BOHR Journal of Computational Intelligence
and Communication Network
2023, Vol. 1, No. 1, pp. 47–53
DOI: 10.54646/bjcicn.2023.08
www.bohrpub.com

REVIEW

# The strategic analysis and operation of the multiservice model used for synchronous transmission in communication networks

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**Received:** 05 June 2023; **Accepted:** 16 June 2023; **Published:** 30 June 2023

The core idea of asynchronous transfer mode (ATM) technology was revealed a long time ago. The main technology under development at the time was time-division multiplexing (TDM) technology, which consisted of synchronous switching based on the sequence number of bytes in the integrated frame. The main disadvantage of TDM technology, also known as synchronous transport module (STM) synchronous transmission technology, is the inability to reallocate the bandwidth of the integrated channel between subchannels. During those periods when no user data is sent on the subchannel, the aggregated channel still sends the bytes of this subchannel filled with zeros. Efforts to load sub channels' idle periods necessitate the introduction of a header for each subchannel's data. In intermediate statistical time-division multiplexing (STDM) technology, which allows idle periods to be filled by transmitting bursts of traffic from other sub channels, headers that actually have a subchannel number are introduced. In this paper, the strategic analysis and operation of technologies used in multiservice networks were discussed. Simultaneously, the structure of data sets is drawn into sets resembling computer networks. The fact that each packet has an address allows it to be transmitted asynchronously since its location relative to data on other subchannels is not its address. Asynchronous packets from one subchannel are inserted into the free time slots of another subchannel, but they are not mixed with the data of this subchannel because they have their own address.

**Keywords:** ATM, TDM, synchronous, switching, transmission, subchannels, STDM, multiservice networks

## Introduction

Nowadays, passive networks based on optical fiber are becoming more widespread. Copper twisted pairs do not compete with passive optical networks (PON) in terms of size, speed, and data transmission range, noise immunity, and scalability (1–3). If initially twisted pair cables were preferred due to the high cost of optical raw materials and equipment, now they differ little in terms of capital costs and labor intensity of computer installation (4, 5).

It is still popular to build integrated-type networks – fiber to the home (FTTH), where the copper pair is used only in the section from the switch to the subscriber (6). However, the dynamics are increasingly moving toward PON, and the installation of a passive network allows for modifications without interfering with the system architecture and allows cable rerouting (7–10).

However, installation is capital-intensive and complex, so it is important to entrust this work to trusted professionals (11). They can create thoughtful system configurations with the ability to optimize customer needs for seamless operation (12). The services of the upper layers of the network should be similar to the services of the integrated services digital network (ISDN) network—a variety of

interactive services such as fax transmission, distribution of television (TV) pictures, voice mail, email, and video conferencing (13, 14).

The high speed of ATM technology creates many more opportunities for high-end services that cannot be realized by ISDN networks—for example, the transmission of color TV images requires bandwidths in the region of 30 Mbps (15–17). ISDN technology cannot support such speeds, and this is not a major problem for ATM (18). ATM standards are developed by a group of organizations known as the ATM Forum under the auspices of an Institute of Electrical and Electronics Engineers (IEEE) *ad hoc* committee and ITU-T and ANSI committees (19).

ATM is a very complex technology that requires standardization in various aspects, therefore, although the main core of standards was adopted, standardization work is actively underway (20, 21). All interested parties participate in the ATM Forum—telecom equipment manufacturers, equipment manufacturers, local area networks (LANs), telecom network operators, and network integrators (22).

Passive optical networks is a highly promising broadband multiservice technology for transmitting data to multiple subscribers using optical fiber (23, 24). This networking method has become popular due to its clear advantages in speed and transfer rates; and room for improvement (25). The main difference between PON and other optical systems is the use of only passive equipment in the entire area, from the core module that transmits and receives information streams to the end user (26, 27).

That means no active switches, routers, media converters, multiplexers, or other equipment that requires additional power or maintenance (28). In a PON system, an optical splitter (splitter, multiplexer, or PLC) is used to split a stream into multiple subscribers. With its help, a transceiver module [junction box, switch cabinet, optical line termination (OLT)] can distribute the signal to unlimited consumers—all this depends on its power and speed indicators (29, 30).

