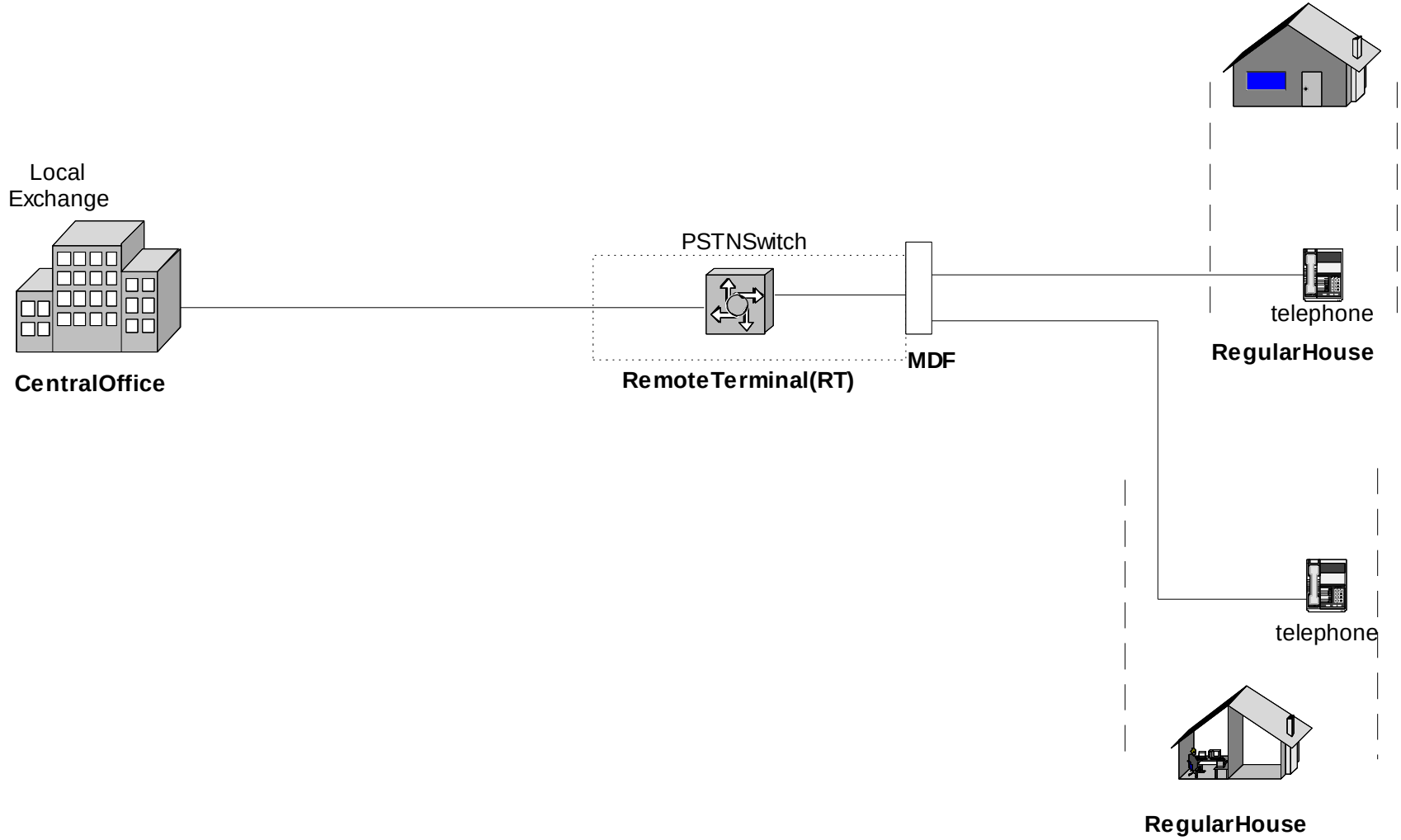
Broadband Technology

An Overview

Typical Narrowband (voice) setup



Voice typically uses the range 300Hz to 3,400Hz. Telephone conversations can be had at 4 Khz.

How does DSL work?

- The local loop of the public switched telephone network (PSTN) was initially designed to carry POTS voice communication and signaling.

- The phone system nominally passes audio between 0.3 KHz and 3.4 KHz, which is regarded as the range required for human speech to be clearly intelligible. This is known as voiceband or commercial bandwidth.

