDC, 1986; Gaio, 1989).
14. This is not, of course, an analogy limited to developing countries. Software production in the West is still dealt with far more as an art, and far less with techniques of management science than many wish to admit.
15. A number of States have also invested in the development of their own new software tools and techniques. While this has certainly created skills within the development centres, the wider value has yet to be proven.
16. In addition to the 301-related pressures discussed above, Press (1991) cites the example of the US company Visible System which filed a claim against a Singapore firm's product, alleging that a subsidy paid by the Singapore Government amounted to unfair competition.
17. Evans (1992) illustrates the danger of such a situation in the dissipation of innovative skills built up within the state-owned Computadores Brasilieros. Once the state model had run into difficulties the only solution was seen to be total private ownership. One might have expected something similar from India but the Department of Electronics—unlike much of the Indian bureaucracy—has striven since the mid-1980s to assist industry, and so is transforming itself from a regulatory to a promotional body (*Dataquest*, 1993b).
18. One of the few advantages of externally-induced liberalization is that it may create the basis for a reorganization and reorientation of state structures, working conditions and staff attitudes which has been difficult to achieve under more incremental processes of change.

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Countries listed in brackets at the end of a reference indicate those for which evidence is presented in that reference and used in this paper where this is not otherwise obvious from the title.


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## APPENDIX I

**Areas for government intervention in IT industry development**

| **Demand side** (IT users) | **Environment and infrastructure** (bridging demand and supply) | **Supply side** (IT suppliers) |
|---|---|---|
| **Information dissemination**<br>- Awareness activities, national seminars, visits<br>- Market research and development | **Strategy formulation and coordination**<br>- Coupling supply and demand initiatives, organizations, policies<br>- Strengthening coordination, monitoring | **Research**<br>- R&D programmes and consortia<br>- R&D loans<br>- R&D incentives |
| **Demonstration projects**<br>- Process application support<br>- Product development support<br>- Public administration modernization | **Telecommunications policies and investments**<br>- Private participation in value-added services<br>- Competition<br>- Accelerated modernization | **Research institutions**<br>- Strengthening and restructuring |
| **Adoption incentives**<br>- Consultancy assistance<br>- Tax incentives | **Standardization**<br>- To strengthen supply and facilitate adoption | **Export promotion programmes**<br>- Foreign recruitment and strategic alliances |
| **Technological capability development**<br>- Adoption skills development<br>- Decentralized application centres<br>- Extension schemes, consultancy development | **Legal framework**<br>- Software protection<br>- Access to public information | **Industrial policy/strategy**<br>- Access to foreign technology<br>- Assistance to small enterprises<br>- Special finance to software firms promoting subcontracting<br>- Subsidy to national champions |
| **Procurement**<br>- Public procurement policies | **Education**<br>- Electronics and software engineering<br>- Managers and professionals<br>- Mass media<br>- Computer literacy | **Software quality and productivity**<br>- Enhancement programmes |
| **IT users/consultancy associations**<br>- Strengthen and use professional associations<br>- Clearing-houses, information networks | **Competition and trade policies** | **Software technology parks**<br>- Specialized services and common facilities<br><br>**IT industry and trade associations**<br>- Strengthen, use, link |

*Source*: World Bank (1992), India: An Information Technology Development Strategy, World Bank, Washington, DC, USA.

(Source: *Electronics Information & Planning*, February 1995)

# G. COUNTRY NEWS

## China

### *China's computer crisis*

Chinese computer manufacturers are having a tough time even though their domestic market is one of the world's fastest-growing.

According to the Ministry of Electronics Industry, the American companies AST Research Inc., Compaq Computer Corp. and International Business Machines Corp. control a combined 60 per cent of China's personal-computer market, with Hewlett-Packard Corp., Digital Equipment Corp. and Apple Corp. sharing much of the rest.

This year, NEC Corp. and Fujitsu Ltd. of Japan joined with plans to increase sales and production in China.

Meanwhile, China's biggest computer company, Beijing Legend Computer Co., holds just 7 per cent of the market, making 45,000 units last year.

Legend's tie-up with foreign companies may help it remain a player, but many small producers have already given up making personal computers.

Ministry officials say China's personal computer sales last year reached 700,000 units, with about 100,000 made locally, 200,000 more assembled in China and the rest imported.

Local companies' difficulties come despite selling into a market that is expected to grow more than 40 per cent in 1995 for the fifth year running, to about a million units.

Though still far smaller than Japan's, with annual sales of 5 million units, China's computer market is likely to record growth rates of at least 20 per cent a year for the rest of the century as incomes rise and the use of computers spreads to more schools, government offices and factories. (Extracted from *International Herald Tribune*, 17 August 1995)

### *Novel battery developed by Chinese woman inventor*

A determined Chinese woman inventor and entrepreneur, Wang Lianxiang, of Dalian in Liaoning Province, has invented a safe, high-capacity electric storage battery and, after a decade-long struggle, she heads a chemical company to commercialize it.

Wang Lianxiang bought 10 ordinary lead-acid batteries and various chemicals to do her experiments. Her objective was to replace the liquid acid with a solid or gel electrolyte. After several months, she did develop a non-liquid electrolyte, but it tended to solidify before it could be put in the batteries.

During one of her experiments on how to control the acid fumes and hydrogen gas from the battery, the battery exploded, knocking her and her sons down.

It was not until 1989, however, that Wang Lianxiang arrived at a completely successful battery with a colloidal electrolyte. In December of that year, the Liaoning Provincial Science and Technology Commission approved her product, which subsequently won first-award recognition at five international exhibitions. But opportunities for private manufacturing were just opening up in China, and it was a slow journey to commercialization of the battery.

In 1992, she was invited by the US Department of Commerce to show her invention. Batteries installed in motorboats as well as passenger cars and trucks passed all tests. A Commerce spokesman praised the battery highly, but added that, unfortunately, this type of battery had been patented in the United States.

Wang Lianxiang smiled and replied that she was well aware of the US patents (No. 5,202,196 for the colloidal cell; 5,167,936 for the gas effluent treatment device) because the inventor was none other than herself. Several family members were also named as participating in the invention.

The battery is now being manufactured by Dalian Haiwan Chemical Power Source Corporation, of which Wang Lianxiang is the chairwoman. (Source: *Chemical Marketing Reporter*, 11 September 1995)

### *Motorola heads for China*

Motorola plans to spend $720 million to build a new 8-in. chip manufacturing plant in Tianjin, China. Construction is scheduled to begin in November, with operation starting in the first quarter of 1998 and an initial production of 3,000 wafers per week. (Source: *Semiconductor International*, October 1995)

## European Union

### *The European Union and electronic databases*

In February 1992, the European Commission released the first draft of a Directive intended to bring electronic databases within the ambit of copyright protection. It was also envisaged that these legal safeguards would be uniform across all the member States of the European Union. To date, however, no agreement has been reached regarding the text or the wording of specific provisions.

The first draft contained a number of clarifications: databases, for instance, were clearly defined as "collections" within the meaning of the Berne Convention. There were, however, a number of clauses with which some commentators were unhappy. There were references to a user's right to extract "insubstantial" amounts of copyright material for subsequent commercial re-use, and a requirement imposed on database owners to license the extraction of substantial portions when materials were not available from other sources.

The EC produced a new draft in October 1993. This addressed some of the outstanding issues, without resolving them. Bodies such as EUSIDIC (European Association of Information Services) still professed themselves unhappy with some of the provisions. Further substantial revisions appeared in October 1994. These included the extension of the basic definition to include *all* collections, whether electronic or otherwise. Despite strenuous efforts, however, the Council of Ministers was unable to reach political agreement regarding the Directive.

Although the currently inconclusive status of the proposed legislation may please those objecting to EC interference, the lack of a clear legal position may create uncertainty for investors. (Extracted from *Bulletin of the American Society for Information Science*, 21(5), June/July 1995)

### *JESSI: What will follow project's end in 1996?*

The largest European collaborative semiconductor project, JESSI (Joint European Submicron Silicon Initiative), ends in 1996.

Possible JESSI successors were discussed at a round-table meeting in Grenoble organized by JESSI, CNET (France Telecom), SGS-Thomson Microelectronics, JEMI France, and LETI (Laboratoire d'études et de Technologie de l'Informatique, part of the French atomic energy organization). The European Commission has earmarked some funds for semiconductor R&D, but the majority of JESSI funding was from industry and national governments.

Heinz Hagmeister, JESSI chairman, is confident that there will be a programme to follow JESSI. It has had successes in chipsets for GSM, digital audio broadcast, ATM, the first open framework in the world for CAD tools, a cheaper 0.7 μm CMOS process, a 0.5 μm CMOS process, flexible wafer fabrications using mini-environments, etc.

Jürgen Knorr, Siemens senior vice-president, feels that Europe must continue to support its electronics industry while Governments in the United States, Japan, Singapore and Taiwan are supporting their industries.

