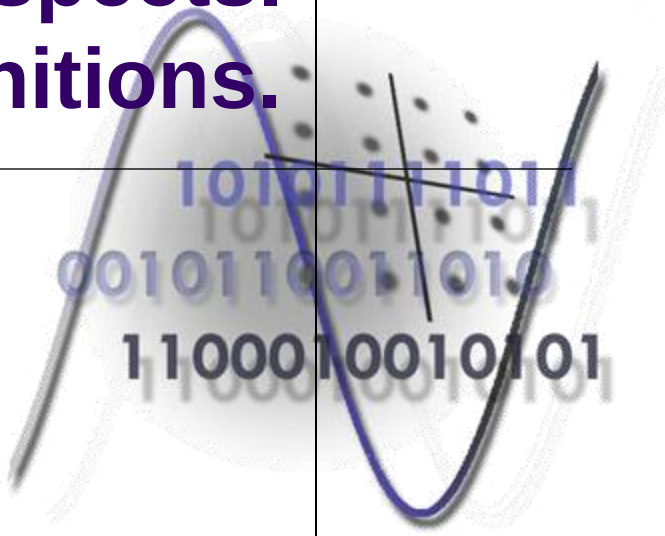
Course 1
A general view on the fixed telephone network. Digital networks. General aspects. Definitions.



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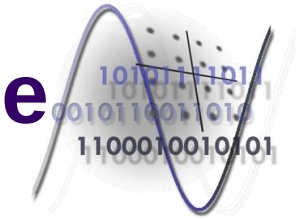
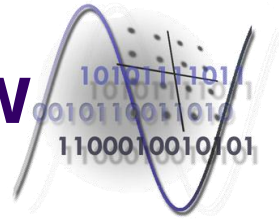
Content of the course



- A general view on the fixed telephone networks;
- Basic aspects concerning the switching techniques;
- IDN networks and the evolution toward ISDN;
- Terms and definitions used for describing the fixed telephone networks.

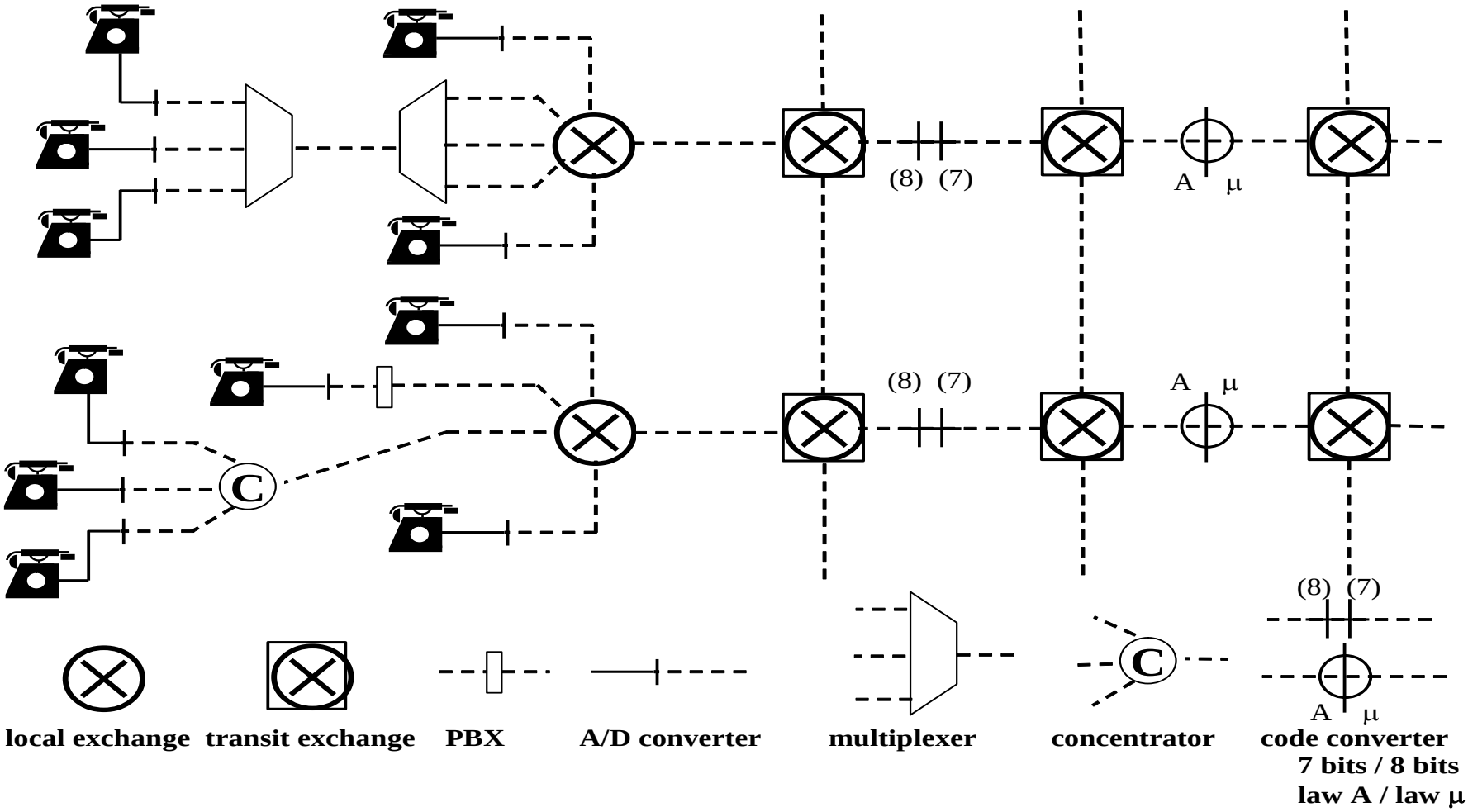
A general view



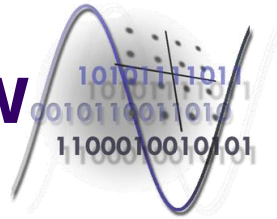
- The telephone networks:
  - communication network dedicated to voice transmission;
  - the network parameters are adapted to the offered service;
    - frequency bands;
    - signal processing;
    - delays;
  - the network must ensure the transmission of the voice signal between two or more subscribers with a given quality of the service:
    - signal to noise/ratio;
    - distortion level;
    - delays;
    - waiting time for connection;
    - connection rejection probability.

A general view

- General architecture of a classical digital telephone network



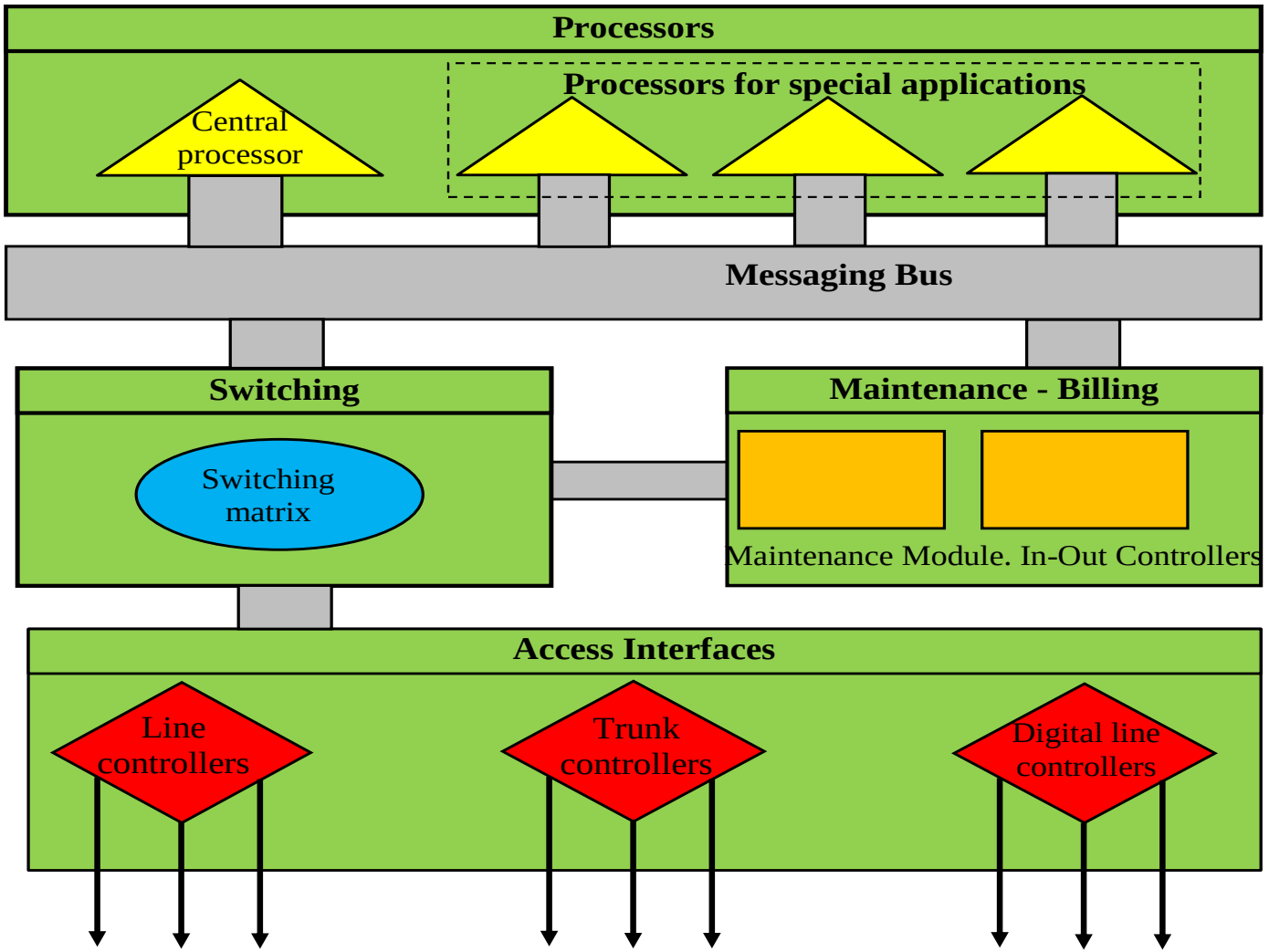
A general view



- The elements of a classical telephone network:
  - subscriber terminal:
    - performs the conversion of the voice in analog or digital signal;
    - ensures the connection to the access network;
  - the analogue or digital access network:
    - allows the access in the network;
    - ensures the remote power feeding and the signaling with the subscriber;
    - could ensure the multiplexing in some situations;
  - the local and the transit analogue or digital switching:
    - ensures connectivity between any two or more subscribers;
  - the analogue or digital transport network between the local or transit switching points;
    - ensures the transmission of the data streams between switching points and the multiplexing of these data streams on wide bandwidth channels.