One of the most significant trends in the telecommunications market is the growing popularity of multiservice communication networks (31). In past years, the services of such networks were primarily aimed at intensive business development, cost optimization, business process automation, modern management methods, and organizations (32). The most effective use of multiservice networks is found in traditional telecommunications operators, thus significantly expanding the range of services offered (33).

For the corporate market, unifying all remote segments into a single pulse service network increases the efficiency of information transfer by an order of magnitude, ensuring data availability at any time (34, 35). Thanks to the ability to exchange large amounts of data between offices, we can organize conference calls and video conferences with remote departments (36). All of this speeds up the organization's response to changes and ensures real-time control of all processes (37).

## Literature review

A multiservice network is a multipurpose environment designed to transmit voice, images, and data using packet-switched (IP) technology (8). It is distinguished by the reliability characteristics of telephone networks (in contrast to the non-guaranteed quality of communication on the Internet) and provides a low transmission cost per unit of information (closer to the cost of data transmission on the Internet) (9). Generally speaking, the main task of multiservice networks is to ensure the operation of heterogeneous information and telecommunication systems and applications by allowing the transmission of normal traffic (data) and traffic of other types of information (voice, video, etc.) in the same traffic environment (20). A single infrastructure is used.

PON is a technology with a common data transmission medium; therefore, separate streams of information must be encrypted (21). This may reduce the effective transfer rate and not protect the information from physical damage. Diagnosing problems in the system between separators is difficult (22).

When choosing a professional installer, it is important to remember that network problems are minimized to ensure proper installation, condition monitoring, and complete service (23). Ethernet passive optical network (EPON), which is based on Ethernet technology, is the next generation of passive networks. Currently, gigabit passive optical network (GPON) is the most modern, convenient, and promising system for building large branch networks (24).

Gigabit passive optical network is based on the synchronous digital hierarchy (SDH) platform [generic framing procedure (GFP) protocol] and allows up to 64 subscribers to connect to one transmitting module at a distance of 20 km (25). The use of splitters and connectors increases the range to 60 km. The average transfer speed reaches 2.5 Gb, although it is technically possible to create a system that can reach speeds of 4–10 Gb/s in each direction (26).

In particular, it lacks specific TDM support, timing, and security switching functions. Such a system works well for smaller operators that focus on Internet protocol (IP) traffic, including IPTV. In general, the choice of technology to build or upgrade a passive fiber-optic network depends on customer conditions, subscriber needs, and development opportunities (35). The installer should thoroughly examine the original data in order to select the technology and create an optimal plan for the future PON (36).

Often, a tree-like PON network topology is used for residential premises. It optimizes fiber utilization by placing as many subscribers as possible on one cable (37). Depending

on the final number of users and the needs of the network, the stream can be branched into one or more layer levels (38).

With fewer numbers, it is easier to maintain the system and perform necessary repairs, and there is less loss in speed and data volume for the end user (39). However, a multilevel system allows the creation of precise settings that make the network more responsive to customer needs.

## Proposed model

Heterogeneity is an inherent quality of any large computer network, and system integrators and administrators spend their time reconciling disparate components. Therefore, any approach that promises the possibility of reducing network heterogeneity attracts intense interest from network experts. ATM technology was created to serve as a unified global transport for a new generation of integrated service networks.

Multiservice networks can be built more fundamentally based on different technologies, an IP platform [IP virtual private network (VPN)], and dedicated communication channels. At the backbone level, the most popular technologies today are IP/multiprotocol label switching (MPLS), packet over SONET/SDH, point of sale (POS), ATM, xGE, dense wavelength-division multiplexing (DWDM), coarse wavelength-division multiplexing (CWDM), and RPR. In fact, today most of the backbone multiservice networks are built on the basis of POS and DWDM technologies, which are noticeable in Russia, as well as IP/MPLS, which are considered especially promising for a large coverage area and a large number of people. According to the developers' plans, the uniformity provided by ATM, a transport technology, can provide the following several capabilities: these are shown in **Figure 1**.

- The transmission of computer and multimedia (voice, video) traffic within a transport system is sensitive to delays, and the quality of service for each type of traffic corresponds to its requirements;
- Hierarchy of data transfer rates from tens of megabits to several gigabits per second with guaranteed bandwidth for mission-critical applications;
- Common transport protocols for local and global networks;
- Preserving the existing infrastructure of physical channels or physical protocols: T1/E1, T3/E3, SDH STM-n, and FDDI; and
- Communication with legacy protocols of local and global networks: IP, systems network architecture (SNA), Ethernet, and ISDN.