Hagmeister suggested there could be more non-European companies involved. JESSI has always welcomed the idea of more collaborative R&D with SEMATECH, but only on an equal footing. There are only about a dozen US companies participating in JESSI programmes.

The round-table participants wanted more small and medium-sized companies involved, with fewer but larger projects, and closer involvement with end users. (Reprinted with permission from *Semiconductor International Magazine*, June 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

## Germany

### *Applications in photonics*

To coordinate the development of telecommunications systems for the twenty-first century, the BMFT (formerly the Federal Ministry for Research and Technology, now the BMBF or Federal Ministry for Education, Science, Research and Technology) started the "Photonics" programme in 1989, an association of participants drawn from industry, research institutes and colleges with numerous individual, inter-coordinated projects and a constant exchange of know-how among the study groups. The first phase "Photonics I" ran from April 1990 to March 1994: the final reports show that German research accomplished an enormous amount of work and is in a good position internationally. It is fully competitive with others in the rest of Europe, in the United States and in Japan, and even ahead in some fields.

The current phase "Photonics II" started in April 1994 and will be concluded in March 1998. In this phase, it is not so much the individual components which are in the foreground but rather the aspects of the system as a whole. The goal is the transition from experimental to real systems, from laboratory models to components which can be produced by industry. To this end, there are a number of "concentratedactions" among industry, research facilities and the universities.

"Photonics III" is then planned for 1998-2002, and here the technological, economic limits between hybrid and monolithic integration should be reached. Further details have not yet been established.

The photonics programme is closely related in content to a number of other R&D activities where there is in part some thematic overlap: III-V-electronics (BMBF), materials research (BMBF), microsystems technology (BMBF), optoelectronic integrated circuits (Deutsche Telekom), optical signal processing (DFG) [German Research Association] and photonics (Volkswagen Foundation).

There are also similar programmes now running in many other countries, such as the United Kingdom, France, Japan and especially the United States: the "information super highway", a tightly constructed gigabit fibre-optic network. In the Near East, 10 nations are involved in the current construction of the "Asia Pacific Cable Network", whose transmissions will run over fibre-optic underwater cables and should be in operation by 1997. (Extracted from *Elektronik*, 13 June 1995)

## India

### *Calcutta gets "smart"*

After decades of socialist isolation, the communist-ruled Indian state of West Bengal hopes to leapfrog into the twenty-first century with an aggressive project to build an "intelligent city" on 40 acres in a suburb of Calcutta. Hoping to lure high-tech business to the region, the state-run West Bengal Electronics Industry Development Corp. will invest in the project, known as Infinity, being funded largely by an area entrepreneur. The proposed complex will include two 22-story "intelli-centres" and 1,200 "intelli-homes", all completely computer integrated and connected to high-speed global data networks. Blurring the lines between home and work, professionals would live on-site while keeping flexible work hours in an energy-efficient environment that could raise productivity. Surpassing constraints of an underdeveloped communications infrastructure, Infinity aims to place Calcutta on the map as the region's up-and-coming technology centre. (Source: *Industry Week*, 3 July 1995)

## Indonesia

### *Electronics and telecommunications development*

The fiscal year 1993/94 became an important milestone in the development of Indonesia, as it was not just the last year of the Fifth 5-Year Development Plan and the last year of the First 25-Year Development Plan, but the beginning of the Second 25-Year Development Plan.

In the First 25-Year Development Plan (1969-1994), the development programme was focused on:

1. Agriculture, with the target of reaching self-sufficiency in food;
2. Basic infrastructure, such as transportation and electricity.

During this period, telecommunications were considered only as complementary to the development programme. This was reflected in the total number of 1.2 million telephone lines installed in the first 20 years.

The impact of this policy strongly hampered the development programme in other sectors, where telecommunications are needed as the basic requirement, such as the industrial and trading sector. At the end of the Fourth 5-Year Development Plan, telecommunications are now considered as part of the basic infrastructure and listed in the priority list.

This was the beginning of the growth in the telecommunications and electronics industries in Indonesia.

The Government's goal is to install 5 million lines or 1 million lines per year.

Today, the capability of the national telecommunications industry can be summarized as follows:

**Manufacturing**

(a) Switching: there are three switching manufacturers under licence from Siemens (EWSD), NEC (NEAX) and AT&T (5-ESS) with a capacity of 350,000 line units per year per shift operation for each manufacturer.

(b) Terminal equipment: telephone sets with a capacity of more than 1 million units per year and pay-phones with a capacity of 200,000 units per year.

(c) Radio transmission and multiplex equipment: local production is still at an early stage.

(d) Cable manufacturing: there are six cable manufacturers who produce copper cable with a total capacity equivalent to 1.5 million primary cable lines per year, with some exported.

The manufacturing of fibre-optics cable began in 1992.

At the moment three local companies have experience in construction management, design, engineering and construction supervision for big projects of 300,000-400,000 primary cable network lines under ICB procedures.

In 1992 the Government invited the participation of the private sector in providing basic services, which until then had been a government monopoly, in three types of schemes:

(a) Joint venture with PT TELKOM/PT INDOSAT;
(b) Joint operation with PT TELKOM/PT INDOSAT;
(c) Joint management with PT TELKOM/PT INDOSAT.

Based on this opportunity, today there are three joint venture operating companies:

(a) PT SATELINDO: for satellite operation, international traffic and domestic cellular mobile telephone systems using GSM technology with a capacity of 350,000 units;

(b) PT PACIFIC SATELIT NUSANTARA: for re-operation of PALAPA B2 satellite;

(c) PT RATELINDO: for operating a fixed wireless telephone system in Jakarta with a capacity of 200,000 units. The Government also plans to issue a tender for private participation in a joint operation scheme for 2 million lines installed within the Sixth 5-Year Development Plan.

In the last 15 years, the development of the electronics industry, especially in consumer products, has shown prospective growth.

Radios, televisions, household appliances, satellite receivers, PCs, etc. have shown competitiveness in quality and quantity, as well as price. Some of them have been exported.

The weakness in the continuation of the development phase is lack of know-how in component design technology.

This situation will lead to dependence by the local manufacturers on the principal technology.

For the last 10 years the economic growth of the country has shown stability and promising growth.

The environmental and the industrialization era for the Second 25-Year Development Plan have encouraged and challenged the national telecommunications and electronics industries to strengthen the local capability in component/chips design and software development.

These will be the common concern of most of the AEU member countries in the region.

Indonesia has the facilities for education and training in telecommunications and has offered all members of the non-alliance countries to utilize these facilities. Some African countries have made use of this offer.

These facilities will also be open to AEU members who need to train their personnel and engineers.

(Extracted from *Electronics Information & Planning*, July 1994)

## Israel

### *Plans for flash fabrication*

Intel has officially confirmed it is to begin building a $1 billion, 0.25 μm, 30,000 wafer a month fabrication for flash memory at Kiryat Gap in Israel. The plant is scheduled to produce its first silicon in the fourth quarter of 1997.

Fab 18, as the new Israel fabrication will be called, is Intel's first new memory fabrication for 15 years. Although it invented the DRAM, SRAM and EPROM, the company subsequently pulled out of all these markets to concentrate on microprocessors.

It is believed that the Israeli Government is contributing some $600 million over 10 years towards Intel's costs in setting up and running Kiryat Gap. (Extracted from *Electronics Weekly*, 25 October 1995)

## Japan

### *Application of superconductivity to power generation*

In Japan, power generation and power transmission facilities are being expanded or newly installed to meet the ever-increasing demand for electricity. The application of superconducting technology to power equipment provides a possible solution. In this project, the objective is to develop compact, lightweight generators of high efficiencies by using superconducting wires for the coils to improve the stability of power network systems. More specifically, a research project extending over a period of 11 years from FY 1988 to FY 1999 is being advanced on a model 70,000-kW class superconducting generator with the objective of commercializing a highly reliable superconducting generator for linkage with power networks. Also under development are AC superconducting conductors and oxide superconducting wires which have a broad range of applications, and basic technologies relating to a lube oil-free chiller system for generating cryogenic temperatures for retaining the state of superconductivity.

To demonstrate the reliability of the superconducting generator, a test facility was constructed in the compounds of the Kansai Electric Power Co. Inc. Osaka Power Plant, and demonstration tests are to be continued on the 70,000-kW class model generators from FY 1996 to FY 1998. The foundation works for various facilities including the frames of the generators, load synchronizers have been completed, the main equipment has been designed and fabricated, and procedures are based on the related laws and regulations. (Extracted from *JETRO*, July 1995)

### *PD/CD-ROM hits Japan desktops*

Since mid-1994, virtually all Japanese computer makers have offered domestic computer buyers multimedia machines with built-in TV tuners and CD-ROM drives. They are betting that a marriage of consumer electronics and computer technology can help close the gap with the United States, which holds a commanding lead in software and networking.