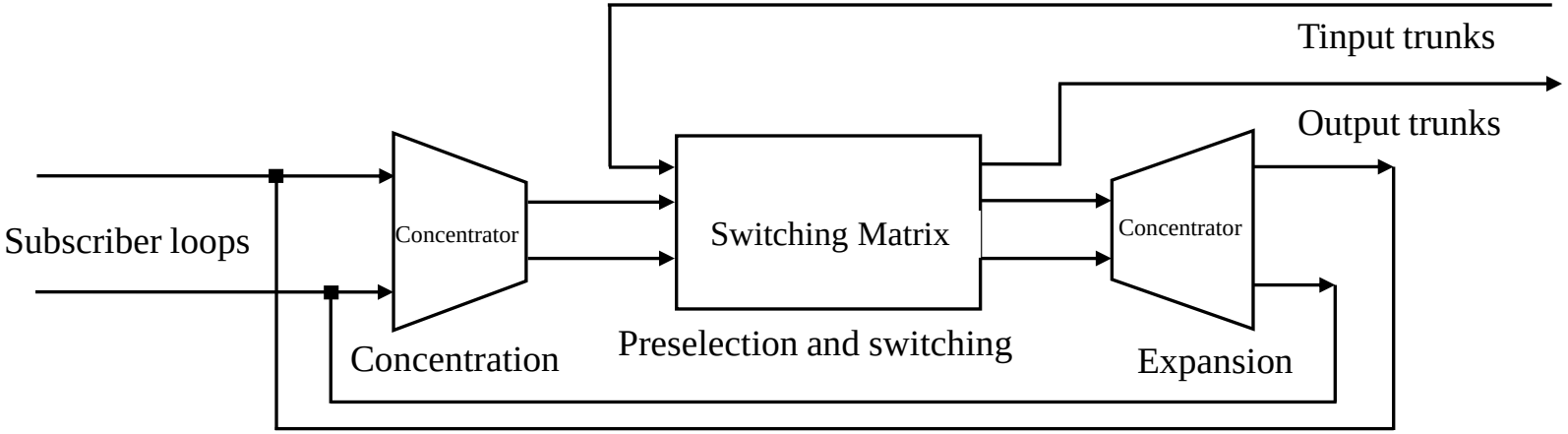
Basic aspects concerning the switching

- The basic architecture of a telephone exchange;



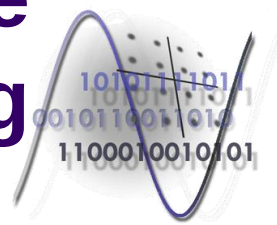
Basic aspects concerning the switching

- Switching module (block schematic) of a local exchange;
  - The switching matrix has a limited number of input and output lines;
    - the number of the subscribers is usually larger (much larger) than the number of input lines of the switching matrix;
      - it is necessary to use concentrators.



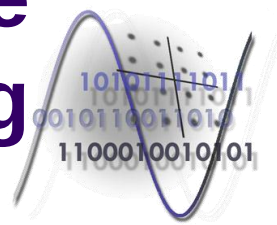
- The switching module of a transit exchange does not require a concentrator;
  - The number of in / out trunks it is equal with the number of in / out lines of the switching matrix.

Basic aspects concerning the switching



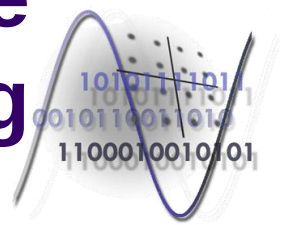
- Typical call structure:
  - Detection of the service request;
  - Dialing connection;
  - Routing through the network;
  - Ringing connection and answer detection;
  - Talk connection;
  - Billing procedure (if necessary);
  - Call disconnect.

Basic aspects concerning the switching



- Definition of trunks in telephony:
  - A single transmission channel between two points that are switching centers or nodes, or both;
  - A circuit between switchboards or other switching equipment, as distinguished from circuits which extend between telephone exchange's switching equipments and information originating / terminating equipments.
- *Note:* Trunks may be used to interconnect switches, (public and private switches), to form networks.
- LATA (Local Access and Transport Area) – the geographic area which is the domain of the local exchange carrier.

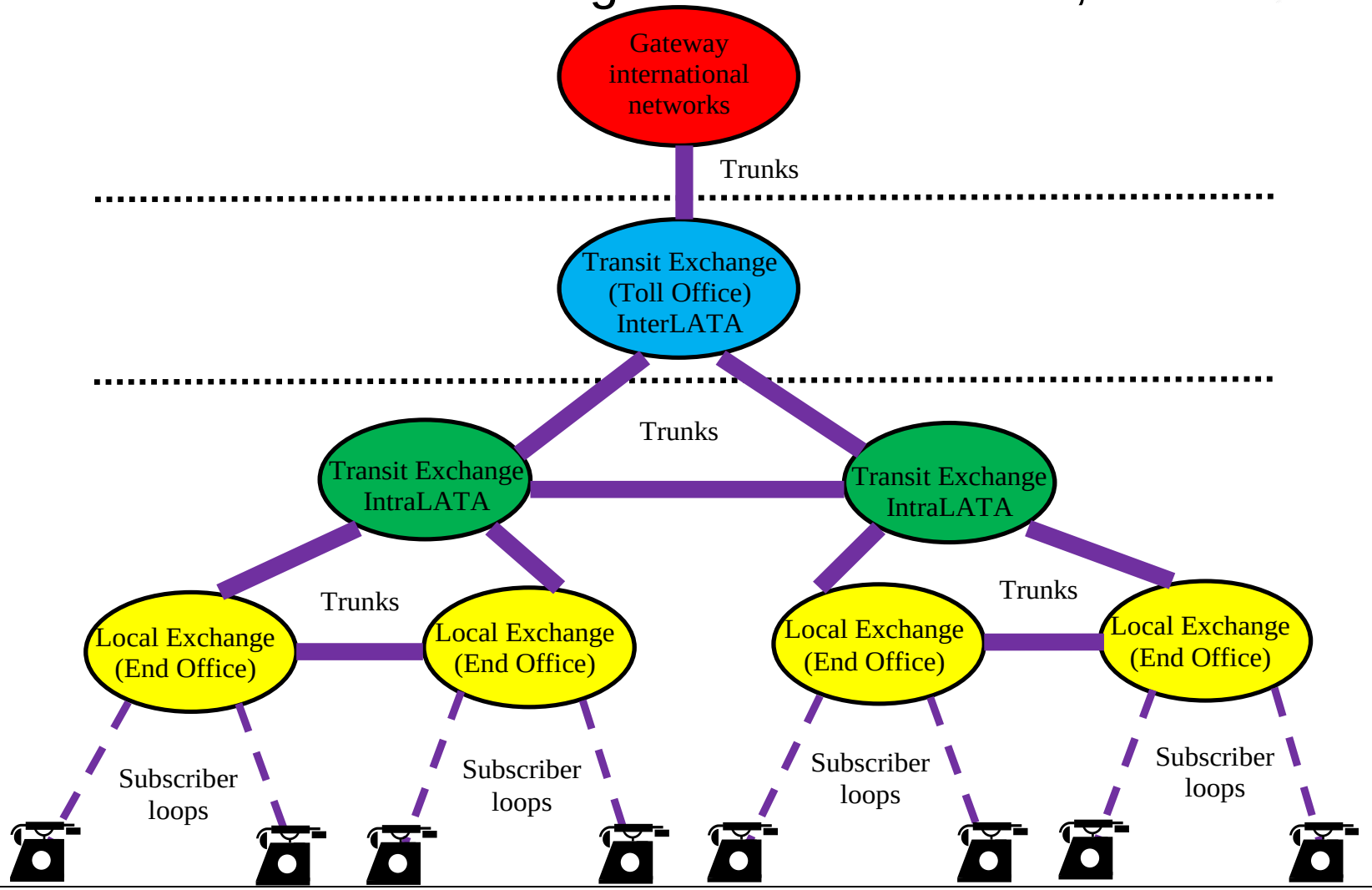
Basic aspects concerning the switching



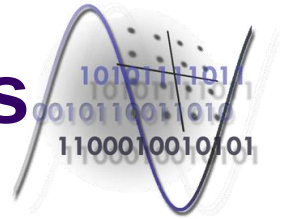
- Local exchange (Central Office / End Office) functions:
  - Connects subscribers to the network;
  - Provide dial tone, power supply and ringing signal;
  - Provide telephone numbers associated with the end office;
  - Connects lines to lines or lines to trunks;
  - Has billing capability.
- Transit exchange (Toll Office / Toll Center) functions:
  - Connects local and transit exchanges;
  - Connects trunks to trunks;
  - Ensures the signaling necessary for trunk connections;
  - Has billing capability.

