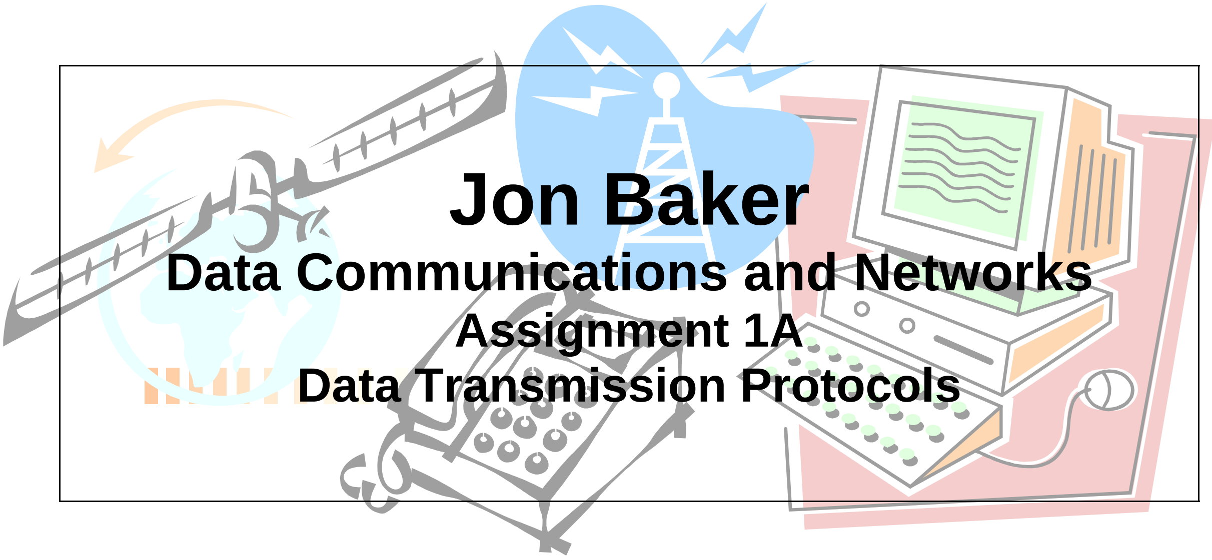


Jon Baker

Data Communications and Networks

Assignment 1A

Data Transmission Protocols

Contents

Assignment Brief

Introduction

You are part of the management team of a company that is wanting to break into the data network market by manufacturing equipment that will enable different terminals to communicate with one another. Your job is to investigate the different hierarchies such as the OSI model, the SNA and the ATM model and make a recommendation on which model the company should use in the equipment.

SNA

Fully describe the Synchronous Network Architecture model that was proposed by IBM.
The description must cover the usage of each layer in the model.

ATM

Fully describe the Asynchronous Transfer Mode model.
The description must cover the usage of each layer in the model.

OSI 7 Layer Model

Fully describe the OSI 7 Layer model that was recommended by the ISO.
The description must cover the usage of each layer in the model.

Comparison

Compare the three models with one another.
The comparison must specify the similarities, differences, advantages and disadvantages of the three models.

Provide a bibliography.