Now Matsushita Electric Industrial Co. Ltd., Osaka, has added yet another high-tech feature to the package—a combination phase-change/CD-ROM drive. The hybrid storage device allows users to record more than 600 Mbytes of data—as much as a CD-ROM disk holds—to a phase-change optical disk at transfer rates that match

that of the CD. The PD/CD-ROM dual drives will be offered on Panasonic-branded "Woody" model computers that are marketed in Japan using the familiar Woody Woodpecker image. (Source: *Industry Week*, 5 June 1995)

### *MITI to establish photon technology centre for next generation laser process technology R&D*

To promote R&D of next generation laser process technology MITI will establish a photon technology centre. The centre will be a joint government-private sector organization. At the outset participants will include domestic manufacturers, but plans call for subsequent participation by foreign manufacturers as well. The centre will address development of 20 kW class semiconductor excitation solid-state lasers, optical fibre transmission systems and the like, which are expected to be utilized in machine tools by the year 2000. Japanese companies hold an 80 per cent share of the world market in $CO_2$ lasers, which are currently the mainstream type, but Japan has fallen behind the United States in development of next generation lasers. Therefore, MITI is aiming for a considerable jump in the level of technology by bringing together laser manufacturers and companies in related fields that have been conducting their own research independently. This project is noteworthy because if development is successful, there is a strong possibility that lasers will be used in all machine tools in the future.

Photon technology is a blend of optical and electronics engineering, and one branch of this field focuses on the practical application of process technology of next generation lasers, such as semiconductor excitation solid-state lasers. MITI is studying the possibility of turning this R&D into a national project beginning in 1995 as an advanced research topic under the Industrial Science and Technology R&D System.

The output of semiconductor excitation solid-state lasers can be transmitted by optical fibres, which means the light can be split, and it is expected that the use of these lasers will expand to fields such as cutting, welding and heat treating instead of the $CO_2$ lasers that are currently being used. Moreover, they offer another advantage because the transmission source can be made very compact and this gives the equipment greater motility.

Faced with low economic growth, companies in machine-related industries are placing great hopes on the development of photon technology, and many consider this project important for increasing their competitive strength in the transition to next generation equipment. (Source: *Nikkan Kogyo Shimbun*, 25 November 1994)

## Republic of Korea

### *Increased production of large flat panels*

The first major challenge to the Japanese monopoly in large colour flat panel displays is swinging into gear with the three Korean electronics majors –Samsung, Hyundai and Lucky Goldstar—sharply increasing production.

Samsung, the most advanced of the Big Three, which has been producing 10,000 TFT panels a month since February, is about to double production to 20,000 a month and has authorized investment of $466 million to double that again to 40,000 a month by 1997.

Hyundai plans to have its 20,000 unit-a-month plant in action this year and to add another $800 million, 30,000 a month factory, by 1998. Lucky Goldstar plans to complete its first, 20,000 unit-a-month factory later this year. (Source: *Electronics Weekly*, 30 August 1995)

## Russia

### *TI explores Russian source for DRAMs*

Texas Instruments (TI) is looking at plans to source DRAMs and EPROMs in Russia. TI executives visited the Russian chip company Angstrem of Zelenograd to discuss the possibility of Angstrem supplying DRAM to TI on a foundry basis. More ambitiously, talks have been held with another Russian company—Electronica of Voronezh—about the possibility of equipping Electronica's new, unused fabrication with a complete TI production line to make 1-Mbit and 4-Mbit EPROMs using 0.8-micron technology.

Angstrem has a new fully-facilitized fabrication capable, with minor adjustments, of Class 1 production—sufficient to make 1-Mbit and 4-Mbit DRAMs. It is big enough to turn out 20,000 to 30,000 wafers a month at 0.8-micron.

Electronica has had a finished fabrication for four years which has lain unused because of lack of funds to start it up. It would be capable of producing up to 4-Mbit EPROMs at the rate of 30,000 wafers a month. (Extracted from *Electronics Weekly*, 1 November 1995)

## Taiwan, Province of China

### *UMC to build new foundry in Taiwan*

Taiwan-based United Microelectronics Corporation (UMC) and a number of other fabrication-less semiconductor companies have announced plans to form a separate Taiwanese company to build and manage a semiconductor manufacturing facility that will be located in the Science-Based Industrial Park in Hsin-Chu City.

The foundry is expected to produce 8-in. wafers using UMC's 0.5 and, when developed, 0.35 and 0.25 submicron processing technologies on a royalty-free basis. It is expected to be completed by the first half of 1997. Total costs for the construction and initial operation of the facility are expected to be $1 billion. (Source: *SI*, October 1995)

## United Kingdom

### *Firms call for government strategy*

UK electronics companies are calling on the Government to play a greater role in developing the core manufacturing capability which they say is vital for their industry and the country.

Through the auspices of the newly-formed Manufacturing Council, 30 electronics manufacturing companies are drawing up proposals calling for the Government to take a strategic view of investment and training in the electronics industry. (Extracted from *Electronics Weekly*, 1 November 1995)

### *Group in NiCd recycling drive*

NiCd battery manufacturers using NiCDs have formed an association to promote NiCd recycling.

The UK NiCd Battery Recycling Group's aim is to persuade the UK Government not to legislate on NiCd recycling by creating an effective voluntary scheme. The overall driver is EU Directive 91/157/EEC, which calls on member States to reduce the quantity of NiCds and some other batteries in general waste.

The proposed scheme is called "reverse distribution" and involves incentives, including possible discount on new batteries, to users who bring back "spent" NiCds.

Other Group targets are local authorities which classify used NiCds as "special waste" which effectively prohibits

transport of them in their areas. (Source: *Electronics Weekly*, 4 October 1995)

## United States of America

### *Record electronics sales*

The US electronics industry hit record sales levels for the first six months of 1995, and the Electronics Industries Association (EIA), which represents US electronics manufacturers that account for about 80 per cent of the industry's dollar volume, predicts nothing but the same through the remainder of the year.

EIA reports that US factory sales of electronics grew 15 per cent during the first half of the year to hit $179.3 billion.

Electronic components and the computers-and-peripherals category led the first half with $48.8 billion and $32.8 billion, respectively. The telecommunications sector grew the most, 24 per cent, to $29 billion. However, the US electronics industry still reports a trade deficit.

A US electronics trade surplus existed in 1983 and in years prior to that, but has since recurred only when US consumption slowed due to recession, as happened in the early 1990s. (Extracted from *Industry Week*, 21 August 1995)

### *DoE laboratories to develop modelling tools*

The Semiconductor Research Corp. (SRC) and three US Department of Energy (DoE) national laboratories have started work under a $100 million cooperative research and development agreement (CRADA) to improve the industry's ability to model and simulate semiconductor materials, devices, systems and manufacturing processes.

The CRADA, one of the largest ever announced, will be conducted at Los Alamos, Sandia and Lawrence Livermore national laboratories, in collaboration with researchers at SRC member companies. The DoE has established a Center for Semiconductor Modeling and Simulation at Los Alamos to coordinate the work of the three national laboratories.

The CRADA includes work in five major areas:

- Implementation of new moving, adaptive computational algorithms needed to model complex three-dimensional device structures and manufacturing processes;
- Development of a combined equipment/wafer simulator that will describe how surface topography is affected during deposition and etch processes;
- Improved simulation tools to predict the behaviour of electrons in semiconductors;
- Improved methods to predict failure in electronic contacts; and
- Predictive codes for such semiconductor manufacturing processes as ion implantation and impurity diffusion.

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### *DoE plans $1 billion supercomputer R&D investment*

The US Department of Energy (DoE) is considering investing as much as $1 billion in an R&D project, called the Accelerated Strategic Computing Initiative (ASCI), to build the world's fastest supercomputers.

The result will be supercomputers with a performance measured in trillions of operations per second (teraflops) rather than current performances in the gigaflop range.

The DoE is expected to make the first funding awards this summer for a massively parallel supercomputer with 2,000 microprocessors and capable of at least 1 teraflop performance.

Industry sources report that the DoE needs extremely fast supercomputers to model nuclear explosions. The DoE project is likely to lead to commercial spin-offs in the form of cheaper and more powerful supercomputers and software. (Source: *Electronics Weekly*, 28 June 1995)

### *US electronics factory sales $84.8 billion in first quarter of 1995*

US factory sales of electronics equipment, components and related products totalled $84.8 billion for the first quarter of 1995, resulting in a 12.8 per cent increase over last year's first quarter sales of nearly $75 billion, according to preliminary data released by the Electronic Industries Association (EIA). The following table details the performance in each major electronics sector.

