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# Prospects of research on integrated switching of voice data and video

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# Prospects of research on integrated switching of voice data and video

G. Perucca (*)

*An evolutionary reference architecture for an integrated switching system is proposed. According to the selected approach overall requirements for a fully integrated switching fabric are listed and several advanced switching techniques are analyzed and classified along key parameters. Indications for selection of a promising set of solutions are then given and preliminary results on an advanced switching technique being investigated by CSELT are reported.*

## 1. Introduction

The present generation of stored program fully digital switching systems, integrated for switching and transmission of PCM channels, has already been introduced in service in its early models since more than ten years. With the fast moving pace of technological progress and the evolution from the IDN to the ISDN scenario time should be ripe for a new generation of switching systems, the so called "fourth generation", oriented to integrated switching of voice, data and video communications.

Indeed the feasibility is now being investigated in several telecommunication research laboratories of new advanced switching techniques designed to support in a more integrated way the full range of switching requirements for the new multimedia ISDN services. In particular in Europe activity and interest in this field is now particularly increasing and has recently been significantly stimulated by the launching of RACE [1].

On the other side a strategy of gradual evolution from the present generation to the new generation of switching systems is generally being pursued by the major manifacturers, even by those proposing the most radical advances [2]. The reason for this can be traced down mainly to two key reasons:

— The development effort of a modern switching system is overwhelming, particularly as far as software is concerned, and the technological pressure to innovate stabilized software is minimal.

— The services and feature requirements of a switching system are a fast moving target. In the short term it is thus necessary to postpone new developments in order to fulfill the increasing feature requirements [3]. In the long term the narrowband voice and data ISDN scenario is rapidly evolving to a broadband voice, data and video ISDN scenario.

In the following a possible way out of the above impasse is suggested via a coherent evolutionary scenario of progressive integration of the switching subsystems.

## 2. Evolutionary scenario for the switching system

The more straightforward approach to the evolution of a modern modular switching systems from IDN, to ISDN, to broadband ISDN is based on the addition of specialized functional subsystems. However the ultimate application of this approach would lead to a composite architecture whose evolution toward a more integrated structure would be greatly impaired. Also serious control problems would arise from coordinated handling of multimedia calls originating from a common integrated ISDN access.

A different, more flexible approach is here proposed (Fig. 1) based on a distributed hierarchically layered control structure where high level, service and software oriented control and processing functions can be progressively added, while low level, hardware and real time oriented processing functions can be progressively integrated as they evolve under pressure of technological advances.

(*) Ing. Giovanni Perucca, CSELT, Torino. Paper presented at the RIENA Joint Conference, 33rd International Congress Electronics/26th International Meeting on Space, Roma, March 1986.

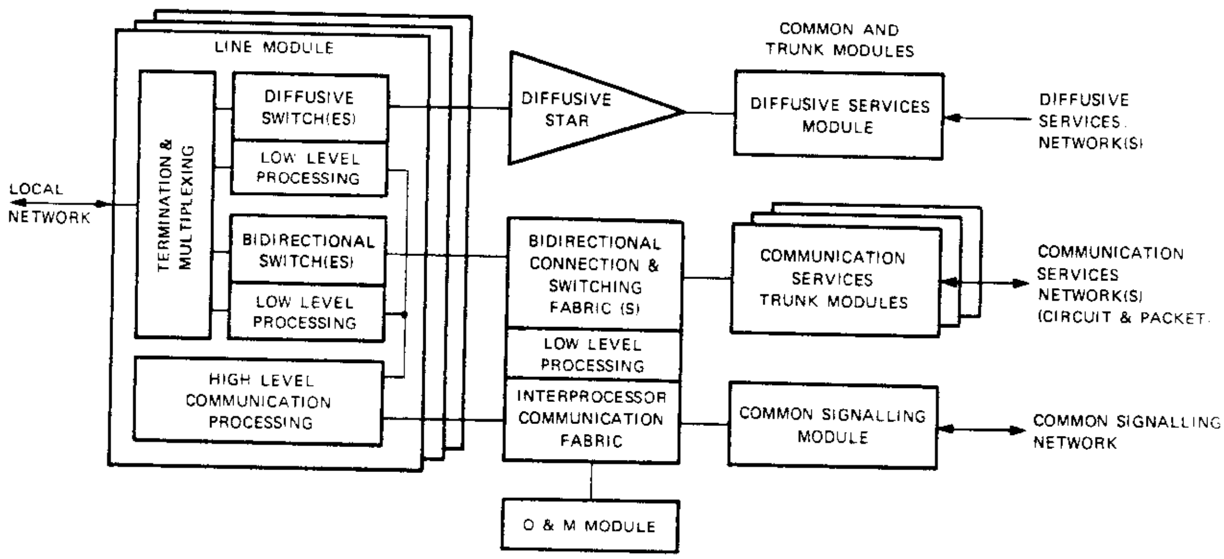


*Fig. 1* - Evolutionary reference model for an integrated voice, data and video switching system.