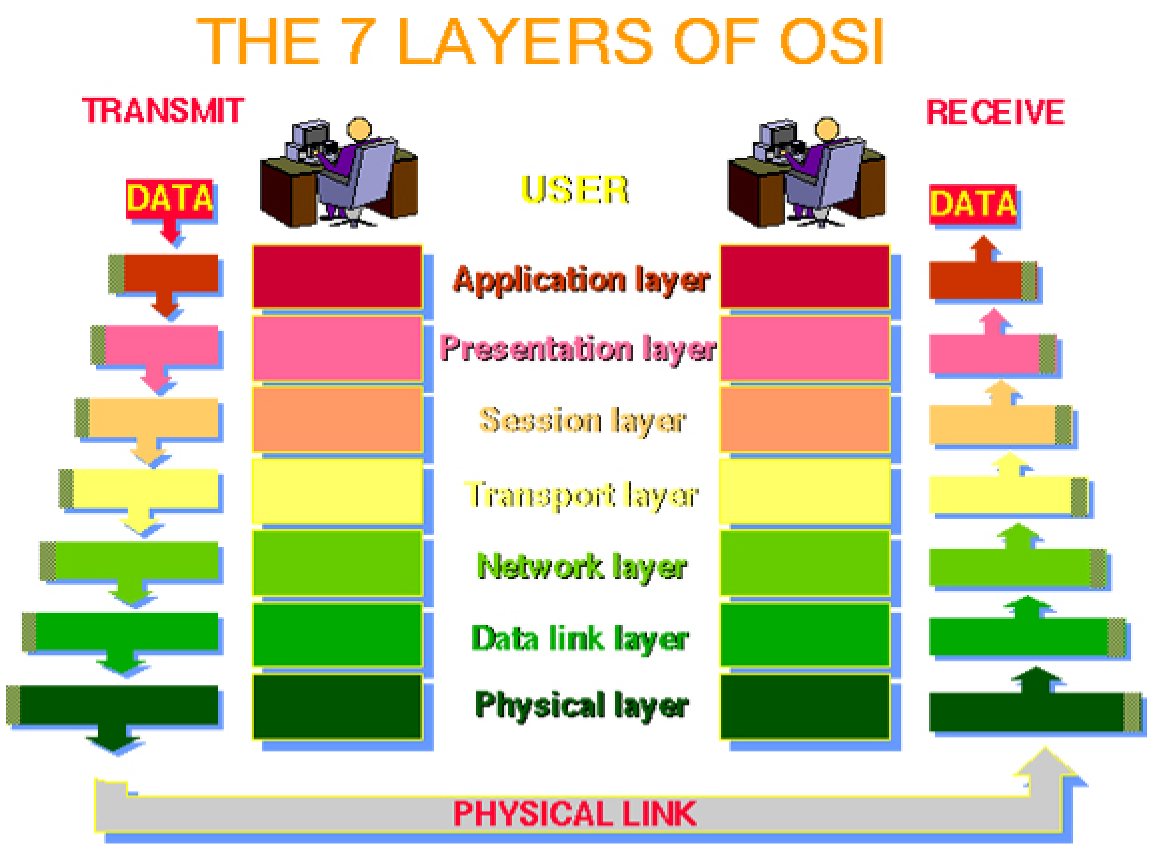
The OSI (Open Systems Interconnect) 7 Layer Model

History of the OSI 7 Layer Model and Introduction

The origins of the OSI 7 layer model start with a group at Honeywell Information Systems. By the mid-70s it became clear that to support the growing database systems a structured distributed communications architecture would be needed so the group studied some existing systems including IBMs systems network architecture (SNA), the work being done by the US Department of Defence agency DARPA on their ARPANET (later to evolve into the Internet). The result was that in 1977 a seven layered architecture known as the distributed systems architecture (DSA) was designed. Meanwhile the British Standards Institute proposed to the International Standards Organisation (ISO) that a standard architecture was needed. As a result ISO created the Open Systems Interconnection subcommittee. When ISO met the Honeywell team they presented their solution and a provisional version of the design was published March 1978. The next version with some minor revisions was published in June 1979 and standardised. The resulting OSI model is basically the same as the DSA model from 1977. Although this model is from the ISO there are many other standards organisations, namely the ITU (International Telecommunications Union).

The Model

The diagram below shows the OSI 7 layer model recommended by ISO.



As the diagram shows the data that you wish to be transmitted starts with the application layer, and moves through the protocol until it reaches the physical layer where it is transmitted over the medium (radio, cable pair, waveguide etc). Once it is at the receiving end it runs through the reverse procedure until it reaches the application layer where it is viewed as it is meant to be.

This model was to be used in switching computers to allow data terminals to be interconnected in an unrestricted way.

Each layer communicates with its counterpart on the other side, for example the physical layers link to each other and the application layer receives the same data it sends. During the transmission process each layer communicates with the one below it, and during the reception process with the one above it.

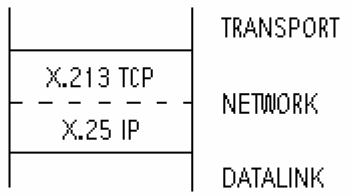
The Layers
Now that I've covered a brief description of how the model works with reference to data movement I will start to explain the function of each layer.