**US factory sales of electronics**
First Quarter 1995
(Millions of dollars, not seasonally adjusted preliminary data)

| | 1995 | 1994 | % ch |
|---|---|---|---|
| Electronic components | 23,400 | 19,592 | 194 |
| Consumer electronics | 2,225 | 2,037 | 92 |
| Telecommunications | 13,530 | 10,876 | 244 |
| Defence communications | 7,050 | 6,903 | 21 |
| Computers and peripherals | 15,420 | 13,968 | 104 |
| Industrial electronics | 7,300 | 7,118 | 26 |
| Electromedical equipment | 2,325 | 2,232 | 42 |
| Other related products | 13,500 | 12,406 | 88 |
| | 84,750 | 75,132 | 128 |

*Note*: Includes specialized and defence communications devices.

(*Source*: US Department of Commerce. Compiled by EIA Market Research Department.)

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### *US HDTV specification to get standard profile*

A digital Standard Definition TV (SDTV) profile may be added to the United States Federal Communications Commissions (FCC) specification for HDTV. The aim is to allow more than one programme channel to be transmitted in a 6 MHz band and create a market for lower resolution TVs.

SDTV was originally called Advanced TV and intended to be analogous to HDTV. It will use eight vestigial sideband (VSB) modulation for transmission, MPEG-2 for transport, employing MPEG-2 main level, main profile for digital video decoding and Dolby Laboratories AC-3 for digital audio.

Work done by Hitachi's Advanced Television Laboratory has indicated that both formats could be handled by a single receiver. (Source: *Electronics Weekly*, 7 June 1995)

# H. AUTOMATION

### *New type of robotic hand developed*

The research group composed of Honda Research Assistants of Tokyo Science University's Basic Engineering Department have developed a new type of robotic hand which can grasp objects with unknown surfaces and weights with the appropriate level of strength exerted through the movement of minute vibrating mechanisms installed in the hand. Even if the weight of the item being held is increased, causing it to begin to slip, the hand can detect the slippage and continue to hold the object with the new most appropriate grip strength required. This technology can probably be used in high-end robots for home use which use a great variety of objects.

Most of the current robotic hands in use first determine the weight of the item to be lifted and then determine the appropriate strength to grip the item with. In the future, if we want to use robots in the home and office, they will require hands which function similarly to human hands. (Extracted from *Nikkei Sangyo Shimbun*, 11 January 1995)

### *Two-armed robot assembles mini-robots automatically*

Fanuc Ltd. has established an automatic assembling system that uses a two-armed robot to assemble the mini-robots manufactured by the company.

The two-armed robot mounts a 6-axis force sensor and a three-dimensional vision sensor and moves on the running axis of the linear motor. Assembly is performed by the robot using both hands like a human being. The assembling operations which used to be performed manually are to be automated to assemble about 100 mini-robots each month.

The two-armed robot is manipulated with a control system, and has a built-in force sensor in each arm and a vision sensor in its left arm. The robot grasps parts from a parts supply pallet to perform various kinds of assembling work such as motor insertion and screw tightening. The robot can also change the screwdrivers to be used in conformance with the size of the screws and bolts to be tightened.

When assembling with both hands, two arms are used in close proximity, but when selecting parts from distant pallets, each arm moves on its running axis independently. Movements are at a fast speed of 3 m/s by linear motor drive. The automatic assembling system consists of a two-armed robot and can assemble a maximum of 500 of the company's versatile type mini-robot per month.

Further details from Fanuc Ltd., Public Relations Div., 2-9-8, Nagata-cho, Chiyoda-ku, Tokyo 100. Tel.: +81-3-3595-2217; Fax: +81-3-3595-2347. (Source: *JETRO*, April 1995)

# I. STANDARDIZATION AND LEGISLATION

## Standardization

### *Taiwanese PC makers back battery protocol*

A number of Taiwanese PC manufacturers are set to announce support for the Duracell-Intel developed intelligent battery protocol for laptop computers.

Their support will increase the likelihood of the SM bus becoming an industry standard. Canon is currently the only laptop PC maker to employ the protocol using a Duracell intelligent battery pack in its Innova Note machines.

The smart battery specification comes in two parts: smart battery data (SBD), which defines 34 data registers that the battery should implement, and a system management bus (SMB), which describes the I²C-like serial communication link.

Together they allow the battery to relay information to the PC such as how much charge remains in its cells and what its optimum charge regime is at any time.

However, no other battery manufacturer has taken up the protocol.

Duracell has designed its own ASIC to implement the protocol and two other chip makers are planning to introduce chips. (Source: *Electronics Weekly*, 12 July 1995)

### *SEMI to track 300 mm development activity*

Semiconductor Equipment and Materials International (SEMI) has issued the first of an ongoing series of reports that will detail the development of standards that support the semiconductor industry's conversion to the production of integrated circuits on 300 mm wafers. The 43-page report, published in April 1995, incorporates information on various SEMI standards task force and committee activities, a list of existing standards specific to 300 mm wafers, as well as data on the recent 300 mm workshops held in New Orleans, Louisiana and Geneva, Switzerland. The report will be updated approximately every four months.

The next edition of the SEMI 300 mm Wafer Standards Activity Report will be issued after several standards-related activities occur in conjunction with Semicon/West95, including the International Workshop on 300 mm Wafer Specifications, 10 July, and the Information Sharing Forum on Interfaces Issues, 12 July. To request a free copy of the report, contact Sue Marquez at (415) 940-7911 or Fax (415) 940-7943. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

### *NIST to expand CIM effort to include discretes*

The US National Institute of Standards and Technology (NIST), headquartered in Gaithersburg, Maryland, has greatly broadened the scope of its one-year-old programme on Computer-Integrated Manufacturing for Electronics to include all discrete-part manufacturing.

The expanded programme, now called Technologies for the Integration of Manufacturing Applications (TIMA), will encompass a new five-year effort to facilitate industry development of real-time "plug and play" manufacturing environments. The affordable manufacturing software systems could be rapidly integrated and reconfigured and, eventually, able to automatically adjust performance in response to changing conditions and requirements. (Reprinted with permission from *Semiconductor International Magazine*, July 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

## Legislation

### *Tomorrow's protection for databases (proposed EU copyright directive)*

The proposed EU directive regarding copyright protection for databases has not yet been formally adopted, but will become law soon. It will not invalidate existing contracts, so database owners might wish to review these prior to its introduction. They should also bear the directive's provisions in mind when designing new databases.

Only databases requiring intellectual and creative effort for their development will qualify for protection. It would be advisable to maintain records of how the database was created so as to be able to demonstrate this if required. In this respect, the directive actually represents a diminution of existing UK copyright law, which covers *any* database.

The new legislation will, however, extend protection to the *contents* of a database, provided it has been compiled by EU nationals or by companies registered in the EU. On the other hand, it also provides for compulsory licensing. (Source: *Computing*, 6 April 1995)

### *Global information flows know no national boundaries and have created legislative chaos*

Cyberspace is unregulated, uncharted territory where there are no rules, but users are expected to abide by the loose code of "netiquette"—a set of ad hoc guidelines intended to discourage users from causing offence to other users. However, the colonization of the Internet by business interests, along with the fast spread of other commercial on-line networks such as Microsoft Network, is beginning to cause change. It is feared that regulatory concerns, together with consumer and supplier caution, are stifling the development of the on-line market. Legal issues are becoming important because of concern about copyright and information theft; libel; financial regulations; and data protection and privacy. Although hotly debated legal topics appear legalistic and hypothetical, they are not expected to remain so.

The momentum of the Internet and on-line services is unstoppable and the market will grow quickly. But the regulatory chaos means that consumers and information and service suppliers are not rushing to embrace the interactive business model. This is delaying the evolution of the on-line market which is affecting software sales and systems, slowing the revenue growth of network providers and restricting the implementation of new infrastructures. In addition, Governments will increasingly call for and eventually implement tighter, international regulation of the Internet and other on-line services. It remains to be seen how this will affect economics and the suppliers. (Source: *Computer Business Review*, April 1995)

### *Electronic copyright—a time to act*

In 1993 the Library Association Joint Consultative Committee Working Party on Copyright produced a statement on copyright which raised issues with regard to using electronic information. This statement was intended to encourage discussion with rights owners. In the electronic environment the legal balance is on the side of the rights owners and there are no exceptions for the exclusive rights for works in digital form. This is causing frustration among users and information professionals. It is thought that if and when the copyright equation is solved, the likelihood is that the privilege of being able to copy digitally will have a hefty bill. Other nations have copyright laws that are similar to those of the United Kingdom, but they differ in subtle ways depending on how the Government sees copyright and whether laws are recent or not. Electronic storage and copying may not be expressly forbidden in other countries.