The proposed model combines the approaches of two technologies—packet switching and circuit switching. The former resulted in the adoption of addressable packet data transmission, while the latter resulted in the use of smaller fixed-size packets, resulting in more predictable network delays. It is possible to transmit different types of traffic in the same network by using the virtual circuit technique, preordering the parameters of the channel's quality of service, and prioritizing the service of virtual circuits with different quality of service.

Although ISDN networks were designed to carry different types of traffic within the same network, voice traffic was clearly a priority for developers. ATM technology has been developed since its inception as a technology capable of serving all types of transportation according to their needs. Any PON has three main components:

- Station terminal optical line terminal (OLT);
- Passive optical splitter; and
- Subscriber terminals are optical network termination (ONT) or optical network unit (ONU).

**Figure 2** demonstrates the PON infrastructure. The OLT transceiver connects the PON to external networks and receives the stream sent to the subscribers via the cable network. A splitter multiplies the signal by 8, 16, 32, or 64 subscribers.

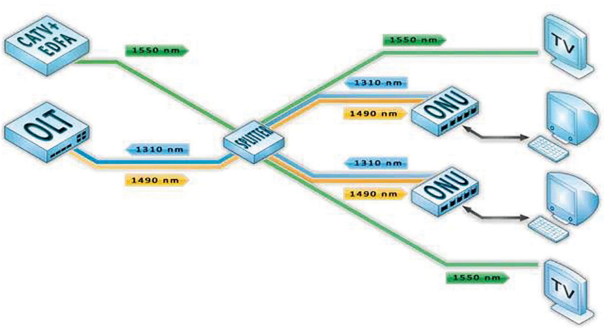


**FIGURE 1 |** Capabilities of proposed model.

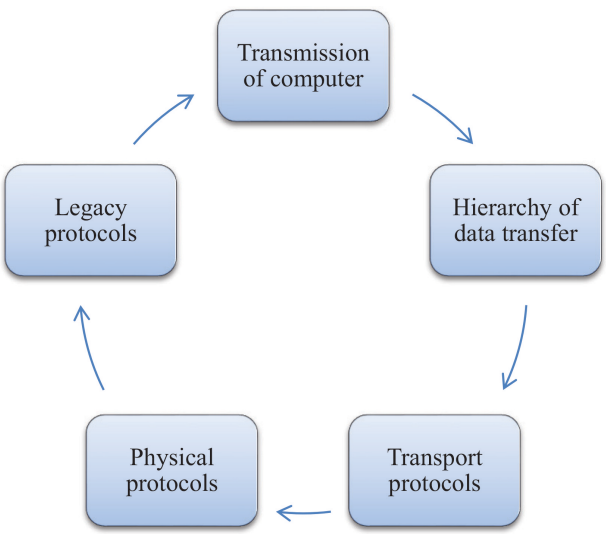


**FIGURE 2 |** Passive optical network.

Each branch shortens the transmission channel somewhat, giving some signal attenuation and reducing its bandwidth. The terminal subscriber equipment is equipped with the interfaces required by the user, including outputs for IP telephony, Ethernet, and Wi-Fi. A multiservice network opens up many opportunities to build a wide variety of redundant services on top of the global transport environment—from pocket telephony to interactive TV and Internet services. The new-generation network has the following features:

- Universal nature serving various applications;
- Independence from the technologies of communication services and flexibility in obtaining the package, volume, and quality of services; and
- Complete transparency of relationship between service provider and users.

Integration of heterogeneous data and speech traffic allows us to qualitatively improve the efficiency of information support for enterprise management; at the same time, the use of an integrated transport environment reduces the costs of building and operating the network. A multiservice network uses a single channel to transmit different types of data, minimizes the variety of equipment, uses uniform standards and technologies, and centrally manages the communication environment. Many service networks support services such as telephone and fax communication, allocated digital channels with a fixed transmission rate, packet data transfer (FR) with required quality of service, image transfer, video conferencing, TV, on-demand services, IP phones, broadband Internet access, the interface of remote LANs operating in various standards, and the creation of user-modifiable virtual corporate networks.