Let's start by presuming that there is some data about to arrive at the physical layer on the receiving side.

The Physical Layer
This layer is the physical transmission medium and the transmission hardware. This layer does not supply error correction or detection it only transfers the data. The ITU recommendations for this layer are X.21bis and V.24 for an analogue connection to the PSTN, I430/1 for ISDN, the ISO recommendations are all designed for LANs.

The Datalink Layer
This layer can provide error detection and recovery. It is also used to transfer control data as well as the message data. It is responsible for initiating, maintaining and terminating a call. The ITU recommended protocol is the Highlevel Datalink Control (HDLC) protocol. This protocol is a derivative of the Serial Datalink Control (SDLC) protocol. On land systems the recommended protocol is the Link Layer Control (LLC) protocol.
As said, this layer starts, stops, and controls the data transfer as well as sending the data. It does this through three different data *frames*. These are the unnumbered frame (this is the frame through which calls are started, cleared and where the mode of the call is setup), the supervisory frame (where the transfer of data is controlled), and finally the information frame (where the actual data is transferred).

The Network Layer
It is not possible in the OSI model to have a *null* layer, a layer which contains nothing. It is however possible to divide a layer up into sublayers. There can be up to three sublayers per layer, namely the upper, middle, and lower sublayers. The Network Layer is divided up into two sublayers. The diagram



following shows them, with the TCP (Transmission Control Protocol) upper layer connecting to the Transport Layer to be discussed next and the IP (Internet Protocol) lower layer connecting to the Datalink layer discussed previously. The Network layer allows for the establishment of Virtual Circuits and allows multiplexing of different bitstreams to take place. The Virtual Circuit (VC) is basically a call taking place. There are two types of VC, they are permanent and switched. A switched VC can be thought of as a normal telephone call, when you pick up the receiver to make a call a connection to the exchange is established, when you wish to end the call you put the receiver down and the connection is severed, this is how a switched VC is used, only active while the call is. A permanent VC is self-explanatory, it is always there, regardless of whether a call is active. This system also allows for connection and connection-less oriented services.
As said this layer also allows for multiplexing of datastreams, up to 4096 between a DTE (Data Terminal Equipment, eg a computer) and a multiplexing point to be exact. Each one of these streams is given a Logical Channel Number (LCN).

The Transport Layer
The Transport layer can be thought of as the bridging between the mainly hardware layers and the mainly software layers, it shields the software from the reality of the network. The layer provides two functions, the first being that if the network does not re-sequence the data packets into the correct order that will be done here, the second being that the layer can choose between three types of circuit and five classes of service.

The Session Layer
This layer regulates the transfer of data. It inserts synchronisation points into the session for easy recovery of data in the event of a failure. Since it initiates and disconnects calls it is also used for determining the call cost.

The Presentation Layer
Since all different terminals do not use the same protocol they cannot communicate thus a standard protocol must be used, this is named the Virtual Terminal Protocol. The presentation layer converts the used protocol to the virtual terminal protocol in the transmit direction or the virtual terminal protocol to the protocol used by the local terminal in the reception direction.

The Application Layer
Finally, this protocol actually implements the necessary software required by the user.

Another Way Of Looking At This

The concept of ‘layers’ in protocols is not the easiest concept to grasp with speed, to simplify matters the description below can be used.

James Bond meets Number One on the 7th floor (Application) *of the spy headquarters building. Number One gives Bond a secret message that must get through to the US Embassy across town. Bond proceeds to the 6th* (Presentation) *floor where the message is translated into an intermediary language, encrypted and miniaturized. Bond takes the elevator to the 5th* (Session) *floor where Security checks the message to be sure it is all there and puts some checkpoints in the message so his counterpart at the US end can be sure he’s got the whole message. On the 4th* (Transport) *floor the message is analyzed to see if it can be combined with some other small messages that need to go to the US end. Also if the message was very large it might be broken into several small packages so other spies can take it and have it reassembled on the other end. The 3rd* (Network) *floor personnel check the address on the message and determine who the addressee is and advising Bond of the fastest route to the Embassy. On the 2nd* (Datalink) *floor the message is put into a special courier pouch (packet). It contains the message, the sender and destination ID. It also warns the recipient if other pieces are still coming. Bond proceeds to the 1st* (Physical) *floor where Q has prepared the Aston Martin for the trip to the Embassy. Bond departs for the US Embassy with the secret packet in hand. On the other end the process is reversed. Bond proceeds from floor to floor where the message is decoded. The US Ambassador is very grateful the message got through safely. "Bond, please tell Number One I’ll be glad to meet him for dinner tonight".*