International legislative solutions need to be found to solve the disparity in national laws and tighten the digital environment to make it safe for creators, prevent privacy and encourage use. Other areas to be explored are electronic tagging devices; digital fingerprint systems; electronic licensing and copyright clearance systems; standard agreements between librarians and publishers; and pilot electronic document delivery schemes. Librarians in the United States are campaigning and have a working document under discussion which outlines the rights lawful users should expect. Although it relates to US copyright law, the same principles could be used and professionals should start to lobby the UK Government and the European Commission. Users should, for example, be able to read and browse electronic information without charge; preserve in digital format copyright material held in library collections; and fulfil inter-library document requests electronically. (Source: *Library Association Record*, April 1995)

# J. RECENT PUBLICATIONS

## CD-ROM databases in electronics: a compendium

CD-ROM databases in the last two years have emerged as an important source of technology information relevant for the electronics industry. Certain selected CD-ROM databases for the electronics sector have been set up in India's Department of Electronics. During this process, most of the titles of CD-ROM databases available commercially in the world (more than 5,000) were scanned and analysed to select those which are relevant for the electronics industry (including telecommunications and software). We present here 72 such selected titles for the benefit and use of the electronics industry. As the titles are continuously being added to with the growth of knowledge and information, the list is not exhaustive. Titles preceded by = have been procured in DoE and operationalized. Titles preceded by + are under procurement.

**ABI/Inform Ondisc**
*Subjects*: Business information, management information
*Description*: The disc provides high-quality targeted business information in short
*Publisher*: UMI (University Microfilms International)

**ACEL Electronics Index Plus**
*Subjects*: Electronics, semiconductors, product information, directories, electrical engineering
*Description*: The CD-ROM identifies electronics products, various product literature, their suppliers, agents and their addresses, around Australia; brand names, Australian agents and product catalogues. It also identifies ICs, discrete semiconductor and optoelectronic components, brings out equivalent devices, sources, data sheets and locates Australian suppliers from over 400 manufacturers world-wide
*Geographic coverage*: International
*Publisher*: ACEL Information Pty Ltd., Australia

**BCQ Information System**
*Subjects*: Information about business, civil engineering, electrical engineering, electronics, media
*Description*: The disc, brought out by Electronic Library Directory system, details the software and graphics board use for developing products in market sectors and currently provides information to architects, builders and quantity surveyors, with over 250,000 pages of manufacturers' product literature and specifications
*Geographic coverage*: United States, Europe, Australasia, Asia
*Publisher*: BCQ Ltd., Poulter Communications plc, UK

**CAPS (Computer Aided Product Selection)**
*Subjects*: CAD, electronics, engineering
*Description*: CAPS is a complete illustrated electronic parts selection system listing thousands of parts from manufacturers' catalogues
*Geographic coverage*: United States
*Publisher*: Cahners Tech. Inf. Service

**CASSIS**
*Subject*: The disc provides patent information provided by the US Patent and Trademark Office to its network of patent depository libraries. It contains around 5 million patent records with their patent numbers, and technological classifications, patent title, state or country origin, owner, year of issue, status, and the abstract
*Publisher*: National Information Service Corp. (NISC), USA

**CD-FICHE—Automated Logistics Procurement System**
*Subjects*: Aircraft, aviation industry, electronics, government information
*Description*: CD-FICHE is a PC-based management information system designed to support logistics and procurement needs. Contains millions of part numbers, references, cross-references, alternative manufacturers, pricing and technical specifications relating to US Government parts data
*Geographic coverage*: United States, Europe
*Publisher*: USA Systems Inc., USA

**# Communications Infodisk**
*Subjects*: Computer industry, CD-ROM industry, technical specifications, telecommunications
*Description*: The disc is a detailed information provider on major technology advancements in voice and data communications—hardware, software services, new and emerging technologies. Also provides the latest information on networking and integration issues, growth planning, systems and design management, equipment and services
*Geographic coverage*: United States, Europe, Asia
*Publisher*: Faulkner Information Services, USA

**Communication Master**
*Subject*: Computer programs
*Description*: Communication Master contains thousands of utilities, technical notes, communication programs and many other reference files useful for most types of networking needs
*Publisher*: Powersource Computer Vertriebs GmbH, Germany

**ComNet 93**
*Subjects*: Conference proceedings, communications, electronics and telecommunications
*Description*: A comprehensive post show reference to use at home or share with colleagues back at the office. It includes over 125 ComNet Conference and LiveNet Program descriptions with presentation graphics, over 450 exhibitor and 185 new product listings, a Speaker Directory including 284 contacts, and an Export Interest Directory. It is a database of articles from ComputerWorld, InfoWorld and Network World is also include.
*Geographic coverage*: World-wide
*Publisher*: Emerging Technology Applications (ETA), USA

**+ Computer and Communications Technology Documents on CD-ROM**
*Subject*: Computer programs
*Description*: A collection of international standards, technical reports and data from the following bodies: ECMA, ITU, CCIR, CCITT, ETSA, ANSI, ISO/IEC, IEEE, EIA
*Publisher*: Technical Indexes Ltd., UK

**The Computer File**
*Subjects*: Company information, computer industry
*Description*: Contains a database listing the UK operators and owners of mainframe, mini and personal computers
*Geographic coverage*: United Kingdom
*Publisher*: CML Data, UK

**# Computer Select**
*Description*: Technology and business periodicals; specifications for over 7,000 products of computer hardware, software and data communications; company profiles; etc.
*Publisher*: Ziff Comm.

**# Computer Products Database**
*Subject*: Computer programs
*Description*: The disc contains reviews of the top 10,000 computer products in various directories. Among the product categories covered are: accelerators, array processors, CAD/CAM/CAE, cartridge tapes, co-processors, computers, concentrators, controllers, CRT displays, daisywheel units, PCs, drives, printers disks
*Geographic coverage*: World-wide
*Publisher*: GNL Corporation (Computer Review), USA

**ComputerWorld on CD**
*Subjects*: Communications, electronics information technology, telecommunications
*Description*: The CD contains fully indexed text from ComputerWorld's weekly news and features, as well as articles from ComputerWorld's Client/Server Magazine. Selected graphics from each issue show industry trends, product comparisons and more
*Geographic coverage*: World-wide
*Publisher*: Emerging Technology Applications (ETA), USA

**Computing Archive**
*Subjects*: Computer, computer industry
*Description*: The disc provides information on trade computing literature, scholarly professionals. It covers all the computing subjects. Queries may be made on title, author, keyword, publisher, data
*Publisher*: Association for Computing Machinery

**Concise Engineering and Technology Index**
*Subjects*: Engineering, science and technology, electronics, mechanical engineering
*Description*: The disc contains information from over 400 core journals and conferences, derived from Ei Compendex* Plus; Concise Engineering and Technology Index provides access to a collection of up to 2,150,900 key abstracts. Each year, 40,000 new abstracts are added to the collection. Each record provides abstract, title, year, author, source, descriptors and other fields for searching. The areas covered are chemical technology, electrical engineering, computer technology, mechanical engineering, manufacturing, etc.
*Geographic coverage*: World-wide
*Publisher*: SilverPlatter Information Inc., USA

**Concise Engineering and Technology Index**
*Subjects*: Engineering, science and technology, electronics, mechanical engineering
*Description*: The disc provides access to core engineering literature. The index covers 425 engineering journals and conference proceedings
*Geographic coverage*: World-wide
*Publisher*: CD Plus Technologies, USA

**+ Consumer Reports**
*Subjects*: Standards, consumer information
*Description*: The disc contains complete text of major articles appearing in Consumer Reports (it is a monthly consumer advisory magazine containing results of product tests and purchasing recommendations). It covers products and services of significant cost or lower priced products that are typically bought frequently or in large quantities, incorporating such products as appliances, automobiles, electronic goods, test reports, including brand-name ratings, etc.
*Publisher*: DIALOG Information Services Inc.

**D.A.T.A. Parametric Access Library (D.A.T.A./P/A/L/Selector II)**
*Subjects*: Electronics, engineering, semiconductors
*Description*: D.A.T.A./P/A/L contains technical parameters on over 1.4 million active and discontinued semiconductors dating back to 1956 on a single disc. The 10 categories included are: integrated circuits—digital; interface; linear; memory; microprocessor; programmable logic; discrete semiconductors-diodes; opto-electronics; thyristors; transistors
*Geographic coverage*: World-wide
*Publisher*: D.A.T.A. Business Publishing, USA

**DATAPRO on CD-ROM—communications equipment and services**
*Subjects*: Communications, standards, technical specifications, telecommunications
*Description*: It contains a comprehensive collection of the McGraw Hill Series of reports on computer sciences and telecommunications technology. Full text, hierarchical and title words are the various access modes
*Geographic coverage*: Europe, Asia, Pacific Rim
*Publisher*: Bureau Van Dijk SA; Datapro Information Services Group, Belgium, and USA

**DATAPRO REPORTS**
*Subjects*: Computers, computer programs, telecommunications
*Description*: Contains the McGraw Hill Series of reports on computer sciences and telecommunications technology. Access modes include full text, hierarchical and title words
*Publisher*: Bureau Van Dijk; Datapro Research Group, Belgium

**DOD Standardization Service**
*Subjects*: Aviation industry, engineering, technical specifications, defence and defence industry, electronics, standards
*Description*: The CD provides full text information of over 50,000 active US military and federal specifications, standards, drawings, qualified products lists and many other related documents. Also includes summary reports and detailed outlines of each document. Available in five subject sections
*Geographic coverage*: World-wide
*Publisher*: Information Handling Services Inc., USA

**DODISS Plus Service**
*Subjects*: Aviation industry, engineering, electronics, government information, military information, standards
*Description*: The disc contains detailed summaries of about 50,000 active US military federal standardization documents. Also contains references to over 150,000 historical standardization documents and references to related documents including DoD and Directives
*Geographic coverage*: United States
*Publisher*: Information Handling Services Inc., USA

**+ DefenceNet — Global Defence & Aerospace Intelligence**
*Subjects*: Defence and defence industry military information
*Description*: This is a global defence and aerospace database. It has various defence-related articles, news items, international awards, leading defence journals and newsletters. It also contains new and emerging defence products and technologies, R&D materials and components, world-wide information on some specific areas of interest, e.g. anti-missile defence, COMINT/LINT/SIGINT, laser and infrared technology, etc.
*Publisher*: TELDEN Adv. Sys. Ltd.

