BROADBAND ISDN AND HS-LANs

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Abstract: The third generation of LANs should reach the Gbit/s range. Moreover, the integration of different types of traffic on the same medium will impose constraints in terms of throughput, delay, delay dispersion, reliability and sequenced delivery. The third generation should take all of these constraints into account. In the same time, high-speed telecommunication technology is emerging through Broadband ISDNs (Integrated Services Digital Networks). The standardization of B-ISDN follows the ATM principle (Asynchronous Transfer Mode) chosen by the CCITT Study Group XVIII.

The purpose of this paper is to give some ideas of expected evolution in the field of Broadband ISDN and High Speed LANs.

1 - Introduction

An architecture for digital network service integration must support a wide spectrum of user needs. We give in Table 1 some classical digital throughputs for several services.

Alarm/Security System	4 bit/s
Computer terminal applications	256 bit/s
Digitized telephone speech	16 Kbit/s-64 Kbit/s
S_0 interface	144 Kbit/s
S_1 interface	1536 Kbit/s
S_2 interface or picture phone	2 Mbit/s
File mass transfer	10 Mbit/s-80 Mbit/s
Interprocessor bus	16 Mbit/s-100 Mbit/s
Color television	34 Mbit/s
FDDI interconnection	100 Mbit/s
Very high quality video service	512 Mbit/s

Table 1. - Throughput of some classical sources

The computer communication world is evolving towards high-bandwidth. This for the support of different services: graphical visualization, I/O channel access, military command and control application, broadband ISDN connection,.... For I/O access the speed of the channel is increasing very quickly. It exists now an ANSI standard at 800 Mbit/s: the HSC

(High Speed Channel). This channel has been adopted by IBM (HSC channel), Cray (HSX channel)... With the arrival of powerful processors (Intel 860 or Motorola 88000) the workstations should access the servers at a speed of 2 to 10 Mbit/s. Therefore, several workstations working together will ask for a high throughput.

A very high capacity local network could be used as a backbone network to connect smaller networks in a building environment, which is characterized by workstations, servers, mainframes, etc. This network should provide a high data rate for computer intensive applications, such as computer-aided design equipments, graphics or imaging machines or mainframes. It should also take into account digitized voices, picture phones and more generally ISDN interfaces S_0, S_1, S_2.

It seems clear that the third generation should reach the Gbit/s range. However different types of traffic may impose constraints in terms of throughput, delay, delay dispersion, reliability and sequenced delivery. The third generation should take all of these constraints into account. (First generation is well represented by Ethernet and Token Ring. The second generation provides a 100 Mbit/s range as a capacity. FDDI LAN is a good example of such a network).

The critical research issues for this third generation are numerous.

• First of all the MAC (Medium Access Control) should be addressed. The access control has to be flexible to provide all kinds of services.

• High-speed transfer protocols. The OSI protocols has been developed to provide an architecture for general purposes low speed networks. It is necessary to rethink of the different levels and all the protocols. In particular it is necessary to develop a new transport protocol. Now, the direction is on special purpose transport protocol as UDP (User Datagram Protocol), RDP (Reliable Datagram Protocol), LDP (Loader/Debugger Protocol), NETBLT (High-speed Block Transfer Protocol), NVP (Network Voice Protocol), PVP (Packet Video Protocol), CMTP (Versatile Message Transaction Protocol),...

• Flow control. At 1 Gbit/s, the number of outstanding frames will be several hundred or several thousand and the flow control should be very strict.

In the same time, in the WAN field, is emerging high-speed telecommunications technologies through Broadband ISDN (Integrated Services Data Network). This network is conceived as an all-purpose digital network. The standardization of B-ISDN is running and we know the structure of the internal network. It should follow the ATM principle (Asynchronous Transfer Mode) chosen by the CCITT Study Group XVIII. Recommendation I.121 describes the ATM technique. It is a cell switching. Fig. 2 describes the cell structure adopted by CCITT on June 1989.

