Goals in allocation of resources in high bandwidth networks

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Abstract: *The main aim of B-ISDN (Broadband Integrated Services Digital Networks) is to achieve a complete integration of service, from the traditional ones to the new broadband services, which are at the moment available singularly on private networks, being thus expensive, due to the inefficient use of resources. B-ISDN has to keep into account the different characteristics of each service and provide the user with a unique interface, independent of the kind of service requested. Furthermore, network management has to be kept hidden to the user.*

Keywords: *B-ISDN, ATM, WDM, QoS, virtual channel and virtual path.*

Introduction

Fiber optic media has lead in the design of computer and video networks using an international standard named B-ISDN (Broadband Integrated Services Digital Networks), which has been approved by the ITU (International Telecomunications Union) in 1988. In this case normal data transmissions, audio (telephone) and video (video on demand, video conferencing) are transfered using the same digital networks.
ITU-T (Telecommunications standardization sector) defined as broadband service requiring a bandwidth, exceeding 64 Kbps. Communications based on these services are called broadband communications.
Broadband services include:

- LAN (Local Area Network) interconnection: the number of local area networks based on the different IEEE protocols is growing at an increasing rate;
- image processing: from remote image viewing, medical and scientific applications to document management;
- multimedia applications such as: text, image (static or in movement) and voice;

These applications require the transmission of very large amounts of data.

- CAD (Computer Aided Design) applications used for data processing and simulations using a supercomputer. In this case the bottleneck can be the communication channel which exchanged data. These applications require powerful hardware and software (and very expensive) and high bandwidth networks.

Transmission in B-ISDN

Optical fibers allow the realization of Local to Wide Area Networks, while providing very high transmission rates, exceeding those that can be guaranteed by traditional electronic technology by several orders of magnitude.
Optic fibers have been chosen as transmission for B-ISDN. For example, optical fiber transmission also achieves very low bit error rate when compared to that based on copper-wire, typically 10^{-9} compared to 10^{-5}. [4]
Standardization have worked to a uniform transmission interface. This has brought to the definition of two standards: SONET (Synchronous Optical NETwork) and SDH (Synchronous Digital Hierarchy). The former has been developped in the USA and Canada, the latter in Europe. Both are based on the Time Divission Multiplexing (TDM) technique. I'll not insist into details here, instead, I'll present a novel technique for optical transmissions called WDM (Wavelength Division Multiplexing) that is under development and that seems very promising. [4], [5], [6]
WDM allows the concurrent transmission of multiple data streams on the same optic fiber, subject to the constraint that different data streams use different wavelengths

when using the same optical link at the same time and in the same direction.
WDM networks can either be switchless or switched (reconfigurable). The signal is broadcasted from each station to all other stations in the network.
At the receiver's end, the desired signal is extracted according to its wavelength. Switchless networks suffer severe limitations and are not suited to extension to Wide Area Networks. Such switches can differentiate between several different wavelengths entering the switch along a communication link and direct them of different output ports, but without modulating them; thus, the wavelength associated to a particular signal remains the same as the signal crosses a switch (photonic).
In a switched network that contains only photonic switches each signal has a unique wavelength from source to destination; this is an all-optical or single-hop network.
When one or more nodes of the network can perform opto-electronic conversions, then the wavelength of a signal can change along its path from source to destination and the network is termed multi-hop. Multi-hop networks suffer higher delays, but can be useful in some situations, since they allow a major wavelength reuse. [7]
The high speeds achievable with all-optical networks mainly derive from the fact that the signal is kept in optical form throughout its transmission from source to destination. Since there is no opto-electronic conversion, switching is performed directly on the optical signal.
Intuitively, different communication sessions (data streams on different wavelength) can be seen as light rays of different colors. An important limitation is that the number of available wavelength is relatively small (at most 30-40 in experimental settings).

Switching techniques and circuit switching

Two main switching techniques are available in nowdays network: circuit switching and packet switching.
In the former, on arrival of a connection request between two end-users a dedicated circuit (i.e. a path from source to destination in the network) is allocated to the call, if available. This system is typical, for instance, of telephone network.
The latter method is more recent and is by far the most diffused. The data to be transmitted is split into smaller parts, called packets. Each packet is added the necessary information identifying its source and destination and is then sent. Packets reach their destinations independently of each other, without necessarily being delivered in the same order as they were sent.
There are two variants of circuit switching: datagram and virtual circuit.
The former is packet switching as above defined.
The latter, in a way simulates circuit switching, since packets are delivered the same order as they were sent, in a way that is transparent to the user.

Bandwidth allocation

The network must therefore be designed according to the kind of services it is supposed to provide. Some broadband services require guaranteed bandwidth continuously. This means thet, while simultaneous access to the network must be possible to the largest possible number of users, the network must guarantee them (or a subset of them) the required amount of bandwidth, from start to end of their connections, even if they don't use the requested bandwidth all the time. Their must be a control mechanism to ensure that no user, while transmitting, exceeds the requested bandwidth. New connections are possible only when all resources necessary for them are available.