Operation and maintenance functions are decoupled from high level communication processing functions, which in turn are decoupled from low level communication processing functions, as signalling and low level protocol handling, and from switching and information transport control, down to signal processing and bandwidth compression functions.

The partitioning of the switching functions is based on the services oriented difference between diffusive and bidirectional communication services, usually having different application and traffic characteristics, rather than on the technology oriented differences in bandwidth and burstiness of the communication channels. The monodirectional interactive services are here considered as a subset of the bidirectional services.

The rationale of this model comes from the observation of the so far experienced evolution of practically all existing switching systems. It results that the consistency of the system is based on software, which tends to grow, while the technological pressure for evolution impacts on hardware, which tends to change, mainly in the per line cost sensitive peripheral access layer.

The proposed reference scenario supports progressive migration of functions from common specialized modules at the trunk layer to new releases of more and more integrated line modules at the access layer, as traffic on new services increases. The above migration could even be a geographical one, as switching resources for new services diffuse in an area after initial concentration in a single central office.

According to the latest software technology, new releases of the high level communication processing software in the line module can be simply built by adding the software packages migrating from previous specialized common modules, provided that enough memory and processing capability is available.

TABLE I

Target requirements for an ideal integrated bidirectional switching fabric (orders of magnitude)

| | |
|---|---|
| No. of channels (access layer) | Modular up to $10^6$ |
| No. of channels (connection layer) | Modular up to $10^4$ |
| Total throughput (connection layer) | Modular up to $5 \cdot 10^{10}$ bit/s |
| Instantaneous bandwidth per channel | From 0 to $\sim 5 \cdot 10^7$ bit/s |
| Time averaged bandwidth per channel | From $10^2$ to $\sim 5 \cdot 10^7$ bit/s |
| Burstiness factor | 1 to 100 |
| Switching delay | $10^{-3}$ s |
| Blocking probability | $10^{-4}$ |
| Time transparency capability | Yes |
| Sequence integrity capability | Yes |

A distributed architecture with partition by traffic is thus achieved as a final objective [4].

### 3. Integration of the switching functions

In the proposed reference architecture, integration of the switching functions is a very interesting objective, particularly at the connection layer, as the availability of an integrated multirate and multiservices connection and switching capability would greatly enhance the flexibility of the whole system.

To simplify the problem a separate solution is assumed for the diffusion fabric, which has very heavy traffic and bandwidth requirements and can be implemented at the connection level by means of a star structure.

With this assumption the requirements for an ideal, all integrated switching and connection fabric for voice, data and video are listed in Table I.

These requirements, to be assumed as orders of magnitude, are a combination of the most demanding parameters and condition, such as large sizes, full penetration of narrowband ISDN services, heavy penetration of

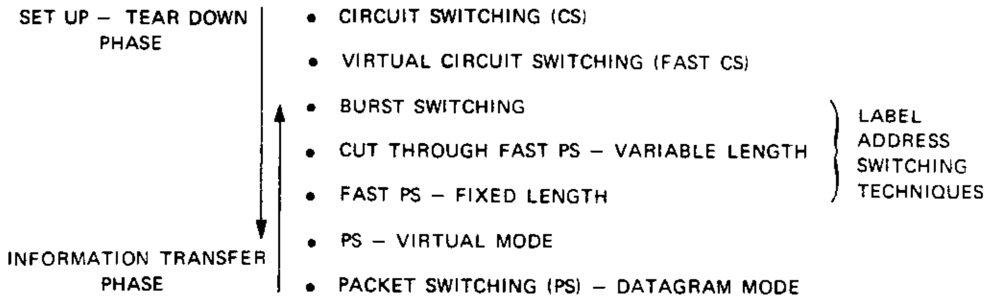


*Fig. 2* - Time allocation of processing resources.

wideband ISDN services (up to 10.000 channels) and low bandwidth compression of the video channels. Therefore a viable scaled-down solution would still be very interesting, with for instance an order of magnitude reduction of some "size" parameters, and no compromise in the "performance" parameters, provided that a strategy for successive modular growth of the system is also available.