Basic aspects concerning the switching

- Local and transit switching – basic schematic;



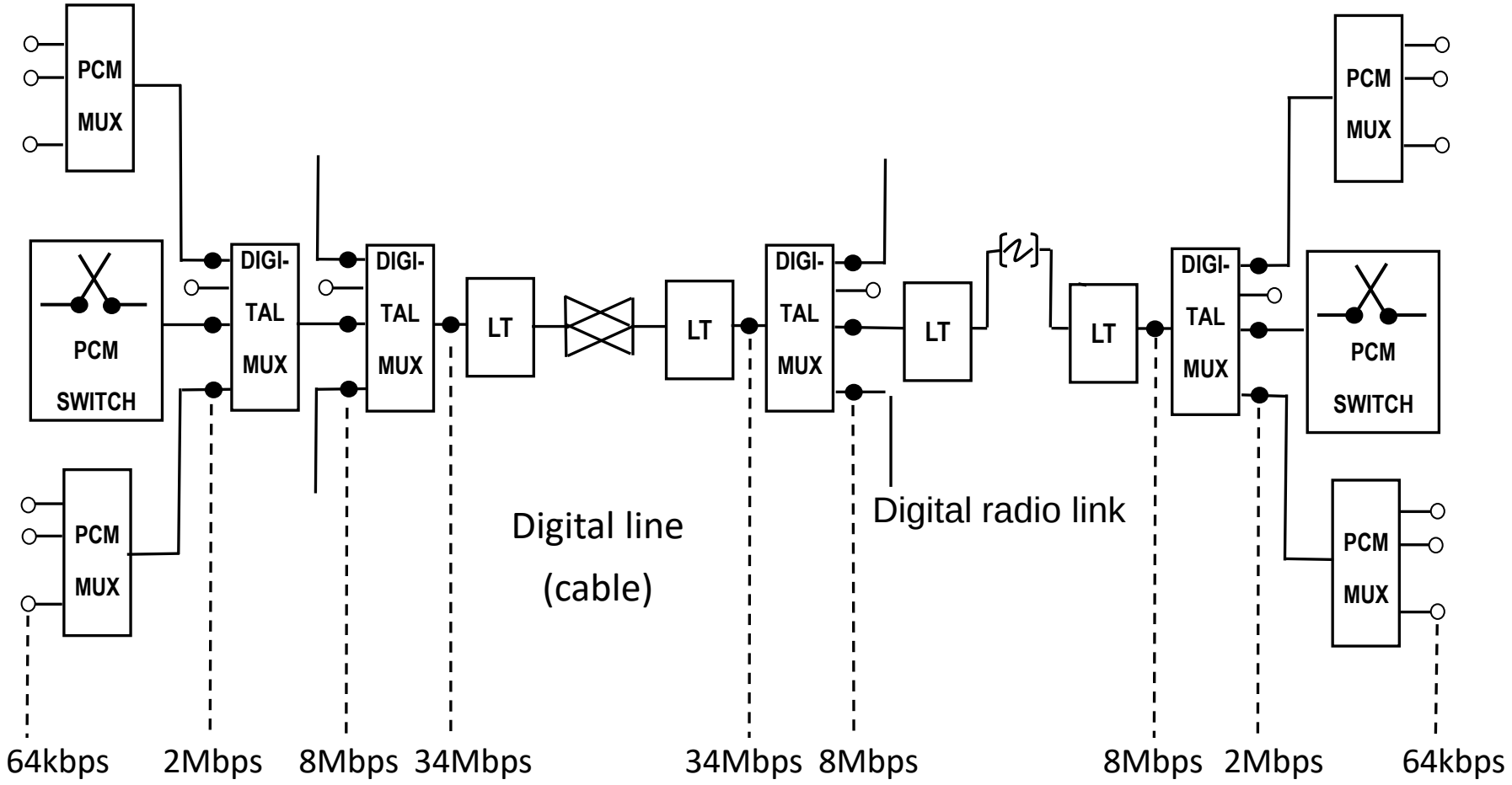
Telephone IDN networks



- IDN (Integrated Digital Network);
  - Telecommunication network dedicated to the transmission of a given type of signal;
    - the term “integrated” refers to the common character of digital techniques used in transmission, switching, multiplexing;
      - processing requested by a telecommunication network.
- Telephone IDN; characteristics:
  - Uses pulse coded modulation (PCM) of the voice signal at a 64kbps rate;
    - this coding technique is used both in the transmission and the multiplexing system;
    - there are differences between the PCM multiplexing and the bit level digital multiplexing.

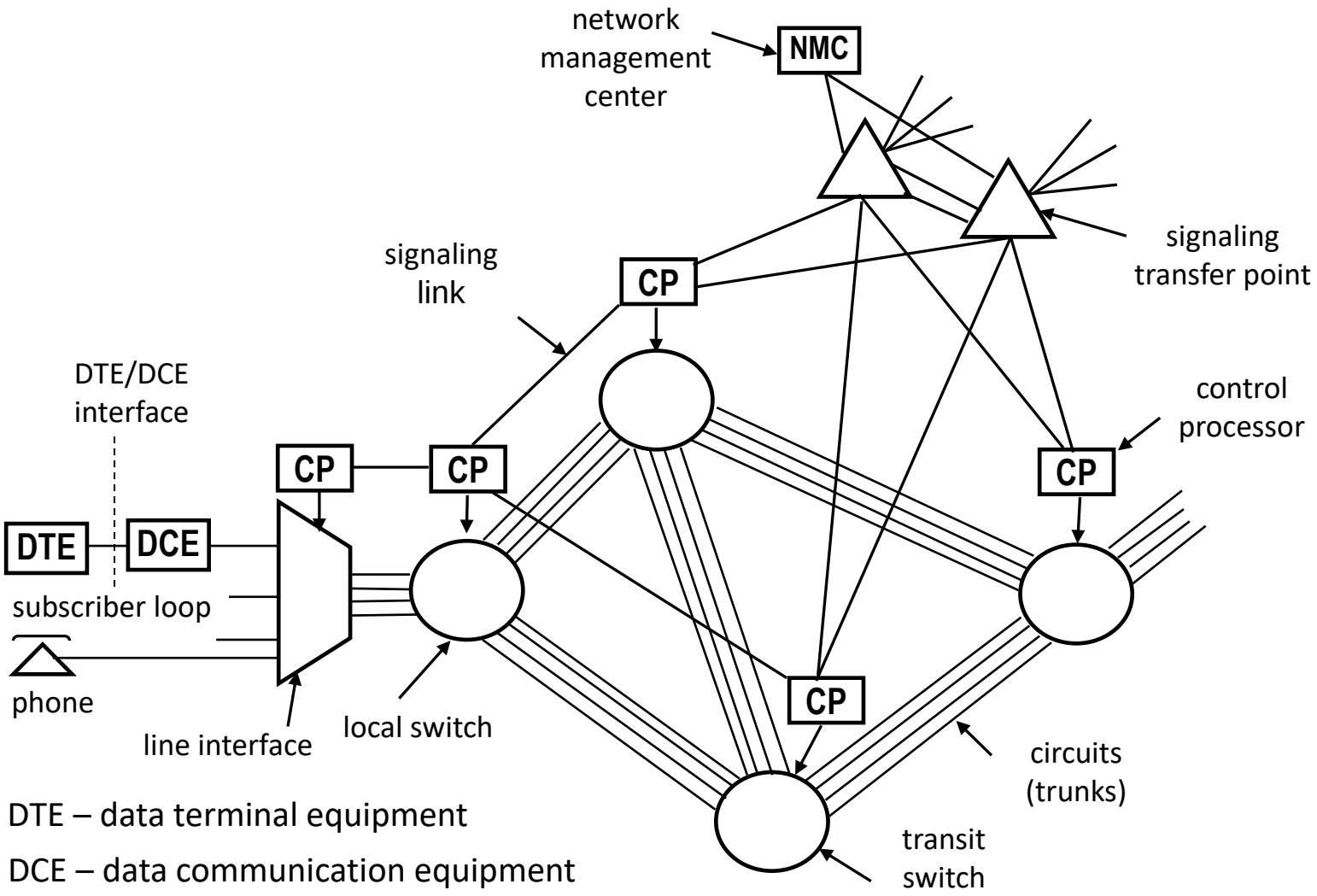
Telephone IDN networks

- Typical multiplexing and transmission system used in a digital telephone network.



Telephone IDN networks

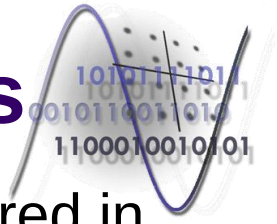
- Basic architecture of a telephone IDN.



Telephone IDN networks

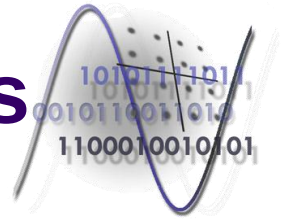
- Main characteristics of the telephone IDN:
  - Circuit switching;
    - it ensures input-output connections at 64kbps bit rate;
      - **the circuit switching (using standardized bandwidths) solves the problem of resource allocation in extended (global) networks;**
    - it operates with multiplexed signals having bit rates bigger or equal with the primary rates – 2048kbps (E1), 1544kbps (T1).
  - The local switches are composed of the subscriber stages (interfacing and concentration role) and group stages (distribution role); the transit switches are composed of group stages.
  - The trunk circuits are provided at 64kbps.
  - The PCM multiplex and switching equipments work synchronously with a common reference frequency of the network;
    - it is necessary to implement o proper distribution of the clock according to the synchronization strategy of the network.