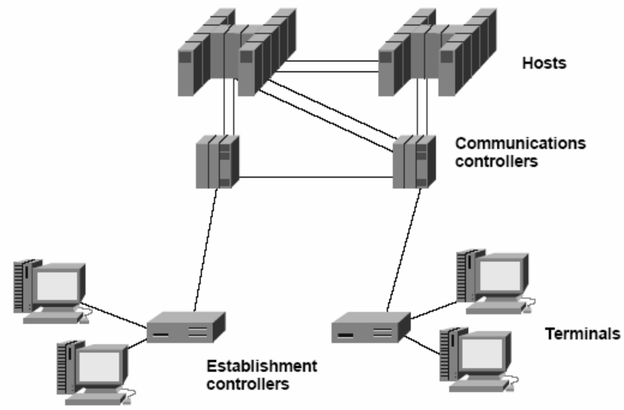
The SNA (Synchronous Network Architecture) Protocol

History and Introduction

"Anything that can go wrong, will go wrong." The attitude used by IBM as the SNA system was developed. IBM attempted to identify everything that can go wrong in a networked environment so that they could offer a reliable communications network to customers. Although SNA was one of the first networking protocols and it is now considered a legacy system it is still widely deployed.

In the early 1970s IBM developed the SNA model under the attitude I mentioned above. It is true that the model works very well so long as the system is installed by a professional team and maintained by a team of technical staff. It is however much less useful if the network is in an environment when a PC can be plugged into the network at any point at any time and there are no trained staff around.

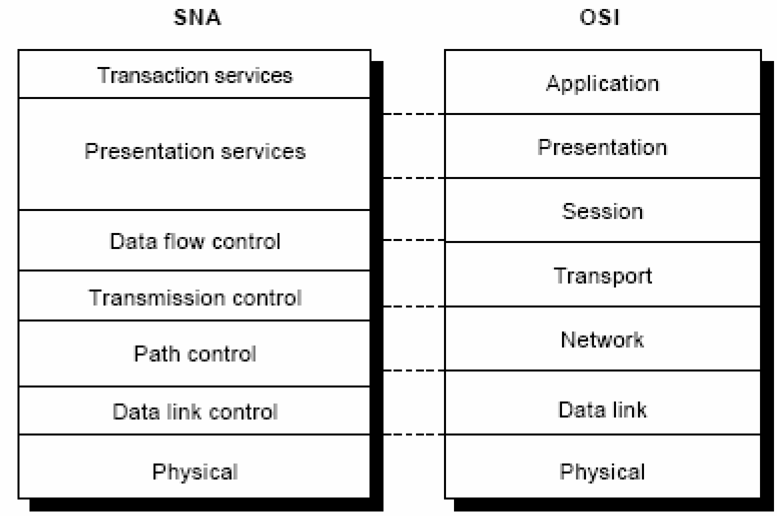
The SNA model is neither simple nor cheap to implement, it is very much the antithesis, the system uses dedicated switching minicomputers (that users cannot use, they run a system called the Network Control Program, NCP) and a central mainframe (again users cannot use, that run a product called Virtual Telecommunications Access Method, VTAM). Please see the diagram opposite to explain this structure. In this system the switching computers connect to user terminals and the switching computers connect to the mainframe. VTAM maintains a list of all the machines and links in the network and selects routes and alternate paths. Though this method of networking is very useful in something such as banking where terminals "stay put" and where reliable connections are an absolute **must**, it does however come at cost since any errors the SNA system develops that it cannot overcome itself, then a message is sent to the technical team that the system requires. The positive side is that since this mainframe keeps a record of all links predefined and the mainframe is responsible for starting and stopping sessions the amount of overheads necessary is dramatically cut down.