**+ Design Automation**
*Subjects*: Computer, computer industries
*Description*: The CD-ROMs provide full text and images of key design automation publication and conference proceedings in the last three decades. It consists of eight CD-ROMs: one disc contains the full text of all the Key Design Automation Publication and conference proceedings in the database, and the other seven discs contain page images of all the publications and proceedings. All the issues from the following titles are included: Design Automation Conference, International Conference on Computer Aided Design, European Design Automation Conference and issues of Transactions of Computer Aided Design and SIGDA Newsletter
*Publisher*: Association for Computing Machinery

**Ei Compendex* Plus**
*Subjects*: Aerospace automotive, computers, robotics, industrial robots, nuclear engineering
*Description*: The disc provides abstracted information from the world's significant literature of engineering and technology. This database covers approximately 4,500 journals and some selected government documents
*Geographic coverage*: World-wide
*Publisher*: DIALOG Information Services, Inc., USA

**Ei Page One—DIALOG OnDisc**
*Subject*: Engineering
*Description*: The CD covers citations from a large number of journals, conference proceedings, selected government reports, and books covering the world's significant literature of engineering and technology. The following branches of engineering are covered: civil; energy; environmental; geological; biological; electrical; electronics; control; chemical; mining; metals; fuel; mechanical; automotive; nuclear; aerospace; computers robotics
*Geographic coverage*: World-wide
*Publisher*: DIALOG Information Services Inc., USA

**Electricity & Magnetism CD-ROM—Student Centred Learning Version**
*Subjects*: Learning systems, electronics, energy, electrical engineering, education
*Description*: This disc contains a wide range of animations, graphics, colour diagrams, text and audio relating to electricity and magnetism. Users can activate animations to show how electric current flows in a circuit or how a lightning conductor works, or use on-screen controls to change elements to see what happens when they alter the voltage. Text icons will supply a text description, and audio icons will narrate the principle involved
*Geographic coverage* International
*Publisher*: Bradford Technology Ltd., Cambrix Publishing Inc., UK and USA

**Electronic Engineering Index on CD-ROM**
*Subject*: Electronics
*Description*: The disc contains manufacturers' catalogues and product information relating to the electronics industry
*Publisher*: Technical Indexes Ltd., UK

**Electronics, Electrical Engineering & Computer Science Index**
*Subjects*: Computer industry, electrical engineering, electronics
*Description*: This database provides bibliographic coverage from over 2,600 engineering journals, conference proceedings and technical reports. Indexed topics include, among others, nano-

technology, telecommunications, laser technology, micromachines and robotics
*Geographic coverage*: World-wide
*Publisher*: CD Plus Technologies, USA

**+ Electronics Strategies**
*Subjects*: Strategic planning, finance, R&D
*Description*: The disc includes Company Reports discussing technologies, collaborative agreements, pricing strategies, product development, management capabilities, etc., industry and market reports, fixed income reports offering expanded financial data on public companies, debt ratings, potential public stock offerings, etc.
*Publisher*: The Investext Group - Thomson Financial Services, USA

**EMC Technology Magazine**
*Subjects*: Electronics, electrical engineering, engineering.standards.technicalspecifications
*Publisher*: DataDisc, USA

**GEMini Atari CD-ROM**
*Subjects*: Computer programs, shareware
*Description*: The CD-ROM supports the Atari ST, TT, Falcon and Portfolio palmtop computers. The disc contains public domain programs, shareware and commercial demo for Atari computers. Directories include accessories, astronomy, database utilities, programming, screen savers, virus and text editors
*Publisher*: Walnut Creek CD-ROM, USA

**Giga-ROM**
*Subject*: Software
*Description*: The Giga-ROM is designed to provide an entire software library in pre-compressed Compact Pro format for BBS and other uses. The Giga-ROM disc (1,700 megabytes) is the world's largest collection of CD software and includes the latest versions of System 7-compatible programs for all Macintosh computers
*Geographic coverage*: World-wide
*Publisher*: Quantum Leap Technologies Inc. (QLTech), USA

**HAP**
*Subjects*: Aviation industry, computer languages, electronics, engineering, mechanical engineering, radiology
*Description*: This is a multimedia CD-ROM which contains technical and medical educational packages on: X-ray technology, magnetic resonance imaging, Lufthansa turbine presentations, Lufthansa hydraulics course unit, aerospace glossary, C language learning, and thin-film technology
*Publisher*: Hamburg Educational Partnership, Germany

**Harris Selectory—ElectronicsManufacturers Directory on Disc**
*Subjects*: Business information, company information
*Description*: This CD-ROM contains business listings of electronics companies with search in company name, address, business description, import/export, computers used, SIC, key personnel, etc.
*Geographic coverage*: United States, Canada
*Publisher*: Harris Publishing Company, USA

**Hobbes OS/2**
*Subject*: Computer programs
*Description*: The disc contains the Internet OS/2 Archives from internet sites, viz. novel.com and hobbes.nmsu.edu. There are archive and compression utilities, modem utilities and communication programs, disc utilities; many video, printer and keyboard drivers; programs for desktop publishing; editors; word processors; technical documents and tutorials; fonts for PostScript, TeX and AFM; icons, bitmaps, graphic images, graphic previewers and bitmap editors; programming tools and source code; GNU utilities, etc. The 150 Mb disc contains OS/2 software and lots of other programs
*Publisher*: Walnut Creek CD-ROM, USA

**HP LaserROM**
**(HP 9000 Series 300/400, Series 700 and Series 600/800)**
*Subjects*: Computer manuals, technical specifications
*Description*: It contains full text of support information from the HP 9000 Series 300/400, Series 700 and Series 600/800 HP-UX User, Reference and Programming manuals, system administrator manuals, subsystems manuals, for computers using the UNIX operating system. The disc also includes HP education catalogue, software status and release bulletins, problem reports, HP Response Center questions and answers, application notes, etc.
*Publisher*: Hewlett-Packard Company, USA

**HP LaserROM—Business Systems**
*Subjects*: Computer manuals, technical specifications
*Description*: This disc, which is brought out by Hewlett-Packard, contains full text of support information for Hewlett-Packard (HP) 3000 business computers that use the MPE V operating system. It includes user and reference manuals, HP communicators, software status bulletins, application notes, quick reference product catalogues, HP information, etc.
*Publisher*: Hewlett-Packard Company, USA

**+ IC/Discrete Parameter Database Service**
*Subjects*: Technical specifications, electronics, standards, military and weapon information
*Description*: The disc provides information on digital ICs, diodes, optoelectronics, transistors and thyristors. Active and discontinued devices and components meet US Military Specifications for high reliability. The service also contains electronic images of manufacturers' databases. Mil Spec QPL M-38510 and S-19500 documents, DESC Drawings and Military Standards
*Geographic coverage*: United States
*Publisher*: Information Handling Services Inc., USA

**IDC ResearchBase**
*Subjects*: Market research, electronics, telecommunications, information technology
*Description*: It provides the latest information technology marketplace. It gives an effective access to a wide range of market intelligence databases, research and analysis, which helps in deciding the planning strategy and formulation in business
*Geographic coverage*: World-wide
*Publisher*: Emerging Technology Applications (ETA), USA

**ITU-T Recommendations (CCITT)**
*Subjects*: Electrical engineering, communications, technical specifications, telecommunications, standards
*Description*: The disc contains ITU-T Recommendations from the International Telecommunication Union, which is a set of standards on almost all aspects of international telecommunications, agreed between telecommunications experts world-wide
*Publisher*: International Telecommunication Union (ITU), Switzerland