Telephone IDN networks



- The exchanges are controlled by software programs stored in reliable processing units.
- The call control information (the signaling) is exchanged between the switching centers through a dedicated signaling network using a common channel (CCS – Common Channel Signaling);
  - the CCS network is a communication network between computers and uses packet switching technique to transfer the signaling messages between the control computers of the exchanges;
  - the CCS switches are referred as signaling transfer points (STP – Signaling Transfer Points);
  - the packet switching used in the CCS network is based on datagrams (DG);
    - DG is a message that contains in his header the addresses of the transmitter and receiver exchanges and can be routed through the network as an independent message;
    - the datagrams corresponding to a given signaling transaction are routed on the same path in the CCS network.

Data IDN networks



- Data applications can be classified according to the terminal activity during a call:
  - the time interval in which the data terminal is active during the data transfer phase;
  - there are two type of data:
    - volume data (ex. facsimile, teletex, file transfer) - are characterized by a intense activity of the terminal;
    - and burst data (ex. start-stop transmissions between the data terminal and the computer, telemetry) - present a low activity of the terminal during the call.
- The IDNs for data communications use circuit switching or packet switching.

Data IDN networks

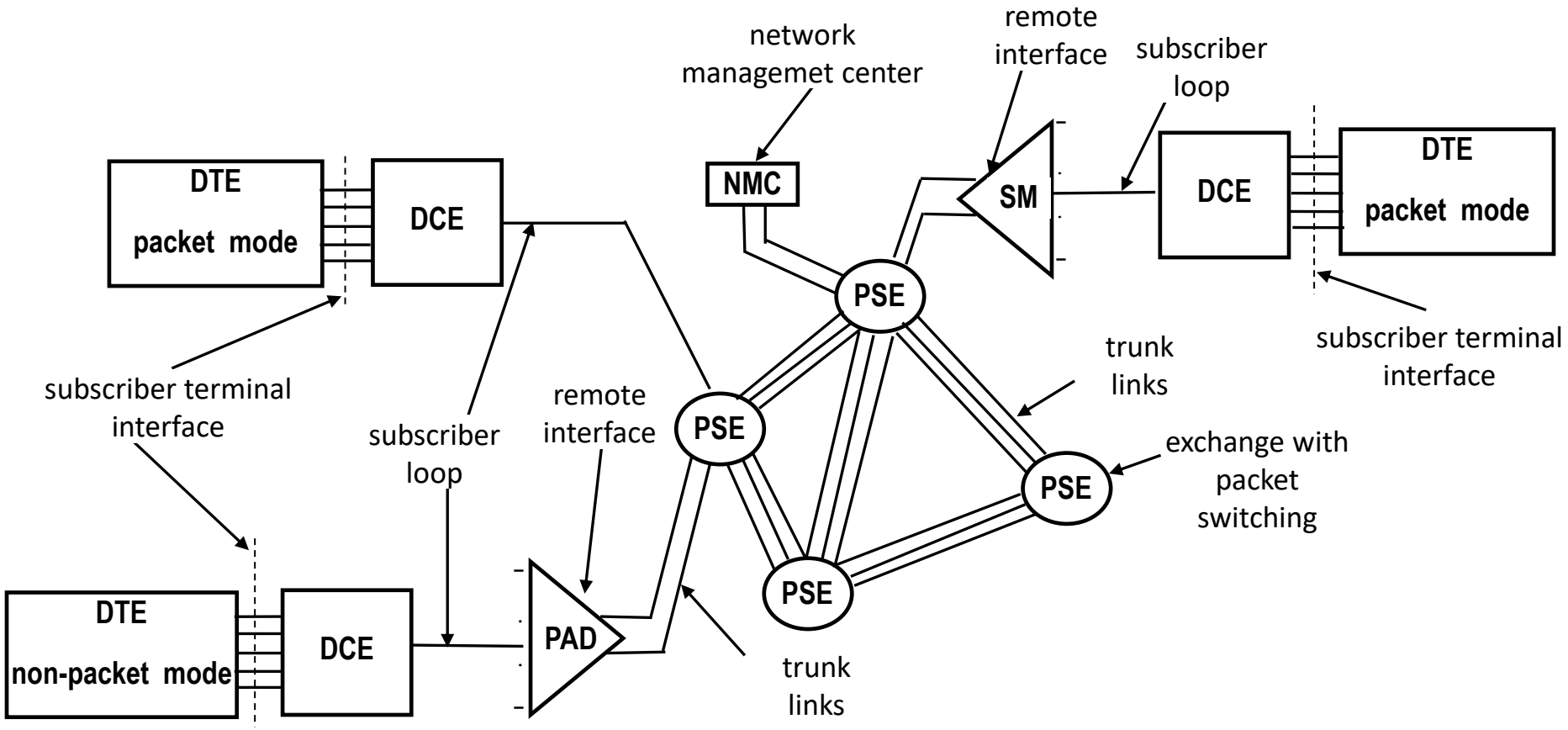
- Data IDNs using circuit switching are designed according to the same rules as the ones used for telephone applications;
  - They are used especially in the case of synchronous transmissions;
  - TDM multiplexing techniques are used to insert several low rate channels into a larger bit rate channel;
    - the basic structure of the network is identical with the one of a telephone IDN (for ex. : the telex network);
    - basic bit rates between the data terminal equipment (DTE) and the data circuit equipment (DCE) are 2.4, 4.8, 9.6, 19.2, 48, 56 and 64kbps.
- Data IDN with packet switching – variant of the message switching techniques;
  - The data are assembled in short messages (packets);
  - A statistical multiplexing (SM) of the packets is used in general on the digital links – having 64kbps rate or multiples.

Data IDN networks

- Packet switching is based on the memorize and send principle;
  - the switches are processing units with stored programs;
  - the users can communicate using:
    - unique data packets (DG) – every packet is (can be) transmitted on a separate path;
    - by establishing a bidirectional transmission implying multiple data packets (virtual call) – several packet are transmitted on the same path.
  - **opposite to circuit switching, it is not necessary to establish a circuit or channel transporting the data;**
    - it is ensured a larger flexibility and a better usage of the network in variable traffic conditions;
  - set up of virtual circuits – achieved by special control packets (have the same format as the data packets and use the same resources);
    - **it is necessary the allocation/ reservation of resources to ensure the continuity of the virtual circuit;**
    - it is allowed a smaller overload of the network (the packets headers contains short number identifying the logical channels instead of the DTE addresses in the case of DG based transmission);
    - it is minimized the probability of delivering the packets associated to a given call in wrong order;

Data IDN networks

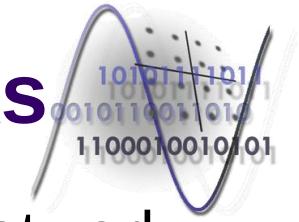
- Basic architecture of a data IDN



PAD – packet assembling/disassembling

SM – statistical multiplexer

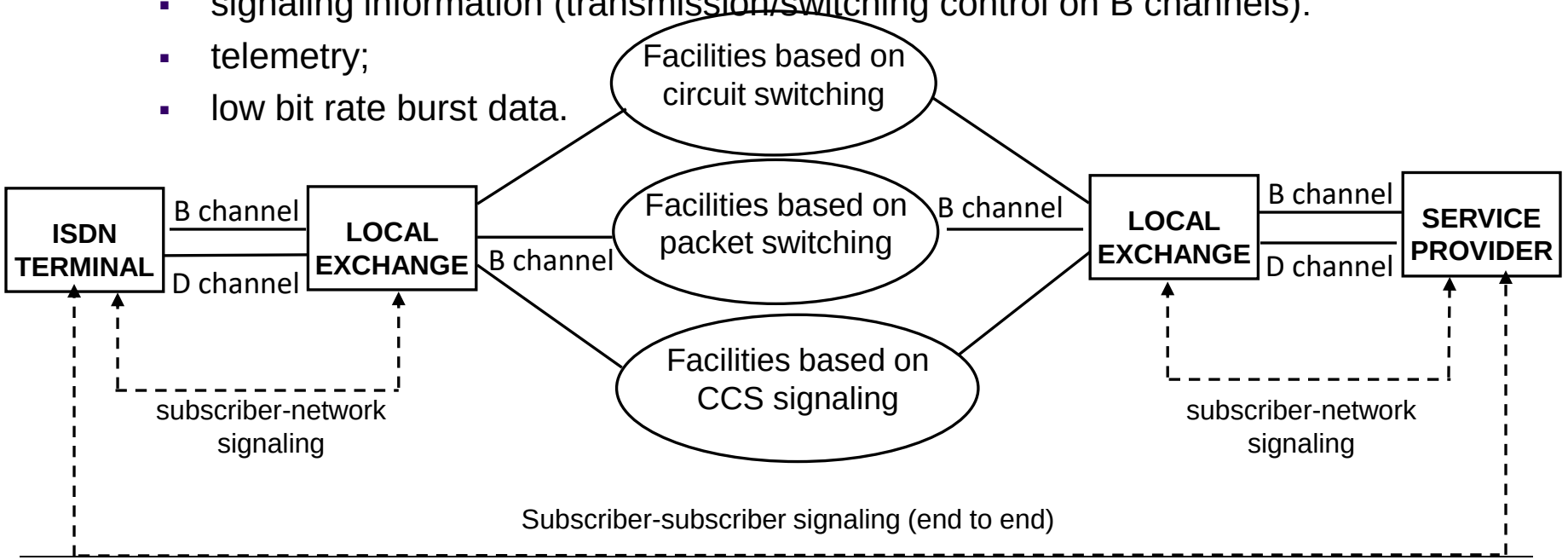
ISDN networks



- ISDN (Integrated Services Digital Network) – digital network with integrated services;
  - Requested by the emergence of new communication services;
- An ISDN network is characterized by three main aspects:
  - 1. End-to-end digital connectivity;
  - 2. Multi-service capacity (voice, data, video);
  - 3. Standard interfaces;
    - it is ensured a multitude of digital communication modes, unitary administration and a limited set of standard user interfaces.
- Usually an ISDN network is based on the telephone IDN with 64kbps bit rate channels, including the digital subscriber line equipments.