- At the local telephone exchange the speech is generally digitized into a 64 kbit/s data stream in the form of an 8 bit signal using a sampling rate of 8,000 Hz, therefore, according to the Nyquist theorem, any signal above 4,000 Hz is not passed by the phone network.

- The local loop connecting the telephone exchange to most subscribers is capable of carrying frequencies well beyond the 3.4 kHz upper limit of POTS.

- *Depending on the length and quality of the loop, the upper limit can be tens of megahertz.*

- DSL takes advantage of this unused bandwidth of the local loop for carrying data.

DSL (Digital Subscriber Line)

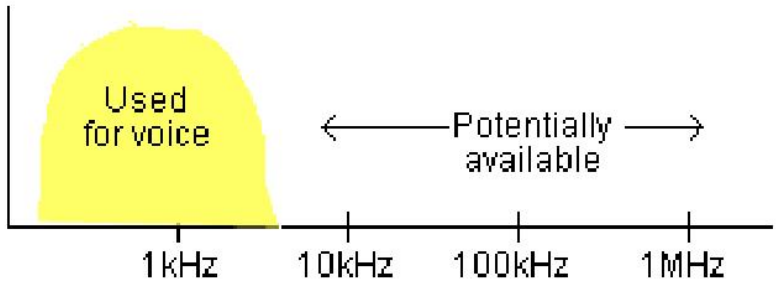
DSL or **xDSL**, is a family of technologies that provides digital data transmission over the wires of a local telephone network. DSL (Digital Subscriber Line) exploits the unused analogue bandwidth that is potentially available in the wires that run from the user premises to the local exchange.

DSL can be used at the same time and on the same telephone line with regular telephone, as it uses high frequency, while regular telephone uses low frequency.

Typically, the download speed of consumer DSL services ranges from 256 kilobits per second (kbit/s) to 24,000 kbit/s, depending on DSL technology, line conditions and service level implemented.

The frequencies that the local loop can carry - and hence, the amount of data transmission capacity that is available - depend on a number of factors such as:

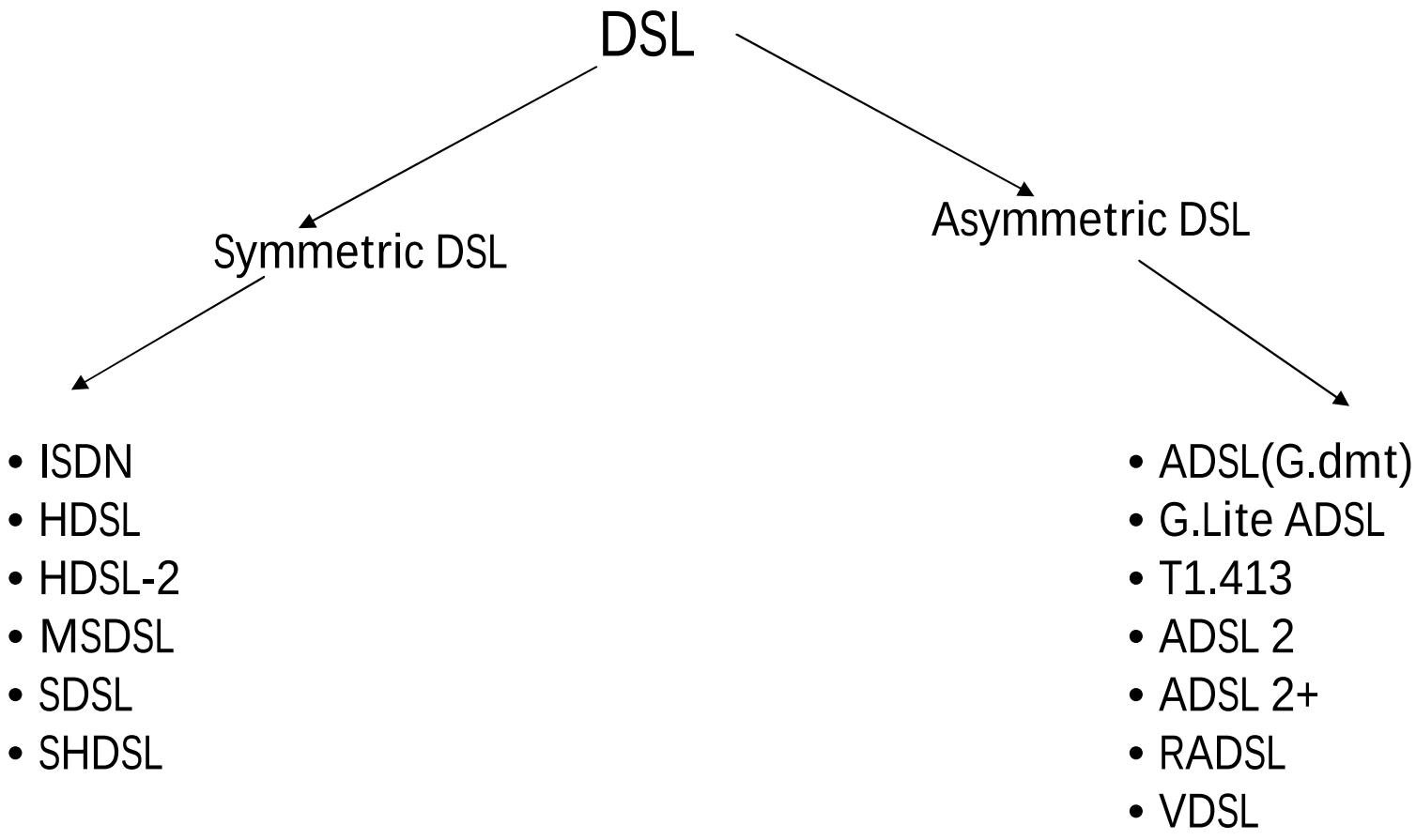
- the distance from the local exchange
- the type and thickness of wires used
- the number and type of joints in the wire
- the proximity of the wire to other wires carrying xDSL, ISDN and other non-voice signals
- the proximity of the wires to radio transmitters.