Multiservice networks is a technological theory or a new approach to understanding the current role of telecommunications, given that computers and data take precedence today compared to voice communication. Built on next-generation broadband communications, this business model enables a wide range of services and the flexibility to build, manage, and customize them. The main differences between such networks are as follows:

- The ability to transmit very large amounts of information to a large number of users in real time using the necessary synchronization and complex connection configurations;
- Intelligence (service, call, and connection control by user or service provider, separate billing, and conditional access control);
- Variation of access (system of access to services regardless of the technology used);
- The complexity of the service (the possibility of several providers participating in the provision of the service and dividing their responsibility and income according to the type of activity of each).

The major issues limiting the spread of broadband access today and the introduction of multiple service networks require significant investments in the industry. Let's not forget about "theft" and IP enforcement. After all, the fight against fraud requires a business model based on content sales with complex management systems, access control, and billing.

## Results and discussion

The proposed multiservice model (MSM) was compared with the existing data gathering and incident response model (DGIRM), array signal synchronous transmission method (ASSTM), symbol-synchronous transmission (SST), and many-to-many data sharing (M2MDS).

**Transfer rate management:** PON supports speeds from 155 Mbps to 2.5 Gbps, enabling the fastest data transfer at the moment. Protection against voltage surges: unlike systems using twisted pair (FTTH, etc.), PON is unaffected by outside influences and is protected against voltage surges, pickups, and interference. The comparison of transfer rate management is shown in **Figure 3**.

The density of the signal (multiplexing) allows, if necessary, to start additional information streams on the existing cable—for this, light waves of different lengths are used. Therefore, the existing cable system can be used to add services like security systems, video surveillance, security, fire protection, etc.

**Multimodal transport management:** A computer can send any type of information (data, video, and voice) and information flows of any origin to an apartment or office. PON uses passive tubes that do not require electrical power or additional maintenance. The development of capabilities, speed, and cost reduction of components allows

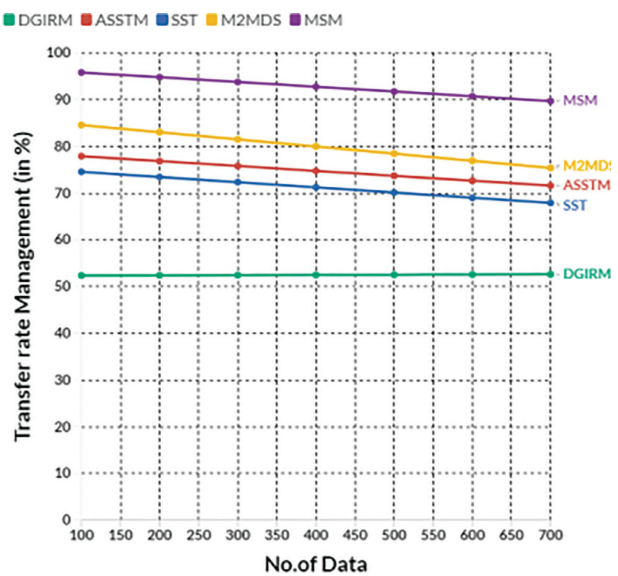


**FIGURE 3 |** Comparison of transfer rate management.

this technology to be considered one of the most promising data transfer methods. The comparison of multimodal transport management is shown in Figure 4.

**Capacity management:** The system can process streams from multiple sources simultaneously without losing quality. Multiple computers, TVs, IP phones, etc. can be connected to one subscriber port. Subscribers are connected to the network quickly and without communication interruptions. The comparison of capacity management is shown in Figure 5.

**Optimum utilization management:** Connecting as many subscribers as possible to a single fiber reduces cable usage, which can result in significant cost savings. There is no need to house the equipment for the PON network in external boxes, so the system is easily accessible for inspection, modification, and repair during the cold season and stored in all-weather equipment. The comparison of optimal utilization management is shown in Figure 6.