ATM (Asynchronous Transfer Mode)

ATM is the most common network protocol under consideration for the very fast B-ISDN.
ATM is a switching protocol that was explicitely designed to meet the requirements

of B-ISDN and to make up for the gap existing between the high bandwidth capabilities of nowdays transmission means (such as optical fibers) and the switching speeds achievable in conventional networks.

The idea at the base of this protocol is that, in delivering a packet, switching should be simple and performed in a hardware (therefore fast) fashion at most of the nodes traversed by the packet, requiring more complicated processing (involving software) only at a (possibly) small subset of them.

The term asynchronous derives from the fact that data transmission between two terminals is independent of their internal clocks, the speed is automatically adapted to that of the slower one.

In ATM data is transmitted in small packets of fixed size, called cells, to each of which a small header is added, containing the information identifying the packet and its destination. Each cell contains 48 bytes of information and 5 bytes for the header. This choice represents a good trade-off between two drawbacks: long packets mean long delays, while short packets mean unfavourable ratio between the sizes of data and header in the packet.

In ATM data is carried after establishing a point-to-point connection between the end users that wish to communicate. All packets into which the data to be transmitted is split are transferred using this connection.

The ATM transport layer is organized as a two levels hierarchy that makes it independent of the physical transmission means and that uses the concepts of virtual channel (VC) and virtual path (VP). in order to route cells, each node in the network contains two routing tables, called: virtual path table and virtual channel table.

A virtual network is built upon an underlying physical network, as shown in the figure 1.

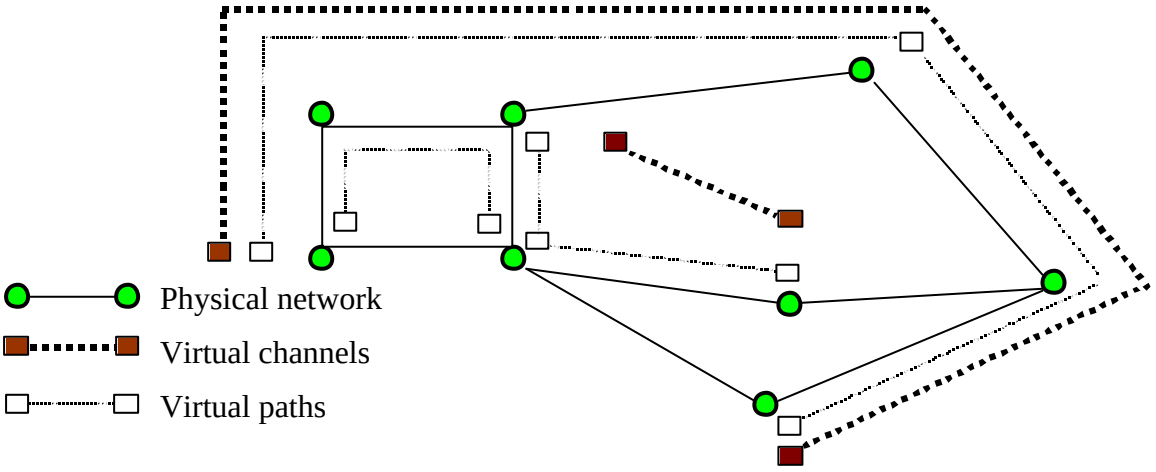

Fig.1. Example of virtual path layout

Virtual paths are simple paths in the network, while virtual channels are obtained from the concatenation of a certain number of virtual paths, so that esch of them may link together several virtual channels sharing parts of their routes.

Ouality of service (QoS)

I describe this concept more in detail. The definition saying that the quality of a given service in a B-ISDN network is acceptable when the network can provide it continously and satisfying the minimal requirements for that kind of service and for the user's needs.

The fundamental issues concern the quality of service:

1. Performance: this concerns the quality of a connection of a given service and can be negotiated between the user and the

network manager, through the specification of some parameters such as the bandwidth, the maximum delay, the throughput, etc.
Even when no performance is negotiated, the minimum QoS for the requested service has to be guaranteed.
2. Priority: this concerns the definition of different classes of service, according to which users are allowed access to the network. Two policies are used in the first the network reserves resources, even if they are apparently available. With the second policy instead, lower classes may not use these resources, even if they are apparently available. With the second policy instead, lower classes services may be preempted from higher class ones. This may cause lower class connections to be interrupted. More about QoS can be found in [2].

Conclusions

As to network management for efficient allocation of resources, the following goals are the most important:
- maximize the efficiency in resource management and the quality of service has to be guaranteed to users (see in this paper the concept of quality of service);
- efficiently manage situations of high congestion using the optimal algorithms;
- construct a robust network, that recovers from faults in the shortest possible time.

A low hop-count means low packet delivery delays and corresponds to a better quality of service.
Quality of service and bandwidth allocation represent two main issues that exist in high bandwidth network management.

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