xDSL

Refers to different flavors of Digital Subscriber Line

Variants in DSL Technology



Symmetric Vs Asymmetric

Symmetric bandwidth corresponds to the situation when the maximum rate of transfer is the ***same*** in both directions i.e. upload and download speed.

Asymmetric bandwidth corresponds to the situation when the maximum rate of transfer is ***different*** in each direction. A typical case might be a DSL line with 768 kbps upload and 2 Mbps download.

Asymmetric DSL Standards
==========
ADSL: (Full Rate asymmetrical DSL)
G.lite ADSL (or simply G.lite)
RADSL: (rate adaptive DSL)
VDSL (Very high bit rate DSL)

Symmetric DSL Standards
==========
SDSL: (Symmetric DSL)
SHDSL (Single-pair high-speed DSL)
HDSL: (High bit rate DSL)
HDSL2: (2nd generation HDSL)
IDSL: (Integrated services digital network DSL)

What is ADSL ?

Asymmetrical digital subscriber line (ADSL) is emerging as the optimal solution to high-speed Internet access technology. ADSL matches the asymmetric pattern of Internet traffic with speeds of up to 8 Mb/s downstream from the network to the end user, and up to 640 kb/s upstream from the end user to the network. Because ADSL can transmit both voice and data simultaneously over an existing, single copper pair up to 5.5 KM long, it is the perfect solution for service providers to meet the increasing customer demand for faster Internet access. With its amazing speed and economical use of the installed base of copper cable, ADSL keeps the service cost low for both service providers and end users.

An ADSL system consists of the following components:

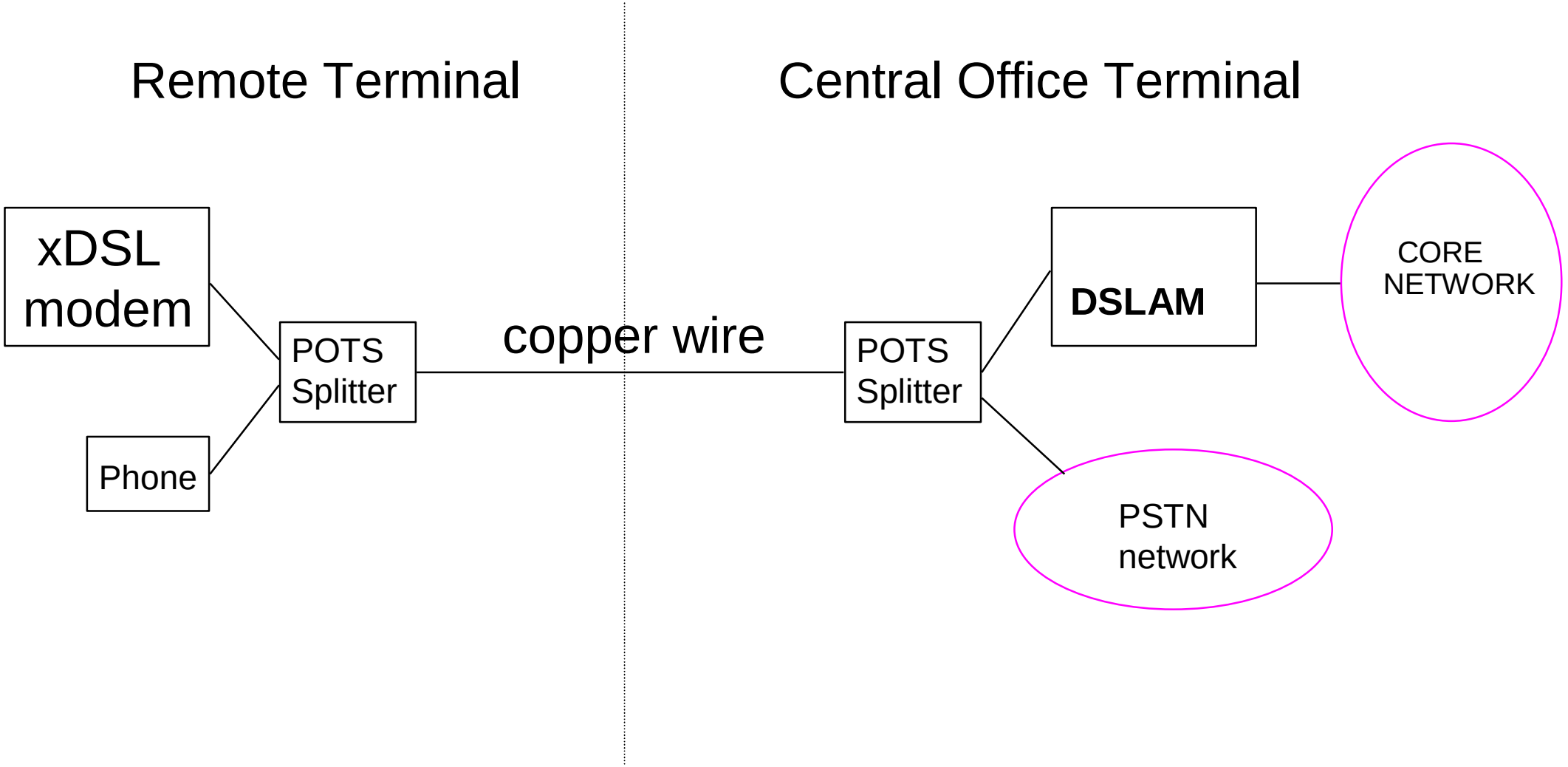
- ADSL transceiver unit-central office (ATU-C), also referred to as DSLAM

- ADSL transceiver unit-remote (ATU-R), also referred to as an ADSL modem

- Splitter – low pass filter for separating POTS from ADSL

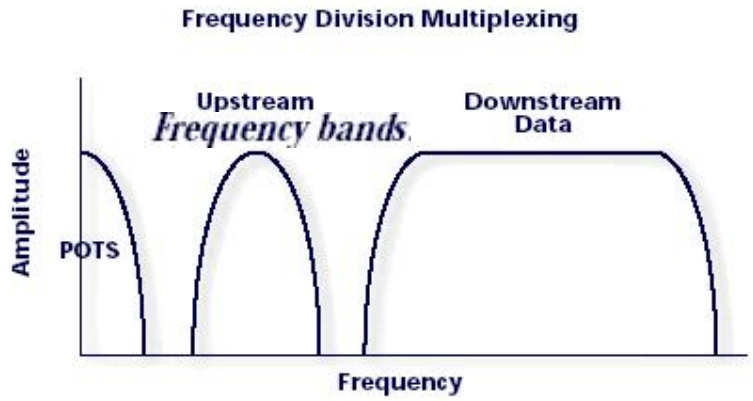
- Digital subscriber line access multiplexer (DSLAM) – Multiplexes many ADSL copper lines into one Ethernet uplink fiber and include the splitter in ATU-C Frame.