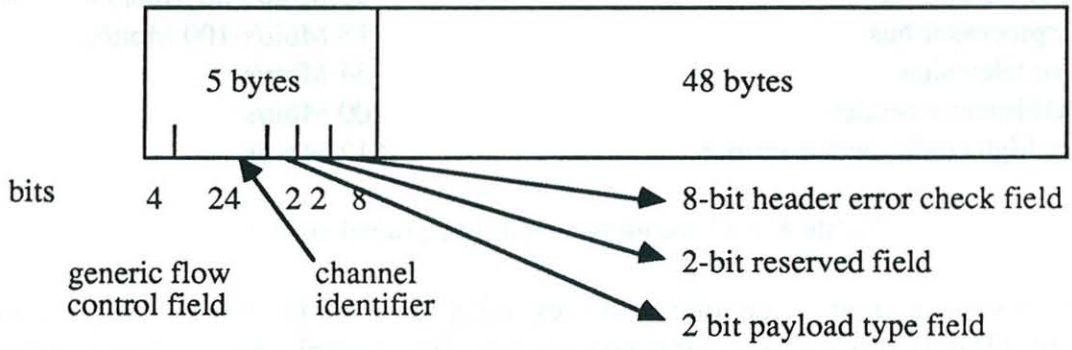

Figure 2. - The ATM cell

In the header we have:

• 4-bit for the control of multi-access sources;

• 24-bit label with up to 12 bits for VPI (Virtual Path Identifier) and 12 to 16 bits for VCI (Virtual Channel Identifier);
• 2-bit payload type field;
• 2-bit reserved field;
• 8-bit header check field.

2 - Examples of high speed LANs

A lot of solutions have been proposed in the literature. We just give some well known possibilities. A first solution is given by the FDDI ring LAN (Fiber Distributed Data Interface) [1] [2]. The FDDI ring is specified by the ANSI (American National Standards Institute) committee as the standard for a 100 Mbit/s LAN. It will use fiber optic cable. The FDDI ring is a combination of two independent counter-rotating rings, each running at a 100 Mbit/s data rate. If both rings operate simultaneously, the effective throughput is 200 Mbit/s. It is also possible to have configurations where one ring connects all the nodes, with the second counter-rotating ring connecting only a few selected nodes.

The FDDI LAN is designed to allow links of a least 2 km in length between adjacent nodes, with no optical bypasses on either end. The stations are serially connected by a transmission medium to form a closed loop. The packets are transmitted sequentially from one station to the next, where they are regenerated and retimed before they are passed on to the following station. The stations not participating in data transmission can either be bypassed or function as active repeaters. The addressed station copies the packet as it passes. Finally, the station that transmitted the packet strips the packet off the ring. A station gains the right to transmit when it has the token, a special packet that circulates on the ring behind the last transmitted packet. A station that wishes to transmit, captures the token, puts its packet on the ring, and then issues a new token, which the next station can capture for its transmission.

The exact access scheme is called timed token access; it allows each node a fair share of access to the network while maintaining an upper limit on the token rotation time. The token rotation time determines how often the nodes get an opportunity to transmit. In order to satisfy the requirements of various applications, a node must know two things:
• the maximum latency before the token returns again to the given node;
• the amount of traffic that the node can send once the token returns.

The FDDI protocol allows the node to determine both these parameters through a negotiation protocol.

A node can negotiate a synchronous throughput and every time the token is received a synchronous packet is sent. The leftover bandwidth supports the asynchronous communications. This bandwidth is shared by all the asynchronous nodes. The asynchronous packets can have eight possible priorities which are determined by a threshold time value.

When several customers ask for high capacity channels with synchronization constraints on the signals (isochronous possibility), FDDI 1 is not an acceptable solution. FDDI 2 could be a good solution but token ring at very high speed seems inacceptable.