Following this approach, it is worth noting that several solutions have already been proposed of potentially growable fully integrated switching fabrics which compare quite satisfactorily with the above scaled down parameters. Moreover laboratory demonstrators with currently available technologies of some of the proposed solutions are now being assembled.

A few indicative examples can be presented among many available.

- A 4.5 Gbit/s voice, data and video demonstrator system with switching delays of less than 10 $\mu s$ is being assembled in Europe by CNET [5].
- A 1.5 Gbit/s, 0.5 ms architecture for vice and data, which will be extended to higher throughputs for voice, data and video applications, has been studied in USA by ATT [6].
- A 5 Gbit/s, 4 ms solution has been proposed in Japan by NEC [7].

Some options are thus already available and it has been noted that they can be seen as a continuum between the traditional circuit switching and packet switching techniques [8]. All of these options are in fact trying to get the best of both worlds, i.e. from circuit switching the low fixed delay and from packet switching the dynamic use of bandwidth [9].

Some of these techniques were initially intended as voice and data integration solutions for narrowband ISDN communications and have been later extended to cope with wider bandwidth requirements of broadband ISDN.

## 4. Analysis of available options

In order to gain a better insight of the options for a full integration of the switching functions it is here proposed to classify and analyze them on the basis of two key parameters: the allocation of the processing resources and the allocation of the transport resources, being the former the layered levels of processing and the latter the connection and switching fabric in the reference model proposed in Fig. 1.

As far as processing resources are concerned, attention is focussed on their allocation in time. Allocation in space can then be performed according to the principle that the less time intensive functions can be integrated in the higher level layers.

Following this approach, the best definition of the basic circuit switching and packet switching modes is the one stating that in circuit switching the processing functions are performed before and after the information transfer phase, i.e. during the set-up and tear-down phases, while in packet switching the same functions are performed mostly during the information transfer phase [10].

The various switching techniques can thus be analyzed by ranking them as in Fig. 2. For example the most advanced circuit switching techniques apply the virtual call concept [11], thus transferring some processing activity from the initial call set-up phase to following simplified "message" set-up and tear-down procedures during the active periods of the information transfer phase. The converse shift of processing activity characterizes the difference between datagram mode packet switching and virtual mode packet switching.

As far as allocation of transport resources is concerned, some preliminary considerations apply. First, the information to be transported and switched between the input and output channels can be seen in its more general form as a set of strings of time synchronous bits [12]. They have random distribution of arrival times, of number of bits and of clock rates with several orders of magnitude of variance, i.e. from a continuous string of bits of over ten Mbit/s to a small number of bits of less than 1 kbit/s. Second, in all the integrated techniques proposed, as they strive for some dynamic allocation of bandwidth, the information to be transported and switched between the input and output channels is presented in some time division multiplexed form.

According to our approach, again the circuit switching and packet switching modes can be seen as two different ways of allocating in time the information to the transport resources: by interleaving or by buffering and queueing.