However, the recent developments and expansions of networks and computers in general forced IBM to update their SNA system. The *classic* SNA is now referred to as Subareas and the new SNA is referred to as APPN (Advanced Peer-to-Peer Networking). With APPN it is much easier to alter the network without requiring a team of specialists.

It is therefore not a stretch of the mind to believe SNA is a much more complex system than most others.

The Model
Here you can see the SNA model compared to the OSI model.



The Layers
Below each of the different layers of the SNA model are described.

Physical Layer
The SNA physical control layer is concerned with the actual methods of data transfer used in the system and the interface concerned. There is no set definition of what should be used here, it is assumed that this is implemented via other standards. This is similar in function to the OSI physical layer.

Data Link Control Layer
This layer is concerned with data error control, control data, and is also responsible for starting, maintaining and clearing calls. SNA supports many protocols over this layer, including: SDLC, System/370 channel, Token-Ring, and X.25, however, only SDLC is used on communications links in which master and slave stations communicate. This is similar in function to the OSI Datalink layer.

Path Control Layer
The two major functions here are routing and flow control. Routing; since there can be many data links connected to a node, path control insures that data passes un-errored from source to destination. At the start of an SNA session the path control layers on the start and end node, along with each in between work to select the most efficient route for the communication. This is done via the mainframe which holds the node link information. Since this is only established for the duration of the session is it known as a *virtual route*. Flow control; the path control layer is also capable of separating long messages into shorter data blocks as well as grouping shorter messages into larger blocks to enable SNA to be as efficient at data transfer regardless of message length.

This layer is a key construct within the overall SNA network model. This is the layer responsible for routing data as I have stated, this routing is one of SNAs major differing points to other models. The path control layer uses functions provided by the path control and the data link control (DLC).

Transmission Control Layer
This layer offers reliable end-to-end connections, session encryption/decryption and pacing. Pacing is where the speed of transmission is controlled to make sure the amount of data being sent is not more than the receiver can handle. Though this can be viewed as flow control, pacing is more controlled as the networks NAUs (Network Addressable Units, an item on the network) negotiate and control pacing. This layer is similar in function to the OSI transport layer.

Data Flow Control Layer
The data flow control layer has a selection of transmission modes:

- Full-duplex – Each device can transmit simultaneously
- Half-duplex flip-flop – Each device can transmit but not simultaneously
- Half-duplex contention – Where there is a master and a slave unit and only the master can transmit

Presentation Services Layer
The presentation layer is responsible for transferring the format of the data from one to another as with the OSI Presentation Layer, for connection and disconnection of a session, updating network configuration and performing network management. It is also possible for this layer to perform compression and decompression of data should this be enabled.

Transaction Services Layer
Finally, this layers function is to provide application services in the form of programs that implement distributed processing or management services.

As I said in the introduction IBM enhanced, or more accurately overhauled SNA. APPN (Advanced Peer to Peer Networking) is the second generation SNA, however, although IBM introduced three more network points, the *Logical Unit*, the *Advanced Peer to Peer Computing* and *Node Type 2.1* the system is still very much SNA based.