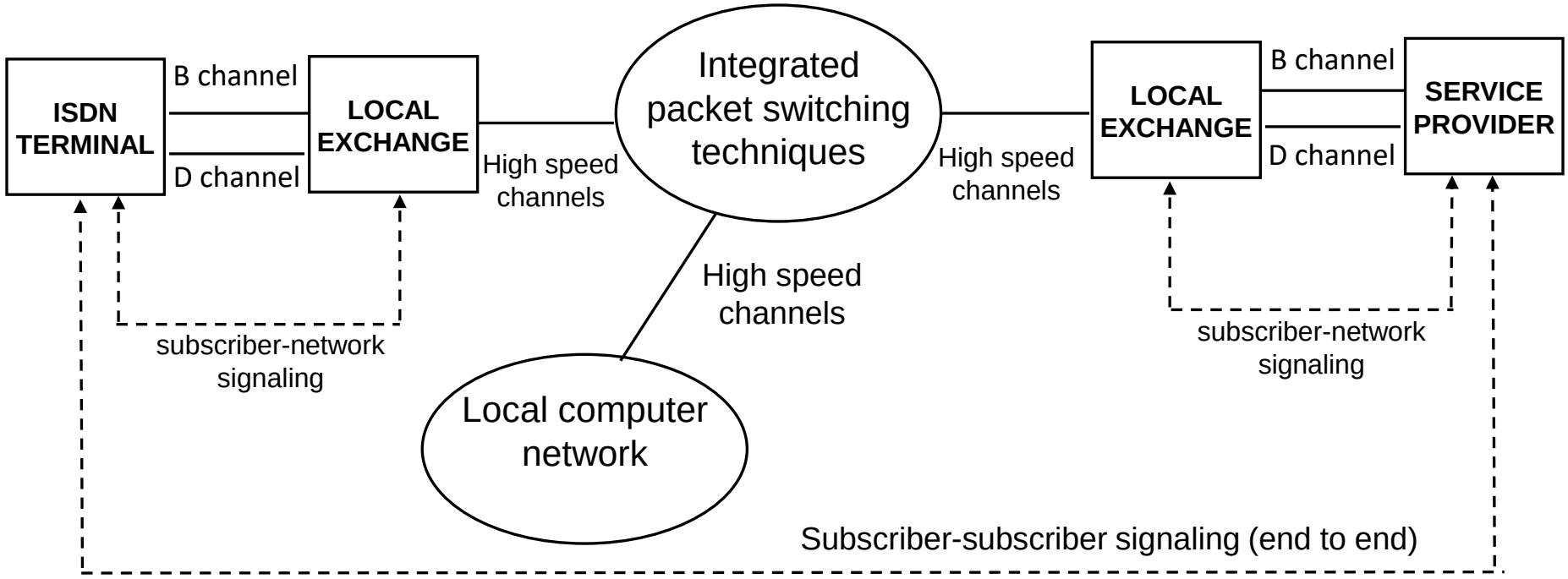
ISDN networks

- In the evolution toward ISDN we can distinguish three phases:
  - Early ISDN architecture with voice and data transmissions capabilities;
    - it is based on B type channels (64kbps);
      - data channels, typical PCM voice channels;
    - and on D type channels used for:
      - signaling information (transmission/switching control on B channels):
      - telemetry;
      - low bit rate burst data.



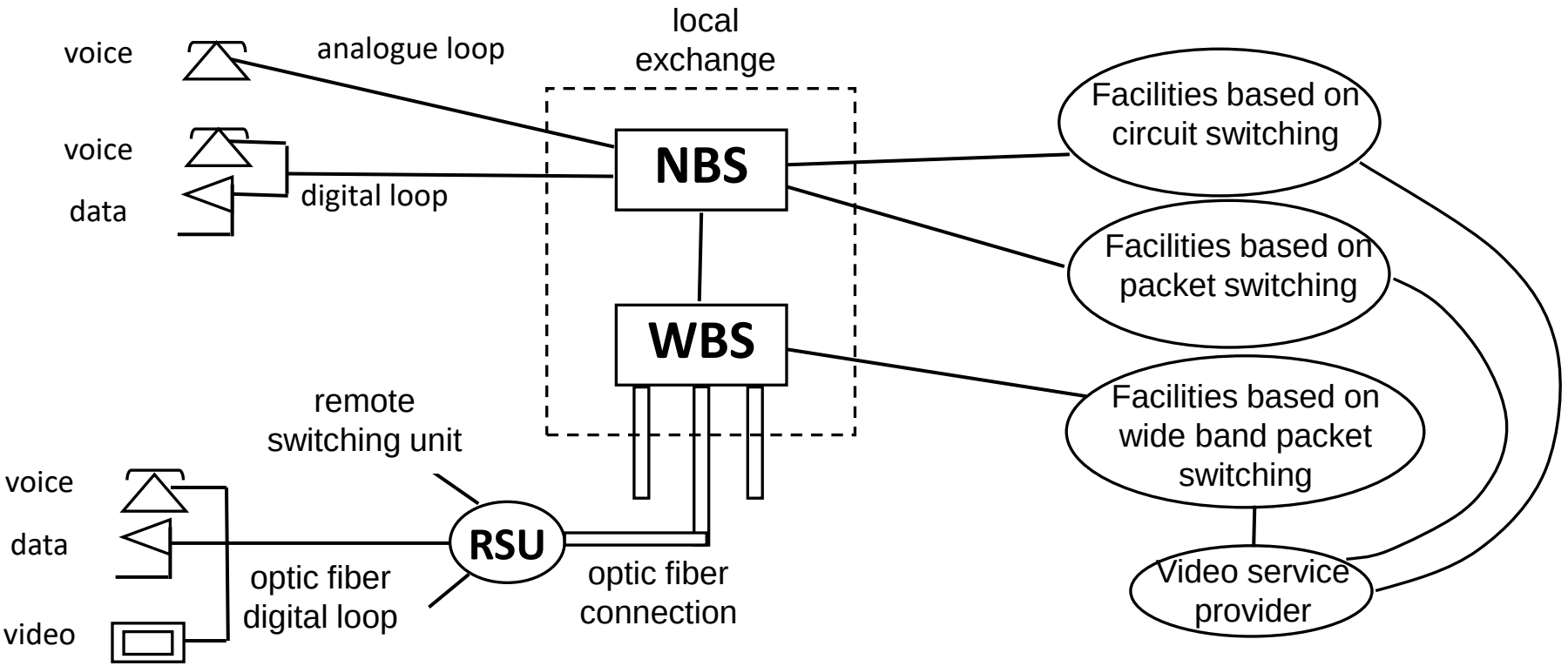
ISDN networks

- Advanced ISDN architecture for voice and data;



ISDN networks

- ISDN architecture with wide band capability;

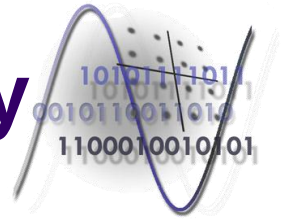


RSU – remote switching unit

NBS – narrow band switching system

WBS – wide band switching system

VoIP Technology

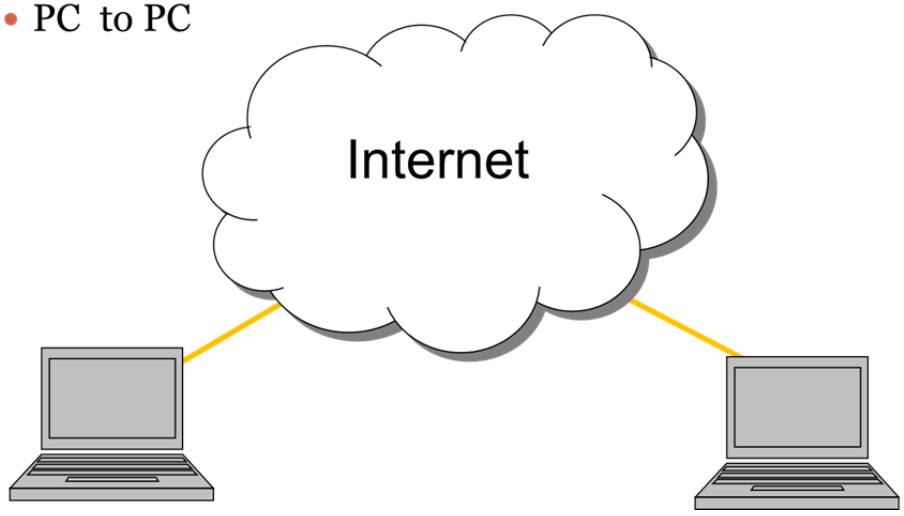


- Voice over Internet Protocol (VoIP)
  - is a technology that allows to make voice calls using a broadband Internet connection instead of a regular (or analog) phone line, also referred to as IP Telephony
  - VOIP uses the Internet Protocol (IP) to transmit digitized voice as packets over an IP network.
    - VOIP can be achieved on any data network that uses IP, like Internet, Intranets and Local Area Networks (LAN).
    - the voice signal is digitized, compressed and converted to IP packets and then transmitted over the IP network.
    - signaling protocols are used to set up and tear down calls, carry information required to locate users, and negotiate capabilities.
    - VoIP includes Voice over Broadband (VoB), Voice over Digital Subscriber Line (DSL), Voice over Internet (VoI), Voice over Wireless Local Area, Network and Internet telephony.