**Information World Review in the 90's**
*Subject*: Computer, CD-ROM industry, library and information services
*Description*: Contains the full text of the Information World Review from January 1990 to the present
*Publisher*: Learned Information

**Internet Info**
*Subject*: Telecommunications
*Description*: The disc provides detailed information that is available on the Internet, about computers and networks—answers to Frequently Asked Questions (FAQs), Internet RFCs and IENs, computer security documents, Internet Network maps, Usenet technical discussion archives, ftp site lists, extensive bibliographies and technical book reviews, and documents and standards from IEEE, ISO, NIST, ANSI and others
*Publisher*: Walnut Creek CD-ROM, USA

**Introduction to Personal Computers and DOS—Skill Builder**
*Subjects*: Training, software
*Description*: This is an interactive CD-ROM which gives an overview of the personal computer, components of the computer system, Disk Operating System (DOS), managing DOS files, overview of DOS utilities, etc.
*Publisher*: Applied Learning International, UK

**ISIS Software Select, PC-Software**
*Subject*: Software
*Description*: The disc details more than 5,000 software products for personal computers, e.g. for Macintosh OS, MS DOS, MS Windows, MS Windows NT, OS/2 or Novell NetWare. It includesgeneralapplications,industry-specific applications, technical and scientific applications, and systems software available in Germany, Austria and Switzerland
*Geographic coverage*: Germany, Austria, Switzerland
*Publisher*: Nomina Gesellschaft für Wirtschafts- und Verwaltungsregister mbH, Germany

**ISIS Software Select, UNIX-Software**
*Subject*: Software
*Description*: The disc describes around 3,500 software products for computers using the UNIX operating system, e.g. for workstations with AIX, HP-UX, SINX, Sun OS and ULTRIX; and PCs with SCO-UNIX, etc. The database includesgeneralapplications,industry-specific applications, technical and scientific applications and systems software available in Germany, Austria and Switzerland
*Geographic coverage*: Germany, Austria, Switzerland
*Publisher*: Nomina Gesellschaft für Wirtschafts- und Verwaltungsregister mbH, Germany

**Jane's Avionics 1994-95**
*Subjects*: Aviation industry, aircraft, communications, electronics
*Description*: The disc provides technical details of military and civil airborne electronic equipment world-wide. Each section deals with a major category of avionics equipment subdivided by country and manufacturer (with manufacturer contact details)
*Geographic coverage*: International
*Publisher*: Jane's Information Group, UK

**Jane's C4I Systems 1994-95**
*Subjects*: Communications, defence and defence industry, electronics, military information
*Description*: A comprehensive guide to command, control, communications computers and intelligence systems world-wide in production or in service. Each system is analysed in terms of technical specifications, program history, methods of operation and production or in-service status with armed forces world-wide
*Geographic coverage*: International
*Publisher*: Jane's Information Group, UK

**+ Jane's Radar & Electronic Warfare Systems 1994-95**
*Subjects*: Communications, defence and defence industry, electronics, military and weapon information
*Description*: An important source for data on defence radar and electronic warfare systems. Details of development, specifications, performance, in-service status, contractors and main sub-contractors are given for each item. The disc is split into two main sections—Radar Systems and Electronic Warfare Systems—with a further section devoted to Analysis Tables
*Geographic coverage*: International
*Publisher*: Jane's Information Group, UK

**Jane's Underwater Warfare Systems 1994-95**
*Subjects*: Communications, defence and defence industry, electronics, military and weapon information
*Description*: Covers all aspects of the underwater warfare scene whether ship-borne, submarine-borne or airborne, including underwater weapons and their fire control systems, mines and mine countermeasures, sonar, sonarbuoys, processing and display equipment, underwater communications, ranges and targets, hydrographic systems, acoustic and electromagnetic countermeasures, oceanography, degaussing systems, and submarine electro-optics. Individual entries give details of development, performance, specifications, status and deployment, plus an analysis summary
*Geographic coverage*: International
*Publisher*: Jane's Information Group, UK

**Jewel Box Vol. 1**
*Subject*: Computer programs
*Description*: This shareware disc was made for Apple Macintosh. The disc contains over 240 megabytes of public domain programs. Subjects covered are: utilities (with virus information and programs), communication, mathematics, science and other educational programs
*Publisher*: Borsu International BV, Netherlands

**Learn DOS for Fun**
*Subjects*: Computer programs
*Description*: The CD contains over 3,000 databases on TEXT editing, engineer reference, desktop publishing, workperfect communication and business information
*Publisher*: Powersource Computer Vertriebs GmbH, Germany

**Libris Britannia CD-ROM**
*Subjects*: Computer programs, shareware
*Description*: Contains more than 600 megabytes of public domain and shareware for the IBM PC. Includes sections on electronics, engineering, mathematics, and ham radio, etc. A printed book describing the software is enclosed along with each disc
*Publisher*: Walnut Creek CD-ROM, USA

**Mac Demos**
*Subjects*: Shareware, software, computer programs
*Description*: The disc contains about 350 demo programs for Macintosh computers
*Publisher*: MGE Communications, Italy

**Market Studies Library on CD**
*Subject*: Market research
*Description*: Produced by Find/SVP Inc., a world-wide consulting and research firm, the Market Studies Library on CD contains over 150 in-depth market research reports in the following subject areas: food, health care, pharmaceuticals, construction energy, retail, chemicals, computers, transportation, etc.
*Publisher*: SilverPlatter Information Ltd., UK

**# National Trade Data Bank (NTDB)**
*Description*: International and export data from 15 federal agencies (including export promotion information)
*Publisher*: National Technical Information Service (NTIS)

**+ NUCSSI**
*Subject*: Catalogue of scientific serials
*Geographic coverage*: India
*Publisher*: INSDOC, New Delhi, India

**The OCLC Computer Library**
*Subjects*: Computer programs
*Description*: The disc contains around three lakh citations to material on computers and related subjects, including mathematical applications, communications and telecommunications, and computer industry issues. This includes artificial intelligence, computer engineering, computer-assisted counselling, electronic data processing, electronic publishing, library automation, Boolean algebra, computer music, art and graphics, database management, government regulations, medical research, etc.
*Publisher*: SilverPlatter Information Inc., USA

**The PC-SIG Library**
*Subject*: Computer programs
*Description*: The CD-ROM contains thousands of PC software titles containing many programs. The software included covers many applications: word processing, database management, spreadsheet, programming languages, utilities, games and graphics for IBM PCs and compatible computers. It covers almost all categories of software
*Publisher*: PC-SIG Inc., USA

**# Predicasts F&S Index**
*Description*: Covers information on business and applied technology. The topics include market size and share, new products, industry trends and forecasts, mergers and acquisitions, and so on. The disc contains records from over 2,000 key periodicals.
*Publisher*: SilverPlatter Information Inc., USA

**ProQuest IEEE/IEE Publications Ondisc (IPO)**
*Subjects*: Aerospace, communications, computer programs, electrical engineering, electronics
*Description*: Complete image access to the publications of the IEEE and the IEE from 1988 onwards. Users can search for, retrieve and print exact copies of published material at a single workstation
*Geographic coverage*: United States, Europe
*Publisher*: UMI (University Microfilms International), USA

**ProQuest INSPEC Ondisc—Electronics and Computing**
*Subjects*: Computer programs, electrical engineering, electronics, physics
*Description*: The three-disc set contains the full INSPEC database from 1990 onwards, with approximately 250,000 records per year. Coverage is

centred on four main subject areas: physics; electrical engineering, electronics and telecommunications; control technology, computers and computing; and information technology. The electrical engineering and electronics section covers electronic components and technology, telecommunications, power engineering and instrumentation; the information technology section covers electronic mail, facsimile, computer terminals and communications.