The ATM (Asynchronous Transmission Mode) Protocol

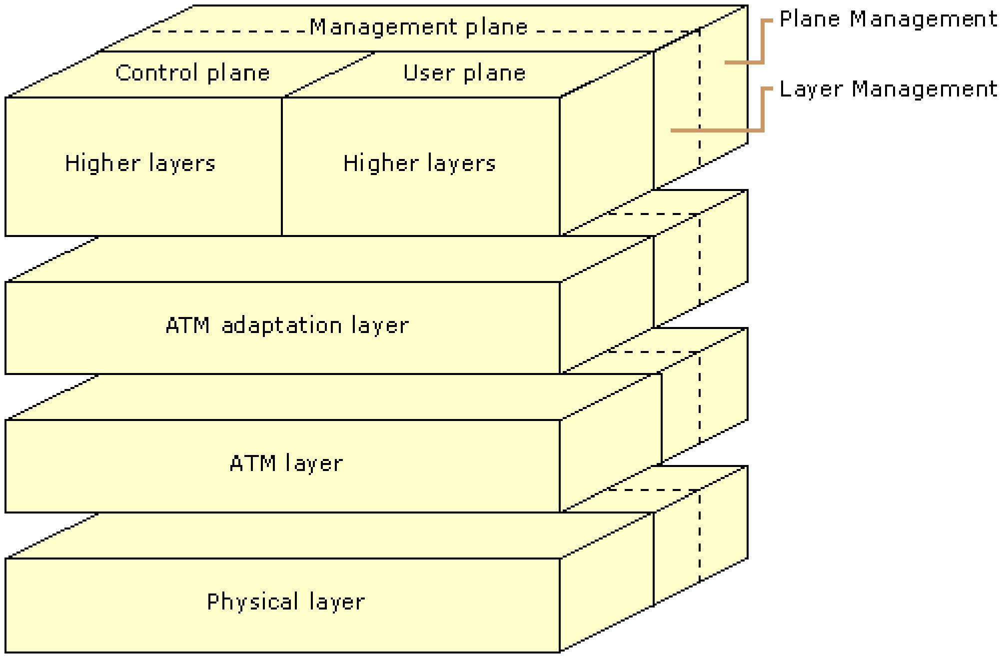
History of ATM and Introduction

The ATM protocol was *born* out of the efforts for Broadband ISDN in the mid 1990s. It was originally bound with the SDH system but has grown to a system of its own.
It's safe to say that when ATM was designed the OSI 7 Layer Model was considered, some of the concepts that the OSI Model uses you will find in the ATM Protocol.
The ATM Protocol is however designed to be a significant step forward in communications technology. ATM has the following benefits:

- Fixed packet size, a small 53 byte/octet packet/cell allows for faster transfer of small bits of information reducing delays on real time communications and allowing for far more efficient multiplexing.
- Transparency: ATM can be used on broadband communications, video, audio, and LAN systems.
- Since fixed size cells are used it makes the design of switching equipment easier.
- Scalability: Various operating rates are supported all the way to 10Gbps and in theory above.

The ATM Model

Below is a diagram of the ATM Model:



There are three planes in the ATM Model: the Control plane, User plane, and Management plane. The user plane carries the information the user is transferring through the system. The control plane carries information such as call setup, switching, and general call administration. Finally, the management plane maintains the network and performs operational functions such as diagnostics. It is of course not possible to have three dimensional data, we are talking about '1's and '0's. Therefore that makes these planes a difficult concept to grasp quickly, the easiest way is by means of comparison, consider that these planes are similar to the way different frames of data are used in the OSI 7 Layer Model, so:

- User plane compares to information frame
- Control plane compares to supervisory frame
- Management plane compares to unnumbered frame

With this in mind we can once again consider the model as two dimensional and we are left with the layers:

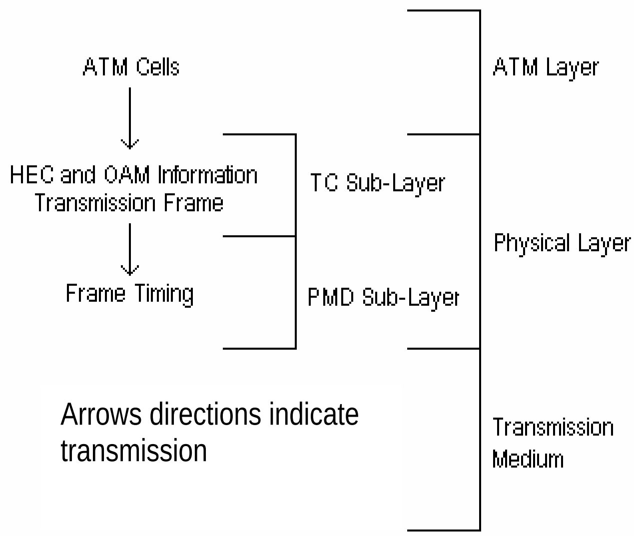
- Higher Layers
- ATM Adaptation Layer
- ATM Layer
- Physical Layer

The Layers
We are going to start from the physical layer upwards.