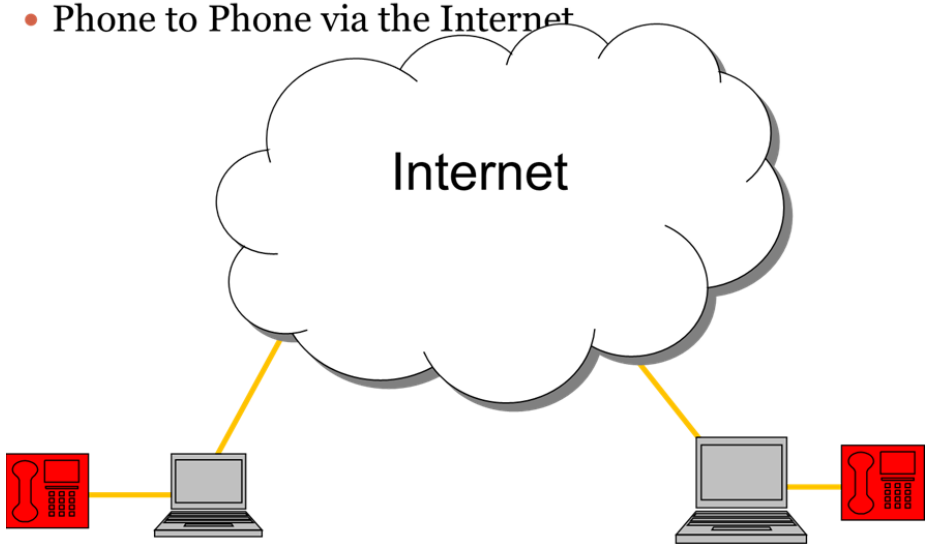
VoIP Technology

- some VoIP services may only allow you to call other people using the same service, but others may allow you to call any telephone number - local, long distance, mobile, and international numbers.
- some VoIP services only work over your computer or a special VoIP phone, other services allow you to use a traditional phone connected to a VoIP adapter.

- PC to PC

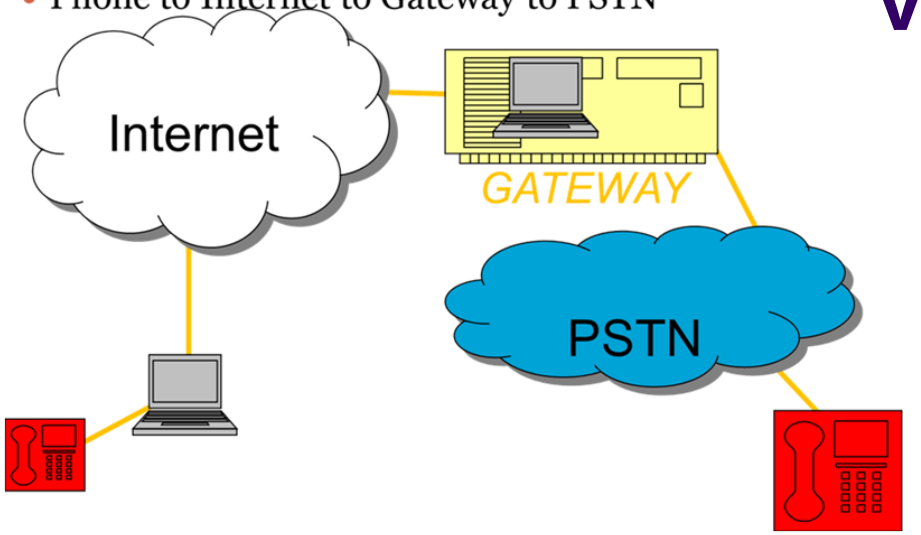


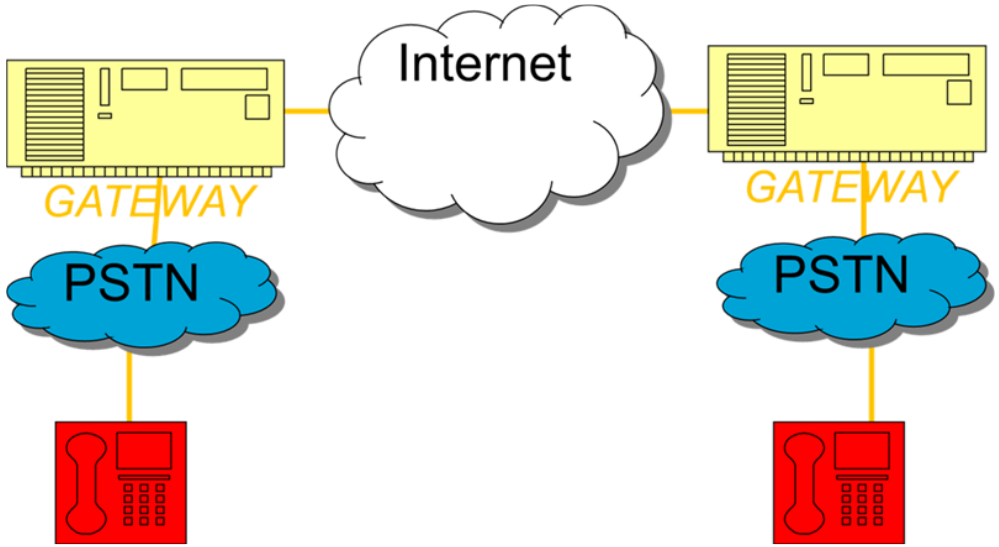
- Phone to Phone via the Internet



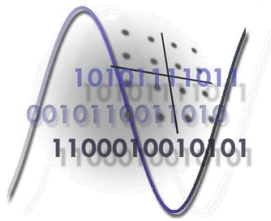
VoIP Technology

- Phone to Internet to Gateway to PSTN

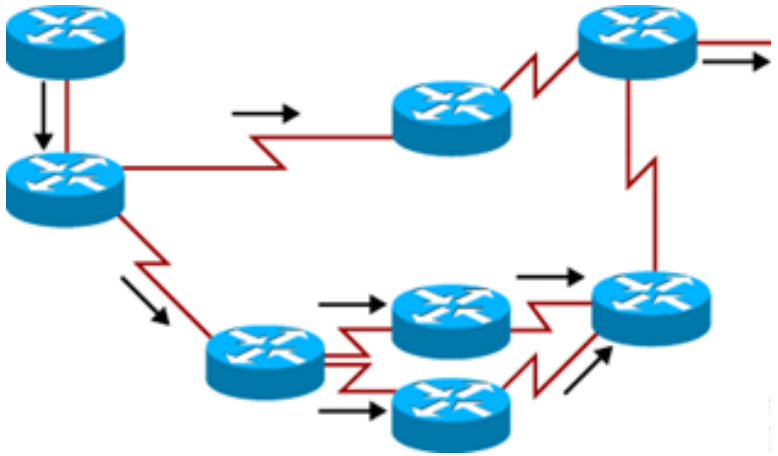




Next Generation Networks (NGN) based on IP architecture

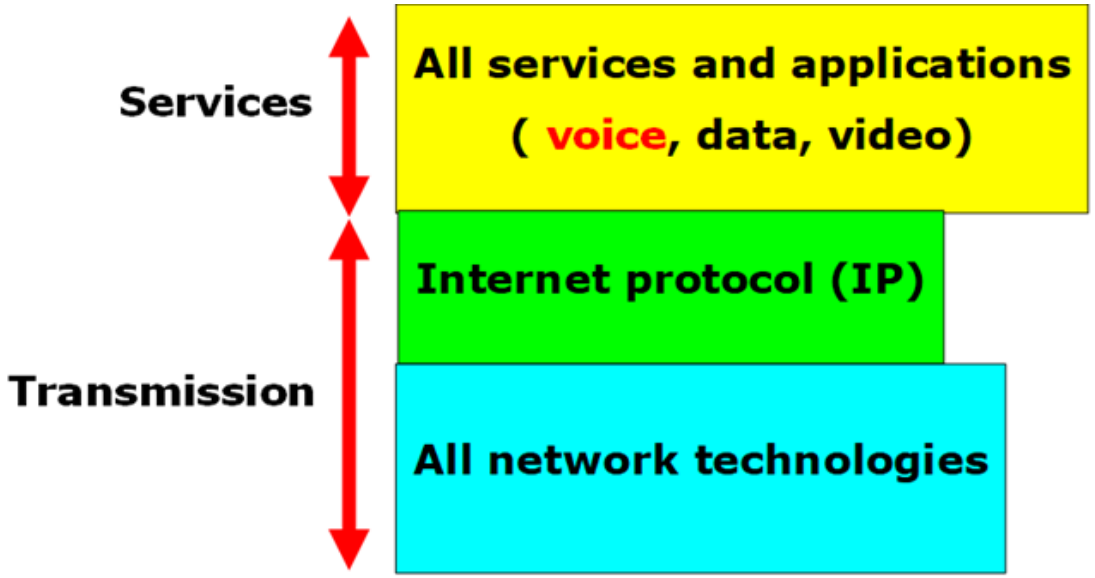


- IP networks – main characteristics
  - IP is connectionless
  - IP provides multiple paths from source to destination
  - IP network issues:
    - Packet loss
      - Loss of packets severely degrades the voice application
    - Delay
      - VoIP typically tolerates delays up to 150 ms before the quality of the call degrades
    - Jitter
      - Instantaneous buffer use causes delay variation in the same voice stream