*Geographic coverage*: World-wide
*Publisher*: UMI (University Microfilms International), USA

**ProQuest INSPEC Ondisc—Electronics and Computing**
*Subjects*: Electrical engineering, electronics, computer programs, control and information technology
*Description*: This disc, brought out by INSPEC, contains information about the electrical engineering and electronics section, which covers such subjects as aerospace electronics, antennas and propagation, electronic circuits, energy conversion, lasers, microwave technology, nuclear instrumentation, power generation and supply, and optoelectronic devices; and the computers and control section, which covers artificial intelligence, computer theory, hardware, software and applications of computing, communications, industrial production, instrumentation, materials, etc.
*Geographic coverage*: World-wide
*Publisher*: UMI (University Microfilms International), USA

**Sevenplus CD-ROM**
*Subjects*: Shareware, software, computer programs
*Description*: The disc has a collection of free software and shareware for Macintosh computers, fully compatible with System 7. Offers 350 MB of demos (about 320 programs), and 200 MB of shareware programs fonts, utilities, Init, CDEV, etc.
*Publisher*: MGE Communications, Italy

**Shipwreck (CD-i)**
*Subjects*: Education, science and technology, electronics
*Description*: An interactive introduction to topics from the Physical Processes part of the Science National Curriculum
*Publisher*: Media Alliance Partnership, UK

**SuperTech Abstract Plus**
*Subjects*: Computer programs, electronics, science and technology
*Description*: The compact disc cumulates all current and past citations and abstracts from CAD CAM Abstracts, Artificial Intelligence Abstracts and Robotics Abstracts. It helps users to conduct full text and fielded searches and browse through indexes (which include author, subject, keyword, title, review classification, source, type of information, and SIC code) and order the full text of the majority of abstracts in print or on microfiche. Nearly 50,000 articles detail the latest R&D developments in the area of neural networks to robotic vision
*Publisher*: Bowker Electronic Publishing, USA

**Technical Literature Database**
*Subjects*: Electrical engineering, electronics, semiconductors
*Description*: The disc covers products produced by National Semiconductors and describes the applications, descriptions, characteristics, diagrams, etc.
*Publisher*: R.R. Donnelley & Sons Company, USA

**Telecom Strategies**
*Subjects*: Strategic planning, R&D focus, assessments of management, sales earning forecasts, etc.
*Description*: The disc contains a unique new resource that puts strategic intelligence on telecommunications companies. It covers the following areas: competitive strategies, merger and acquisition details, marketing and R&D agreements, product development plans, regional and international marketing consideration, etc.
*Publisher*: The Investext Group—Thomson Financial Services, MA, USA

**US Military EMC Specifications**
*Subjects*: Electronics, electrical engineering, engineering, standards, technical specifications, military information
*Publisher*: DataDisc, USA

**1994 IC MASTER CD-ROM Plus**
*Subjects*: Electronics, electrical engineering, engineering
*Description*: The disc contains a directory of IC Manufacturers' Data Pages plus a powerful Inquiry Generation and Tracking System. The disc specs on 100,000 integrated circuits from 260 manufacturers. The search results may be compared on screen or printer
*Geographic coverage*: World-wide
*Publisher*: Hearst Business Publishing Inc., USA

(Source: *Electronics Information & Planning*, February 1995)

### *IEE publishes VDU information pack*

Visual display units (VDUs) are the subject of an information pack published by the IEE Technical Information Unit.

Compiled by Jonathan Crabtree, the pack contains summaries of technical papers selected from the IEE's INSPEC database on: regulations, standards and ordinances; ergonomics; eye problems, screen radiation and screen layout and design; and health effects in general, as well as the specific problems of repetitive strain injury (RSI) and other work-related upper limb disorders (WRULDs). There are also chapters listing books, reports and conference proceedings held in the IEE Library; regulations and standards; short training courses; distance learning; and VDU consultants.

VDUs are a ubiquitous feature of modern life, both at work and at home. But VDU users have learned to treat them with respect, as there are associated ergonomic and health implications.

In response to a European Union directive, the UK Government introduced the Health and Safety (Display Screen Equipment) Regulations 1992, which have been in force since 1993. These regulations enable employees to insist on a proper assessment of the VDU equipment. There have already been many legal cases where incorrect usage has been cited as a cause of WRULDs, the most common of which is RSI. Although the latest NRPB (National Radiological Protection Board) report indicates that VDU screen radiation is not harmful to health, research in this area still proceeds. Similarly, there is a danger of eye problems if too long is spent at a VDU screen at any time.

This information pack is available, price £39, from: Publication Sales, IEE, P.O. Box 96, Stevenage, Herts. SG1 2SD, United Kingdom. Tel.: +44 (0)1438 313311. Fax: +44 (0)1438 742792.

Further details on "Visual display units: bibliography and information pack" and data on other IEE information packs are available from John Coupland. Tel.: +44 (0)171 344 5451. Fax: +44 (0)171 497 3557. E-mail: jcoupland@iee.org.uk. (Source: *Inspec Matters*, No. 82, June 1995)

### *IEE Proceedings journals to go online through OCLC*

The Institution of Electrical Engineers (IEE) has announced an agreement with OCLC to make all 11 of the IEE Proceedings journals available over the Internet beginning in January 1996. The IEE Proceedings will be accessible as both individual journals and one comprehensive journal containing all individual journals.

The IEE Proceedings series comprises 11 titles in the following subject areas: Circuits, Devices and Systems; Communications; Computers and Digital Techniques; Control Theory and Applications; Electric Power Applications; Generation, Transmission and Distribution; Microwaves, Antennas and Propagation; Optoelectronics; Radar, Sonar and Navigation; Science, Measurement and Technology; Vision, Image and Signal Processing.

IEE Proceedings Online will use OCLC's Windows-based graphical user interface, Guidon, which operates in the Microsoft Windows environment. Specific features include: full-text searching of all articles; typeset quality display and printing of text, equations, tables and figures; a table of contents created for each article which allows you to browse the article sequentially or to jump to any listed section; hypertext links to and from the figures and tables as well as footnotes and cited references; linked documents such as comments on articles already published and authors' replies brought to your attention when you view any one of these; hypertext links from cited references to abstracts in the INSPEC Database; automatic notification of newly published articles in your field by weekly fax, mail or e-mail.

**Pricing**

IEE Proceedings Online will be priced on a subscription basis. Subscribers will receive the Guidon client software and their passwords. The basic 1996 subscriptions will be the same as for the equivalent print versions:

| No. of titles | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Price: | £370 | £565 | £685 | £82[illegible] | 0 | £980 |

| No. of titles | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|
| Price: | £1,025 | £1,055 | £1,080 | £1,100 | £1,133 |

**Print Subscriber Discounts**

The price for a combined print and online subscription to one or more IEE Proceedings titles will be 1.5 times the print price.

**Networking**

The client software may be installed on one machine, many machines or on a network server. A single subscription will allow a single simultaneous access across the user site.

The additional charge for 2-5 simultaneous accesses, and additional batches of 5 simultaneous accesses is +100 per cent of the subscription price.

The 100 per cent is based on the full price, not on the print subscriber's discount price.

The IEE's rapid-publication letters journal, *Electronics Letters Online*, is currently available through the OCLC Electronic Journals Online system.

For further information and an order form write to IEE Marketing Department, Michael Faraday House, Six Hills Way, Stevenage, Herts. SG1 2AY, United Kingdom. Tel.: (01483) 313311; Help Desk (01438) 767297; Telex: 825578 IEESTV G; Fax: (01438) 742840. E-mail: inspec@iee.org.uk; Web Server http://www.iee.org.uk/ gopher.iee.org.uk.

### *The Journal of Cellular Engineering incorporating Molecular Engineering*

The Journal of Cellular Engineering (incorporating Molecular Engineering) is a new journal, designed to reflect the growth in the innovative field of cellular engineering.

Subject areas cover tissue engineering, bioartificial organs, biological materials, biomembranes, cell encapsulation, cell-based biosensors, biointeractions, biomimicry, natural neural networks and cell-energy interactions (mechanical, electrical, electromagnetic, magnetic). Aspects of the fields of genetic engineering, biotechnology and gene therapy are also covered where there is reference to bioengineering.

The journal is published by the International Federation for Medical and Biological Engineering in partnership with Peter Peregrinus Ltd. (PPL) who already produce the IFMBE's *Medical & Biological Engineering & Computing Journal*. The journal will be published quarterly. However, volume 1 will consist of five issues: Issues 1—5 August 1995; Issue 2—February 1996; Issue 3—May 1996; Issue 4—August 1996; and Issue 5—November 1996.

The 1995/1996 subscription rate to volume 1 is non-members: International (excluding the Americas)—£196; Individual members of IFMBE member societies: International (excluding the Americas)—£40; IEE members—£45.

### *Publishing and Information Services from the Institute of Electrical Engineers*

The IEE Web server now contains a host of information on all the products and services of IEE Publishing. Recently, demonstration software which can be downloaded has been added for Electronics Letters Online, and several of the computer-based distance learning courses.

For INSPEC searchers, useful information includes the "Search Corner" and "Subject Spotlight" articles from past INSPEC Matters. Full details are given on INSPEC's Home Page. Now some documentation is available in PDF

format including an INSPEC tapes specification overview, and several Chemical and Numerical Indexing Guides. These may be viewed and downloaded using the Adobe Acrobat™ Reader. The following Chemical and Numerical Indexing Guides are available for downloading:

Numerical Data Indexing Thesaurus
Chemical and Numerical Indexing—(Data-Star)
Chemical and Numerical Indexing—(Dialog)
Chemical and Numerical Indexing—(ESA-IRS)
Chemical and Numerical Indexing—(STN)

URLs for various parts of our Web server:

IEE Publishing & Information Services Home Page:
http://www.iee.org.uk/publish/

INSPEC Home Page:
http://www.iee.org.uk/publish/inspec/inspec.html

INSPEC Chemical and Numerical Indexing Guides:
http://www.iee.org.uk/publish/inspec/inspec.html#cniguide