Other project are quite similar to the FDDI LAN. We just list some of these projects. The Lion ring project [3] [10] [11] of the ESPRIT program, an European research program. The access scheme is quite similar using also a daisy chain token ring capability. The fiber optic cable ring operates at a 500 Mbit/s rate through an AsGa technology. An integrated circuit and packet approach, so-called hybrid switching, is adopted. The activity on the digital channel is organized in periodic frames of constant length. Each frame is split into two regions, the first field for circuit-switched traffic and the second one for packet-switched communications.

If the last packet round is not completed before the frame end, it will be resumed in the next frame from the station previously interrupted. The boundary between the two regions is not fixed in advance but moves to follow the actual demand for circuit-switched channels. As a consequence, packet traffic uses only the residual capacity.

The length of a slot assigned to a circuit-switched communications has a duration proportional to the service bit rate designated by user. It can be either kept fixed for the entire call duration or changed dynamically frame by frame. The later scheme is well-suited to services with instantaneous bandwidth fluctuation, such as compressed digital voice and compressed video.

Another example of high capacity local network is Express-Net [4] [5]. The Express-Net is a unidirectional broadcast system with a round-robin type access scheme. The system is consisting of two channels: the outbound channel which all users access in order to transmit, and the inbound channel which users access in order to read the transmitted information. In addition to the transmitting capability on the outbound channel, users can sense activity on that channel in a way similar to that required in other channel sensing systems such as CSMA.

The algorithm uses the End of Carrier on the outbound channel. The mechanism used in determining access right to users in a given round is made independent of the propagation delay, decreasing the gaps between consecutive transmissions to values on the same order of magnitude as the time needed to detect carrier. Moreover, the idle time separating two consecutive rounds is kept as small as a round-trip propagation delay.

In more detail, it is assumed that stations are numbered sequentially following the direction of the traffic flow on the outbound channel. A station which senses the outbound channel busy, waits for the End of Carrier. Simultaneously, it sends carrier on the outbound channel. If carrier is detected, the station immediately aborts its transmission. Otherwise, it completes its transmission. All ready stations, which detect the End of Carrier, act as described above. The only station to complete transmission is the one with the lowest index, among those ready stations which were able to detect the End of Carrier.

Another example of very high throughput LAN is provided by BWN (Backbone Wideband Network), an ESPRIT project of the CEC [12] [13]. The basic characteristics of this LAN are the topology for a broad site environment (25 km), a raw throughput of 167 Mbit/s and a daisy chain token access method. The BWN is a ring with a token but without any priority mechanism in such a way that the release of the token takes place as soon as the station owing the token has completed its transmission. The BWN physical layer is a single fibre optic ring and the reliability of this ring is obtained through a double redundancy scheme at every node.

Many others high bit rate LAN could be examined but they seem quite similar to the previous examples: LAN-DTH [14], Orwell Ring [15]... see also [17] and [18].

All these projects or proposals are limited in speed (100 Mbit/s to 150 Mbit/s). They have a lot of drawbacks: synchronization problems, dependance on the other nodes.... If one node is out of order, the algorithms must be changed to take into account this fact. When a new station is connected, again it is necessary to change several parameters. When several hundred nodes are connected to the medium, the number of problems increases rapidly.

Another important proposal for a high speed MAN standard comes from the DQDB network (Distributed Queue Dual Bus). This DQDB [16] network is now a proposal for Metropolitan Area Networks adopted by the IEEE 802.6 committee. DQDB is intended to conform with the cell structure of ATM.

This network is inspired by the Fastnet network [7] using a dual bus architecture. Every node can communicate to every other node by sending information on A or B bus depending upon the situation of the receiving station. The frame generators send fixed length slots with a deterministic number of slots. The frame is sent each 125 microseconds to cope with the digitized voices. For synchronized data, a reservation scheme is used to take into account the regularity of the packets to be sent.