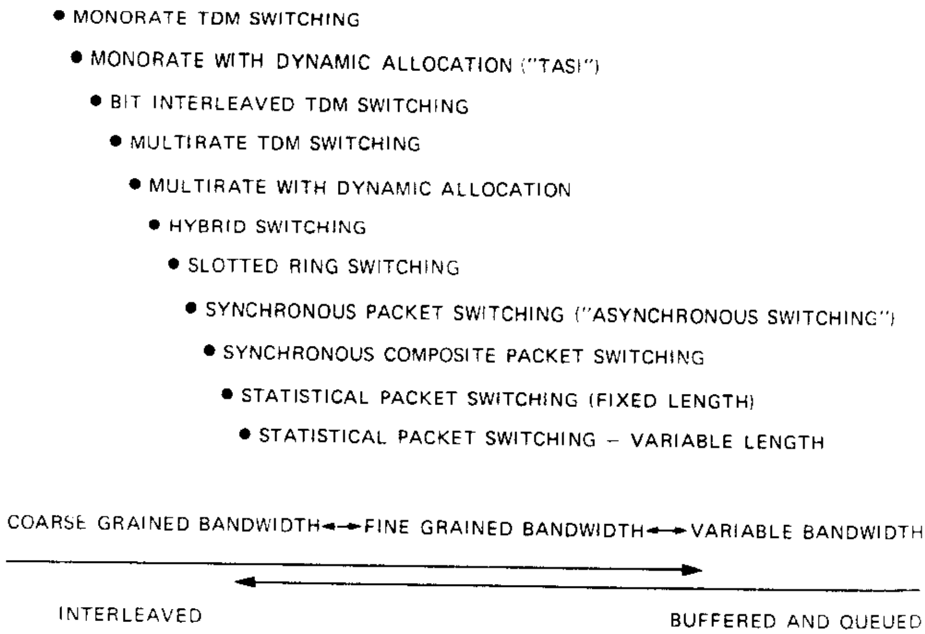


*Fig. 3* - Time allocation of transport resources.

The various switching techniques can thus be ranked as Fig. 3 [13, 14]. We can then assume the two axes of Fig. 2 and Fig. 3 as the vertical and horizontal dimensions of an analysis plane for integrated switching techniques, where all the proposed solutions can be located. In particular, classical TDM circuit switching and packet switching techniques are respectively in the upper left and lower right corners of the plane.

## 5. Preliminary indications for options selection

The above analysis is limited to some aspects of the integration problems, although they are considered among the most significant. Its value is therefore on helping on a first selection of a set of promising options to be further analyzed through performance evaluations and possibly experimental demonstrators.

An interesting result of this analysis is that the techniques located near the middle of the vertical axis, where most reasonably will be found the best compromise for allocation of processing resources, are all label addressed switching techniques.

As far as the horizontal axis is concerned, it should be considered that, according to the so far accumulated experience on digital switching systems, the cost of the switching and connection function is becoming less and less relevant with respect to the cost of the terminating and multiplexing equipment. As a consequence the transport fabric of the switching network should pose no constraints to the way in which input an output channels are organized and multiplexed. This would seem to indicate the right side of the analysis plane for options selection, where most flexible solutions are located.

Conversely, as an evolutionary strategy from ISDN to wideband ISDN is here considered, it is very important that the internal transport mechanism of the switching network be easily interfaced to the first generation ISDN access equipment, where most of the traffic originated will have the standard PCM synchronously interleaved format [15]. This would seem to indicate the left side of the analysis plane for options selection.

An interesting compromise is offered by a particular set of techniques, the ones dividing all types of incoming communications into very short, fixed lenght "micropackets", which are then interleaved whithin a synchronous framed structure.

In this way at the cost of some inefficiency the double advantage is obtained of very short packetizing delays, and of easy adaptability to the synchronously framed world of first generation ISDN.

To the above indications for option selection, other should be added, particularly as regards protocols to handle the low level processing, architectural aspects, such as parallelism for very high throughput capability at acceptable speeds, and suitability to partitioning into a minimum number of VLSI integrated building blocks.

Finally an additional consideration, usually overlooked, is synergism with computer science research and likely fallout from the extremely vast amount of research investment poured in this field all over the world by private companies and public institutions.

Indeed the key problem of fifth generation computer architectures is parallel processing, and this in turn involves the problem of the interprocessor communication fabric having the basic function of addressed, i.e. switched, delivery of messages among hundredths of processors.

It is very interesting to note that, due to the very short transfer times required, the total throughput requested to the interprocessor network can be of the order of more

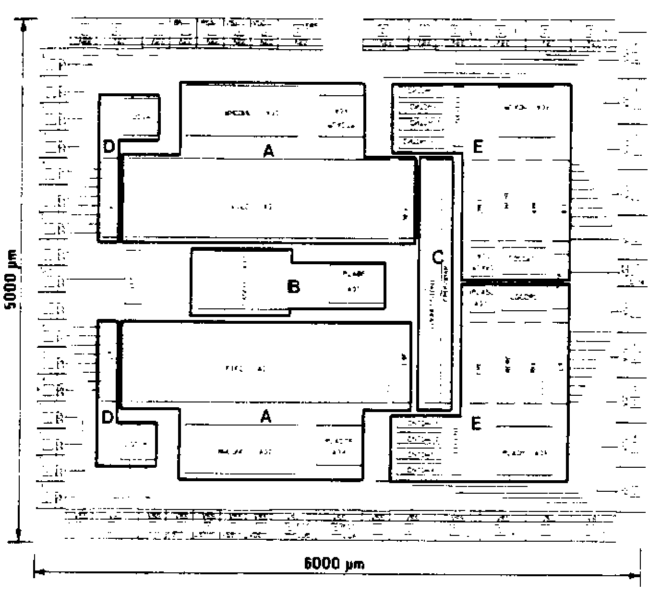


*Fig. 4* - Chip layout of the switching element.