The Physical Layer
The physical layer is in control of passing the data from the other layers and converting it into the appropriate format for the transmission medium whether it be radio, optic fibre,
To be more in depth the physical layer has four key functions:

1. Converts cells to bitstream
2. Control transfer of bits on medium
3. Track ATM cell boundaries
4. Package cells for medium

The Physical layer is composed of two sub-layers as shown opposite, the lower Physical Medium-Dependant (PMD) sub-layer and the upper Transmission Convergence (TC) sub-layer.

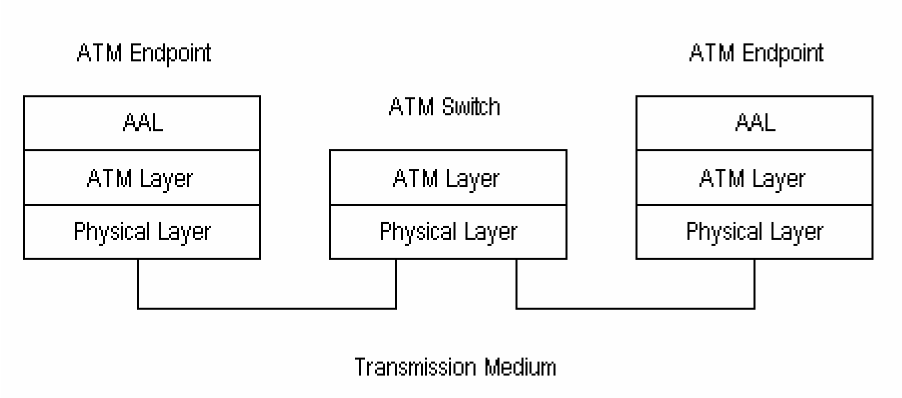


The lower sub-layer, PMD, is different for each differing medium, its function is to provide timing for reception and transmission of bits.

Next the upper TC sub-layer is responsible for taking the ATM cells from the ATM layer. The TC layer is also responsible for adding the header error control (HEC) bits to each of them before constructing the correct transmission frame (eg STM-1) and adapting the cell flow to fit the frame. It also inserts idle cells and Operation and Management (OAM) information were necessary. Of course under reception this process is basically reversed so that the transmission medium outputs ATM cells to the ATM layer.

The ATM Layer
This layer basically is the interface between the cell data and the physical medium, it is in control of header generation, multiplexing/demultiplexing, and the control of cell flow, this is also the layer dealt with at switches.

The diagram below is a sample of an ATM network:



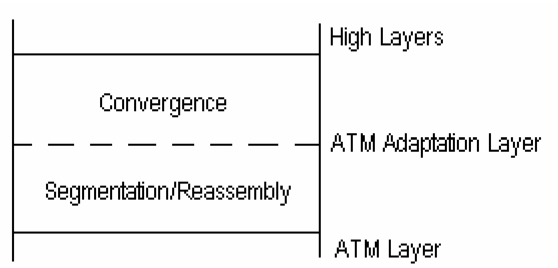
The diagram shows three things of interest:

1. The AAL, soon to be discussed is only required at an endpoint where the original data is needed
2. The ATM Layer is used in ATM switches to process data, and
3. The ATM switches only require layers 1 and 2, whereas endpoints need all three layers

The ATM Layer is responsible for generating the 5 byte header information or interpreting it for reception. It is also responsible for using VCI and VPI and use them for multiplexing and demultiplexing cell flows. The VCI and VPI, (Virtual Channel Identifier and Virtual Path Identifier) are the numbers that identify what VC and VP are being used.

The ATM Adaptation Layer (AAL)
This layer is defined in the ITU regulations I.362 and I.363.

It can be thought of as isolating the higher layers from the reality of the network. The AAL and its sub-layers as shown in the diagram opposite.



The AAL, in brief, adapts higher level data into formats compatible with ATM Layer requirements. To do this the AAL divides the data down into the 48-byte fields. Although all information is divided into similar cells there are five different AAL modes defined dependant on the class of traffic type:

Class	Timing Relationship	Bit Rate	Connection Mode	ATM Adaptation Layer
A	Required	Constant	Connection-orientated	AAL 1
B	Required	Variable	Connection-orientated	AAL 2

C	Not Required	Variable	Connection-orientated	AAL3/4 and AAL5
D	Not Required	Variable	Connectionless	AAL3/4 and AAL5

Please note: Since AAL3 and AAL4 were very similar they were merged into AAL3/4.