For asynchronous streams, a very smart technique is performed. Each station keeps in memory the current state of the number of packets awaiting access. This counter (the request count) cancels one request for each empty slot going through the station in one direction (for example downstream) and add one request for each slot with the specific bit "request control" indicating that a node has a packet waiting for a transmission. The "request control" bit is the second bit of the slot and are going from downstream to upstream. The first bit is the "busy bit" indicating that the slot is filled with data.

When the "request counter" indicates zero, the station can send an asynchronous packet in the first slot with the "busy bit" to zero. This situation indicates that the downstream stations do not need empty slots.

3- Structures of a Gbit/s network

If we are looking at a general network, a first proposal is given by the Bellcore Schitched Multimegabit Digital Service (SMDS), a proposed public data communications service in the U.S., scheduled to start in 1992. An example of such a network is shown in Fig. 3.

In this proposal, DQDB (IEEE 802.6 MAN) is chosen as the Man Switching System (MSS), for use as the subscriber network interface. The terminal equipment is connected on the MSS through a LAN or/and a private MAN. The main difficulty in such a global network is to reach the quality of service necessary for the application. If we are concerned by a digital telephone voice connection, the propagation delay between the two terminal equipments should stay under 27 ms. It is obvious that if we use a FDDI 1 network as a LAN or a MAN, this quality of service cannot be reached.

Let us note that if the data have to go through an ATM network, the receiver MSS must support asynchronous traffic. Therefore, the global network as shown in Fig.4 has to be asymmetrical to take into account this characteristic.

The first question could be: why to use the isochronous part of a DQDB network as soon as frames have to go through an ATM network. The best way to provide end-to-end transport facility is to use an asynchonous cell switching all along the network. Therefore it turns out that all the digital networks we have to go through should be asynchronous cell switching networks.