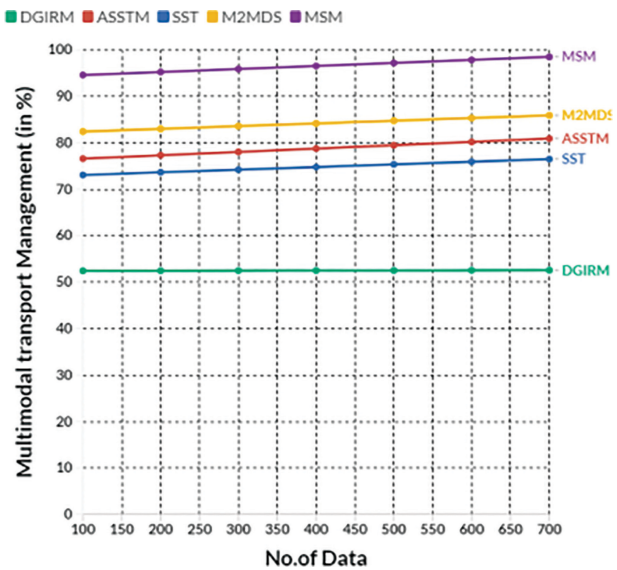


**FIGURE 4 |** Comparison of multimodal transport management.

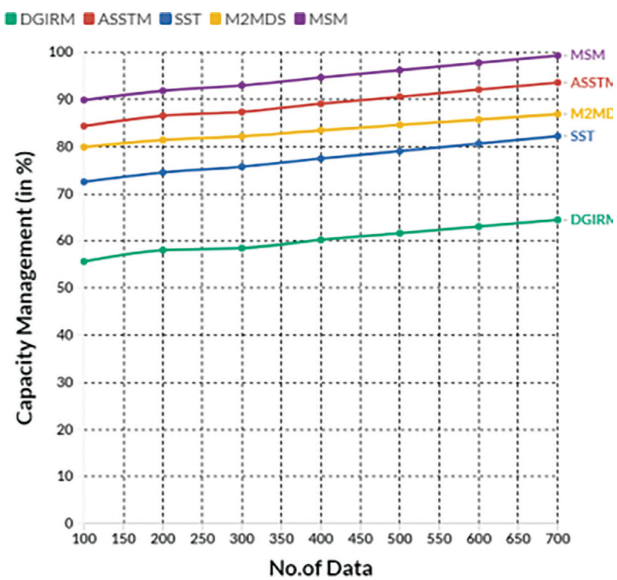


**FIGURE 5 |** Comparison of capacity management.

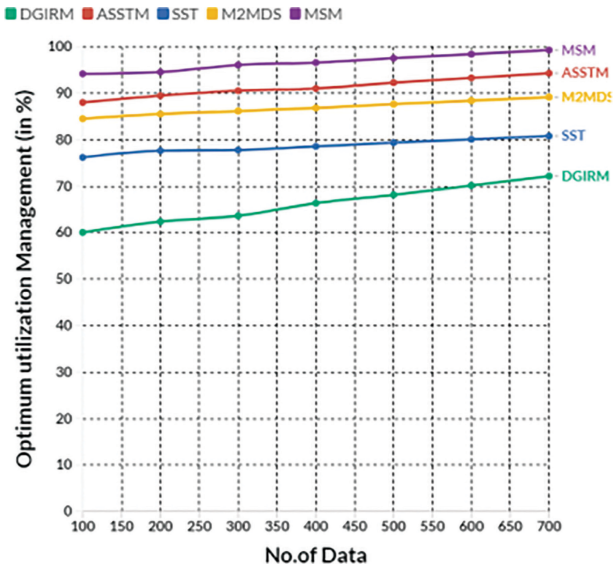


**FIGURE 6 |** Comparison of optimum utilization management.

The circle of potential users of multiservice networks is quite extensive. These are, first of all, business centers, companies located in the same building.

## Conclusion

In general, the topology is selected from various options and the actual conditions of the design based on the principle of maximum convenience for subscribers. Another existing change is GEPON technology. It can be called very economical, but this advantage means some costs in comparison with GPON networks.

Corporate clients have a lot of demand for telephone connections, high-speed Internet access, audio and video conferencing, and alarm and telemetry systems. These are large holdings with geographically distant branches and subdivisions, companies that use remote automated terminals (ATMs, vending machines). These are telemedicine systems of different levels and organizations with mobile communications, distributed offices, switching centers, and base stations that can be connected to a multiservice network.

In addition, our country does not have a powerful multi-gigabit backbone infrastructure or well-developed subscriber networks. It is necessary to completely change the business model for operators, and a large territory and uneven solution depending on the geography and population of a particular region require careful selection of technologies and their combination.

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