The above table lists which AAL would be used under what circumstances. Although not listed AAL 5 actually represents the lack of an adaptation processing standard resulting in non-classified data being mapped into the payload, thus sending and receiving ends must take responsibility for cell mapping. AAL5 is the newer and more efficient protocol and is looked at as a replacement for some or all of the other protocols.

Without going into too much detail in this area it is adequate to say that the Convergence sub-layer uses one of the AAL protocols to supply a packeterised datastream to the lower Segmentation/Reassembly (SAR) sub-layer which digests these into smaller 48-byte payloads.

Of course under reception the incoming 48-byte payloads are converted back into there datastream for the user or higher layers.

Higher Layers
These higher layers can be used but the AAL can be directly linked to Application level and thus these layers do not need to be used, but, should further processing be necessary ATM supports higher level layers. These layers can accept user data, arrange it into packets, and hand it to the AAL.

It is worth noting that the ATM Physical Layer maps well onto the OSI Physical Layer and the ATM AAL and ATM Layers together map well onto the OSI Data Link Layer. The other layers can be composed of the Higher Layers if needed.

Comparison

After looking into these three models and explaining their structure I will now compare them to see what they have in common, their differences and what advantages and disadvantages each one has.

To start with, a brief point by point summary of each model:

OSI 7 Layer Model

Advantages
- *Quite Flexible*
- *Selection of protocols dependant upon medium*

Disadvantages
- *Quite complex*

SNA Model

Advantages
- *Increased reliability over other network types*
- *Errors are taken care of when issued by system*

Disadvantages
- *Cost*
- *Requirement of trained staff*
- *Requirement of network machines that users cannot use*
- *Very complex*

ATM Model

Advantages
- *More flexibility*
- *High level of scalability*
- *Smaller packets mean increased availability of bandwidth-on-demand*
- *High level of transparency allows ATM to be implemented in almost any circumstance.*

Disadvantages
- *No real disadvantages*

SNA Against OSI

The SNA model and the OSI model were designed with different concepts and different implementations in mind. SNA is designed around an architecture that allows for a central system controlling actions on a network designed to forget expense and go for reliability. OSI on the other hand is intended for use anywhere anytime, and while error detection is used it is not considered to the extent of SNA.

On the side of error detection and correction SNA wins completely, the OSI system of error detection and correction is no where near as developed or as sophisticated.

Cost and simplicity wise, OSI is much more available. SNA has a higher installation and setup cost, as well as maintenance, requiring a team of experts for updates and error control. Even considering the newer APPN system, OSI is still a simpler and more cost effective system.

My conclusion here is that SNA is very expensive, and the term *legacy* is well placed. SNA had its day and although it is true that OSI had little error detection and correction compared to SNA, and SNA cuts down on transfer of overheads, it does not justify the cost in most of todays networks.

Given the information in this report, and the comparison here, I would have to side with OSI for todays needs.

ATM Against OSI

The ATM model can be classed as an update on the OSI model in a sense. When OSI was first introduced the technology of the time was very different, the Internet, computer networking and bandwidth-on-demand were terms just starting to emerge or not even heard of, it's no surprise therefore that the OSI model was not designed with these in mind. ATM was.

ATM has a fixed, and small, packet size, this means that if you are transferring a large collection of data that it only gets sent in small 'chunks' and therefore cannot tie up a data path for too long. On the other hand OSI can hold a lot of data in one frame and therefore if this frame was to get in the way of for example a real time telephone call could cause a delay.

ATM is also able to accept various speeds up to 10Gbps and this is not yet its limit. ATM is still very much a developing system and therefore is being improved all the time.

My conclusion here is that ATM is much better than OSI for todays technological needs.

Final Recommendation

I would recommend the Asynchronous Transfer Mode motivated by the descriptions, reasons, and comparisons given previously in this report.

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