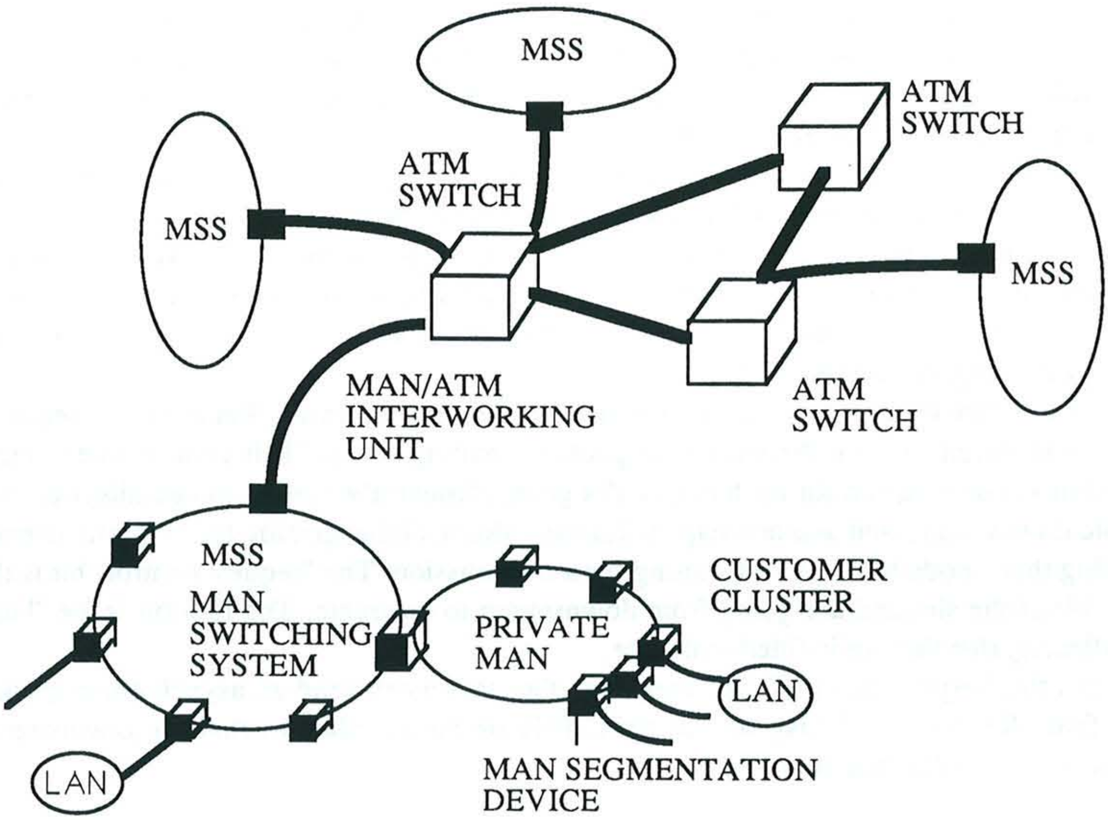

Figure 3. - Schitched Multimegabit Digital Service (SMDS)

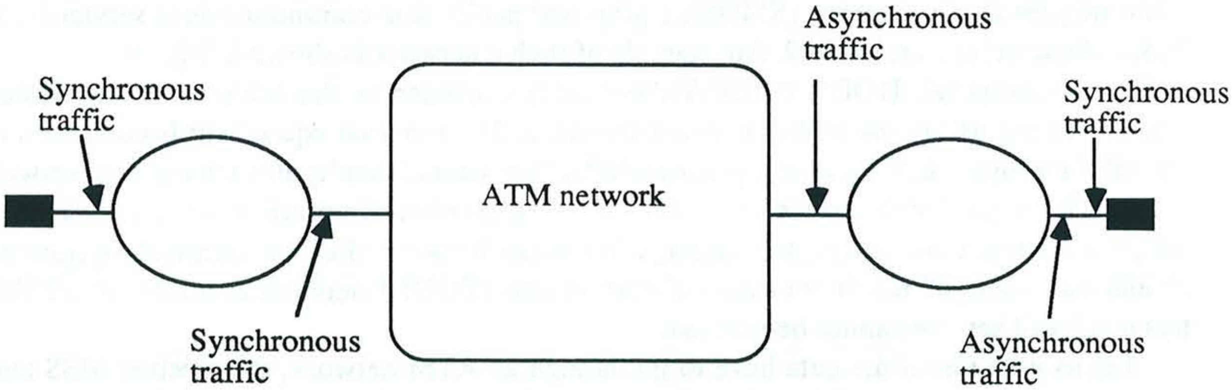

Figure 4. - A non symmetrical global network for a end-to-end synchronous traffic

The second question could be: is it possible to keep the propagation delay inside a 27 ms period. To answer this question, we develop a very simple mathematical model. Let us assume an ATM network with 1 Gbit/s as the capacity of the links. Due to the law of large numbers, the interarrival times are Poisson distributed. As the length of the frames is 53 bytes, the service time is constant. Therefore, on the average, the time to go through the switches is less than 4 µs if the traffic rate is less than 0.9. We can choose a value of 10 µs to go through an ATM switch. This is negligeable in comparison with the propagation delay. The propagation delay on the medium for a 1000 km distance is 4 ms approximately.

If we are considering a voice traffic, the time to provide and to deliver the 48 bytes is 12 ms (6ms+6ms). For a 3000 km distance between the two terminal equipments, 24 ms are absolutely necessary. If 10 switches have to be crossed, the time spent in these switches is 1ms. Then, the total time is now 25 ms. As the maximum time is 27 ms, it is not possible to wait for a long period of time the access instant to a MAN or a LAN. If the LAN is an Ethernet, a Token Ring, a FDDI 1 or FDDI 2 network, the problem has no solution. If we consider DQDB, at the receiver MSS the asynchonous traffic cannot handle such a constraints.

4- Conclusion

The field of LANs is evolving very quickly. It is clear now, that the Gbit/s range must be reached in a small period of time. The total number of projects dealing with this capacity is more than twenty. It seems reasonable to have products in the 1Gbit/s range in five years from now.

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