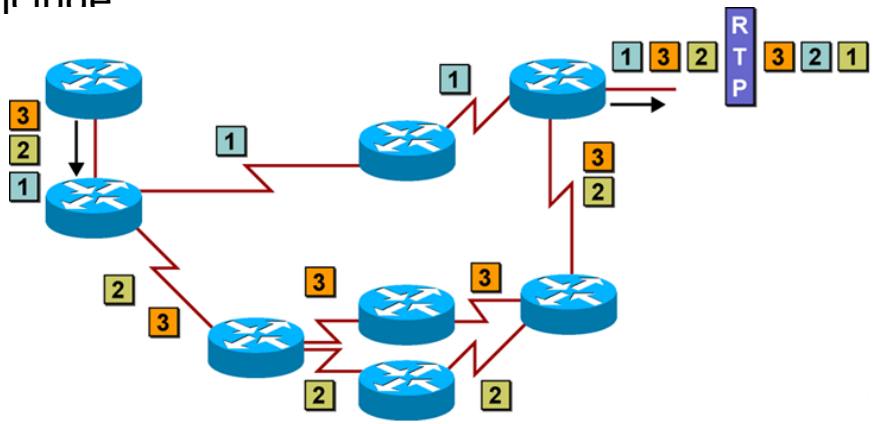
Next Generation Networks (NGN) based on IP architecture

- Concept of IP Communication
  - Protocols split transmitted data into packets, add necessary addressing information to the packets, transmit them, and assemble again the data in the receiving end
  - Communications controlled by a protocol stack

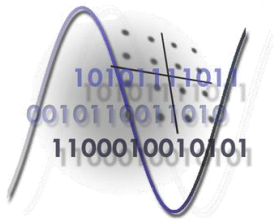


Next Generation Networks (NGN) based on IP architecture

- IP network requirements for voice
  - Consistent Throughput
    - Throughput is the amount of data transmitted between two nodes in a given period
    - Throughput is a function of bandwidth, error performance, congestion, and other factors
    - Tools for enhanced voice throughput include:
      - Queuing
      - Congestion avoidance
      - Header compression
      - RSVP (Resource Reservation Protocol)
      - Fragmentation
  - Reordering of Packets
    - IP assumes packet-ordering problems
    - RTP (Real-Time Protocol) reorders packets

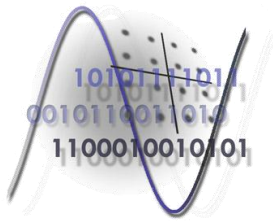


Next Generation Networks (NGN) based on IP architecture



- Reliability and Availability
  - Traditional telephony networks claim 99.999% uptime
  - Data networks must consider reliability and availability requirements when incorporating voice
  - Methods to improve reliability and availability include:
    - Redundant hardware
    - Redundant links
    - UPS
    - Proactive network
    - management

Next Generation Networks (NGN) based on IP architecture

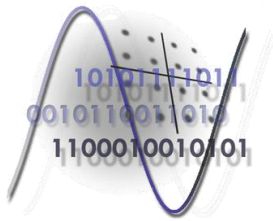


- PSTN telephony vs VoIP

PSTN	VoIP
Circuit switched	Packet switched
E.164 numbering	URL SIP names, E.164, IP addr
Intelligent network / dumb terminal	Dumb network / intelligent terminal
Charging bases: location, distance, time	Charging bases: more limited
Closed system	Open system
Inherited security	Security vital issue

  - E.164 is an international standard (ITU-T Recommendation), titled The international public telecommunication numbering plan, that defines a numbering plan for the worldwide public switched telephone network (PSTN) and some other data networks.
  - PSTN = Public Switched Telephone Network

Next Generation Networks (NGN) based on IP architecture



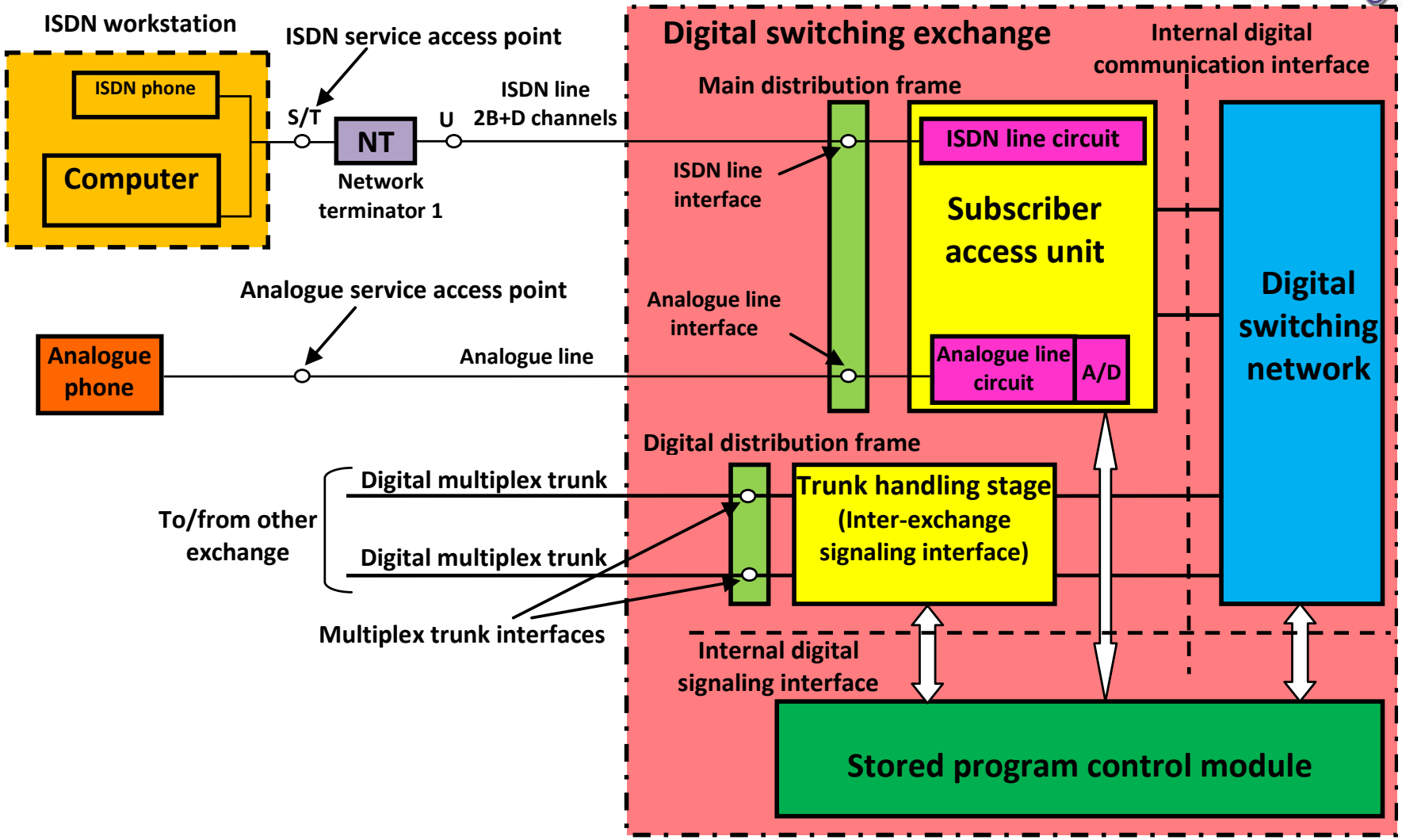
- PSTN telephony vs VoIP

PSTN	VoIP
Tech. quality: standardised transmission characteristics	Tech. quality: depends mainly on delays and delay variations
Remote power feeding	Requires electric power

- Co-existance of IP phone and PSTN phone
  - publicly offered VoIP has to co-operate with PSTN (terminated, originated at PSTN)

