A high-throughput interconnection structure

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ABSTRACT

Today, high-throughput interconnection structure (HTIS) is a concept. This paper surveys the properties that HTIS should satisfy and proposes a new architecture that satisfies some of the HTIS requirements. We describe the topology, the access method, and the logical structure of our experimental network. This network is a part of a project called ESCALIBUR, in which both interconnection architectures and distributed applications are studied. The network architecture presented here is mainly oriented toward local and bus networks but may be extended long-haul networks.
INTRODUCTION

The high-throughput interconnection structure (HTIS) can be defined as a digital telecommunications local network capable of supporting a wide spectrum of user needs that require high capacity. Today, such a network exists as a concept; an actual HTIS system has yet to be physically created and its architecture clearly defined. To satisfy the user's needs, the throughput must be very high. In Figure 1 we give the classical digital throughput for certain services. This figure shows the complex problem of simultaneously satisfying a wide variety of services.

![Figure 1: Mean bandwidth required for certain services](image)

In this paper we give some new ideas on a possible architecture for HTIS. Then we present a project called ESCALIBUR, an example of a real experience in the area of future networks.

SERVICES AND ARCHITECTURE

Three very different services should coexist in a high-throughput interconnection structure: a telephone network, a video network, and a computer bus. Table I characterizes some of the differences of these networks. The problem is to know what sort of architecture is to be chosen. Some partial responses exist: The baseband local network is capable of supporting a data communications channel and a very limited number of telephone channels (response time and asynchronous characteristics of these networks are contradictory to a synchronous real-time digital service). The broadband local network provides a communication backbone that can accommodate application. But the words digital and integrated are not satisfied. CATV technology currently gives the best possibilities. For example, the MITRE coaxial cable LAN has been in operation since 1979. It provides the following services:

1. Twelve video channels
2. One FM radio channel
3. Voice communication
4. One time-division multiple access data bus

Another response to HTIS is the private automatic branch exchanges (PABX): telephone network and limited computer channels. PABX can support between 64 Kbits/sec and 72 Kbits/sec of channel capacity per user.

In these examples, HTIS concepts are not fully satisfied. However, local HTIS can be looked upon as an extension of a broadband local network and a baseband local network. By the mid-1980s, the HTIS will include circuit-switched, packet-switched, and nonswitched capabilities. These three sets of capabilities are interrelated. In some special cases, they may share common facilities and equipment, but the capabilities are interconnected. Essential characteristics of the architectures of the mid-1980s will include digital transmission through a packet-switched network.

The difficulty of integration comes from the necessity of knowing application characteristics. This may lead to networks having sufficient intelligence to determine whether the customer's information should be packet or circuit switched.

A NEW ARCHITECTURAL CONCEPT

To allow a superposition of telephone, video, and data transfers, a new communication concept would provide the main following characteristics:

1. A medium supporting 1 Gbit/sec.
2. An access to the shared medium allowing real-time communication. For example, a carrier sense multiple-access scheme does not permit realistic telephone traffic.
3. Error detection depending on the customer's information.
4. High-throughput output interfaces.

A project shared by the Institut de Programmation of the Université Pierre et Marie Curie and the Ecole Nationale...
Superieure des Telecommunications in Paris is beginning to analyze and experiment with a new concept of HTIS. This project is called ESCALIBUR.

The communication medium comprises $N$ parallel channels. In a first approach $N$ is equal to 64 parallel lines. The capacity of each line is 1 Mbit/sec. This involves a relatively simple technology. Since the first approach uses telephone cables, the future use of fiber optics will allow us to choose speedier lines and a larger network.

An important part of this work is to optimize the number of parallel channels and the capacity of each line to reach the 1-Gbit/sec bandwidth.

The new concept provided by ESCALIBUR concerns frame transport. A frame is carried in parallel over the network. The frame structure is classical and comes from the HDLC standard protocol. Two kinds of frames will be used; they are shown in Figure 2.

I frames are used for asynchronous information transfer with strong error detection and correction. UI frames can transport asynchronous and synchronous traffic with no error correction (e.g., telephone or video traffic).

Our switching technique is a new one for a local network architecture. It is only an extension of bus principles, however, but is connected with the two first levels of ISO architecture. This switching technique involves a simple access logic to the communication medium. It avoids collisions and allows for a completely decentralized management.

The topology adopted is a ring with a "garbage" unit to avoid problems with erroneous frames running around the network indefinitely. The access method is based on the following two main ideas:

1. We use an extension of the register insertion protocol.
2. A frame is only carried away by its emitter (or by the garbage unit if some error occurred).

The access logic is shown in Figure 3. Access is obtained through five registers to guarantee the absence of collision. Let us describe the three possibilities:

1. Introduction of a frame contained in the sender buffer $R_5$. This is possible only if registers $R_2$, $R_3$, and $R_1$ are free. Nevertheless, the communicator cannot send a frame.
2. Passage of a frame. When register $R_1$ receives a frame, a decoder looks at the receiver address field. If the address is not the address of the communicator, the frame is copied on register $R_2$ or $R_3$, depending on the occupancy of these registers. If the sender address field is the address of the communicator, the frame is destroyed in register $R_1$.
3. Reception of a frame. If the decoded address is the address of the communicator, the frame is copied on the receiver buffer $R_4$ (and also in $R_3$ or $R_2$ if necessary).

This access logic guarantees a finite transmission delay for a frame ready in $R_5$.

The ESCALIBUR project aims to propose a new network able to replace both PABX and the baseband local network. If the second characteristic is satisfied, the first one is more difficult to achieve. In effect, we have chosen an internal packet switching following the X25 packet format to make interconnection with public network easier. Packet switching is not appropriate for digitized telephone speech: The voice is converted into a digital signal by means of pulse-code modulation. This technique requires synchronizations, which are generally incompatible with packet switching. As an illustration we can point to the difficulty of integrating digitized telephone voices on the Ethernet network. For a 10-Mbits/sec local network only 10 or so voice channels can be easily supported. In the ESCALIBUR network a circuit switch possibility is mixed with the packet switch, thanks to the station's capacity to recover empty frames regularly. However, to keep the network asynchronous and to avoid the use of a main station to manage the network, this empty frame can deliver...
a high-throughput channel (which is larger than a PCM channel but is used either for voice traffic or for data traffic). This possibility, along with a correct buffering system (placed in each node to avoid echo problems), is the reason why synchronous traffic can be transported through ESCALIBUR.

CONCLUSION

For future high-throughput interconnection structure, it is necessary to develop other new concepts and to make major changes in the architecture and capabilities of data communications equipment. A most important element of change will be that users will have a workstation at their desks with a digital phone, a keyboard, and a graphic screen. This necessitates obtaining very high throughput not only for local but also for long-haul networks. Our objective with the ESCALIBUR project is to propose a solution for local HTIS networks. But with the development of fiber optic cables,15 our solution can be considered feasible for networks of 50 km.

The problem of a network's determining whether the customer's information should be packet or circuit switched has still to be solved. This facility is contradictory to ISO 7-level architecture: Level 2 should know the parameters of level 7. No satisfactory solution has yet been provided.

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