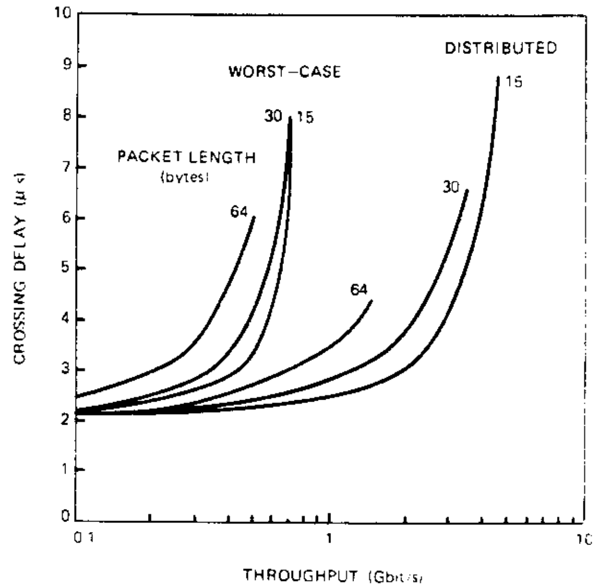


*Fig. 5* - Performance evaluation (function of packet lenght in bytes).

than 10 Gbit/s and that one of the examples previously reported [6] uses exactly the same type of switching fabric, a Banyan self-routing network, as do some advanced fifth generation computer projects [16].

## 6. Prospects of research at CSELT

According to the above considerations a research activity is being carried on by CSELT to evaluate a specific set of advanced switching techniques, based on the label addressed, fast cut-through approach with short, fixed lenght packets, implemented using banyan self-routing networks.

The evaluation results will be compared with the ones already gained by CSELT on multirate TDM circuit switching techniques [17] and on hybrid switching techniques, the last being now utilized in an advanced Local Area Network application [18].

Analysis on the new switching techniques is being carried on along two main lines: performance evaluations by simulation of several design options and assembly of a flexible laboratory demonstrator.

The demonstrator is intended as an experimentation tool aimed to give a better insight of the complex relationships among different aspects, like protocols processing, traffic characteristics and implementation parameters, as physical partitioning, wiring and diagnostics. Main characteristics of the demonstrator are listed in Table II.

Its basic building block is the Switching Element (SE), being now developed as an integrated chip by CSELT, with SGS technology, both for demonstration of switching techniques and of parallel processing architectures.

Chip layout of the switching element is shown in Fig. 4.

It can be easily seen that most of the area is used up by the input buffers (A) and by the input-output control logic (D, E), while the 2 × 2 crossbar switch and its control logic are very simple (B, C).

TABLE II
CSELT demonstrator

| *Switching fabric* | *Switching element* |
|---|---|
| Banyan delta topology | Hcmos technology |
| 7 stage structure (128 I/O) | 23,000 transistors |
| 80 Mbit/s per link | Byte-wide parallelism |
| Variable packet lenght | 100 ns byte transfer time |
| Hands-shake port protocol | 64 bytes buffer |
| Alternate priority cut-through | Activable diagnostics (CRC) |

As far as performance evaluations by simulation is concerned, Fig. 5, shows that, even with the initial technology of the demonstrator, this switching technique would easily accomodate the throughtput requirements for a broadband ISDN scenario with voice, data and compressed video communication services (video conference compression standards).

Further research is needed to accomodate a broadband ISDN integration scenario with higher bandwidth (> 10Mbit/s) bidirectional video communication channels, as worst case traffic patterns could inpair network throughtput.

## 7. Conclusions

A gradual strategy of evolution to broadband ISDN is possible, which could take advantage of highly integrated voice-data and video switching functions.

A first analysis of several possible integrated switching techniques has been performed and detailed evaluation is being carried on by CSELT for a particular set of advanced solutions.

Preliminary results are very promising.

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