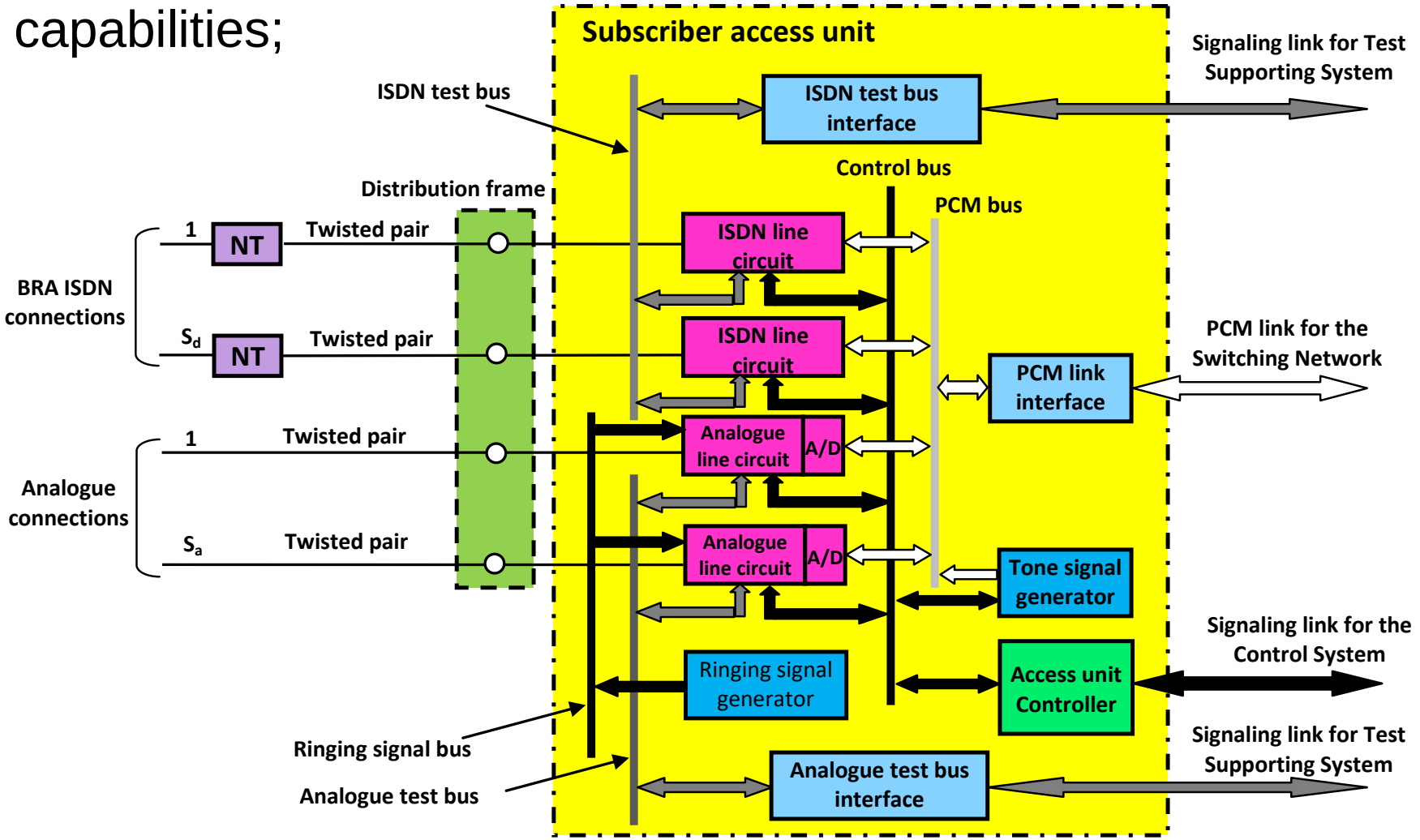
Annex 1: ISDN networks

- Basic architecture of a narrow band ISDN exchange;

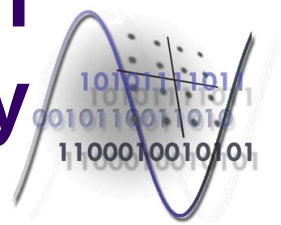


ISDN networks

- Subscriber access unit from a local exchange with ISDN capabilities;

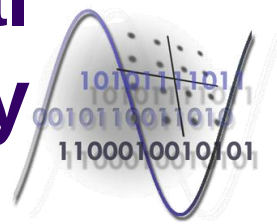


Annex 2: Usual definitions in classical telephony



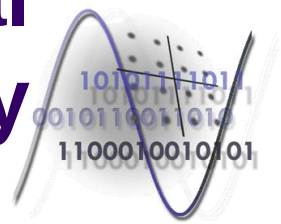
- 1. Transmission channel (path);
  - The combination of means necessary to ensure the transmission of signals in one direction between two points;
    - several channels can be multiplexed on a common transmission medium by frequency or time division multiplexing;
    - a digital channel is provided at 64kbps rate on a digital link;
- 2. Circuit section;
  - Includes two digital channels, one for every transmission direction;
  - It is defined by two consecutive points in which time conversions are performed;
- 3. Circuit;
  - The combination of two channels that ensures a bidirectional transmission between two points;
    - Note: in telephony the term „circuit” is synonymous with „telecommunication circuit” which connects two switching centers;

Usual definitions in classical telephony



- 4. Digital link (Digital path);
  - The combination of means that allow to transmit and receive a digital signal with specified bit rate between two digital distribution frames (or equivalent equipments);
    - Note: a digital link includes one or more digital sections;
- 5. Digital section;
  - The combination of means that allow the transmission and the reception of digital signals with specified bit rates between two consecutive digital distribution frames (or equivalent equipments).
- 6. Digital line section;
  - Consists of two consecutive line terminating equipments, the transmission medium that connects them and the internal cabling of the exchange located between them and the distribution frames (or their equivalent);

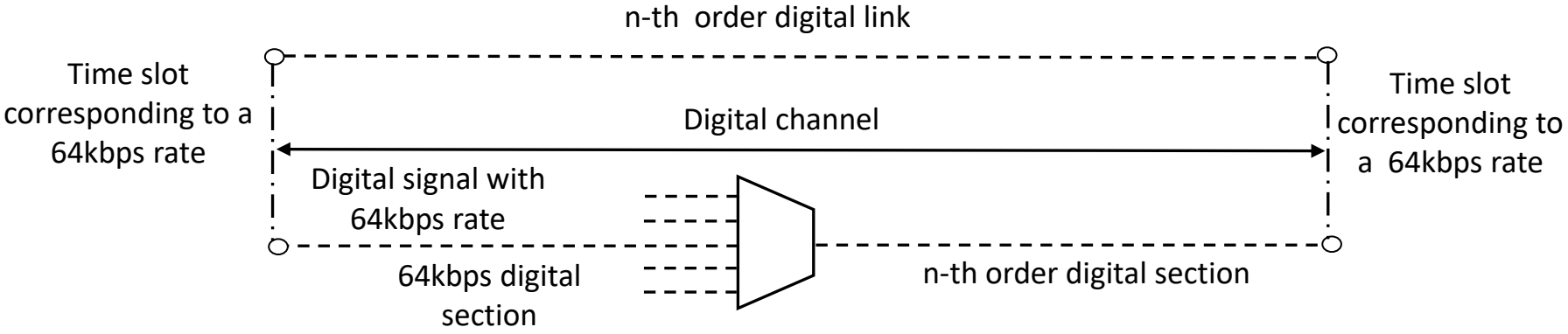
Usual definitions in classical telephony

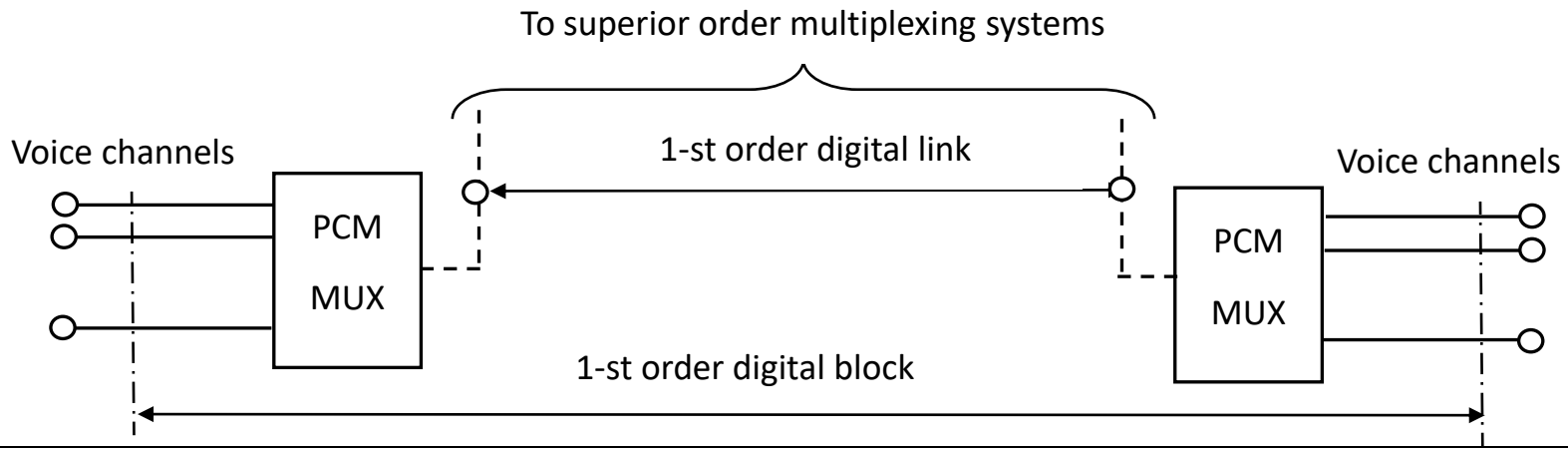


- 7. Digital line path (Digital line link);
  - It is formed by two or more digital line sections connected so that the specified bit rate is the same on the entire path between two terminal digital distribution frames (or their equivalent);
- 8. Digital block:
  - The combination formed by a digital link and the associated multiplexing equipments;
- 9. Primary block:
  - Is the basic PCM group, assembled by time domain multiplexing;
    - Primary block „μ” – basic PCM group formed from 24 basic 64kbps channels having a 1544kbps rate;
    - Primary block „A” – basic PCM group formed from 32 basic 64kbps channels having a 2048kbps rate;

Usual definitions in classical telephony

- 10. Digital distribution frame:
  - It is a frame where are performed all the connections between the outputs of some equipments and the inputs of other equipments;





Usual definitions in classical telephony