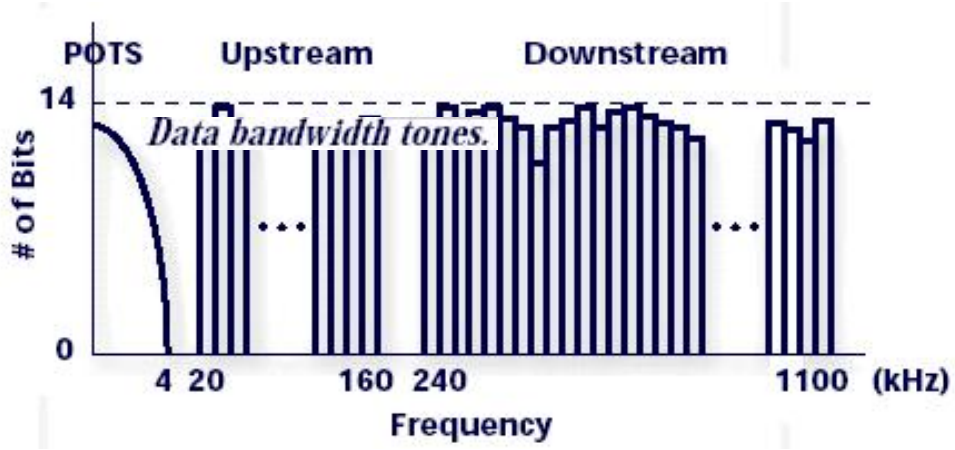
Network Model for Asymmetric DSL



Modulation Techniques

Traditional plain old telephone service (POTS) uses a narrow 4-kHz baseband frequency to transmit analog voice signals. This means that even with sophisticated modulation techniques, current modem technology can only achieve throughput of up to 56 kb/s. To attain a much higher throughput of up to 8 Mb/s, ADSL increases the usable frequency range from 4 kHz to 1.1 MHz. Frequency division multiplexing (FDM) then allows ADSL to create multiple frequency bands to carry upstream and downstream data simultaneously with the POTS signal over the same copper pair. The lower 4-kHz frequency range is reserved for POTS, the middle frequency band is used to transmit upstream data, and the larger, higher frequency band is used for downstream data.





ADSL: Modulation Techniques

- Modulation is the overlaying of information (or the signal) onto an electronic or optical carrier waveform.

- There are two standards for modulating the ADSL signal, known as

  - Discrete Multi-Tone (DMT)
  - Carrierless Amplitude Phase (CAP).

- CAP was the original technology used for DSL deployments, but the most widely used method now is DMT.

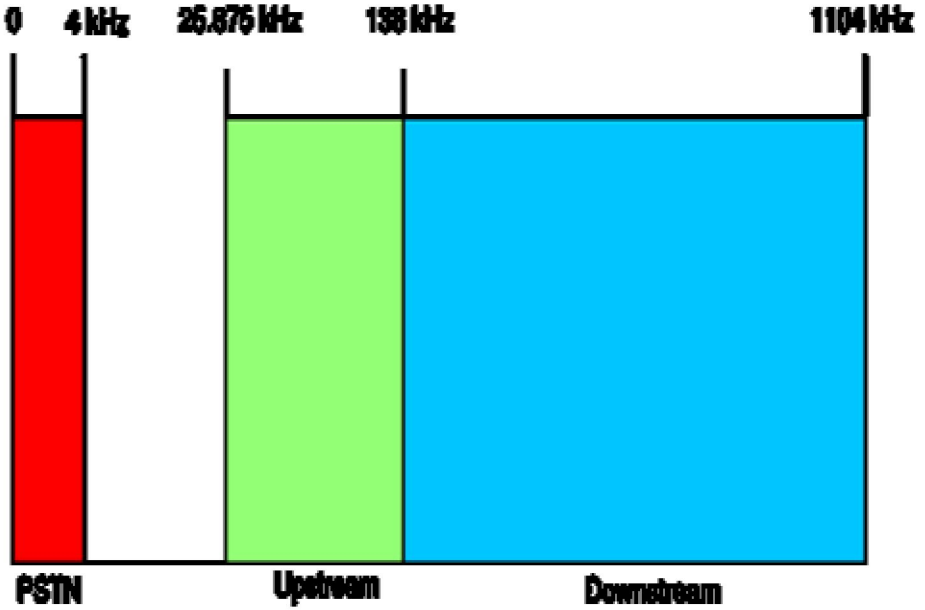
ADSL: DMT Modulation

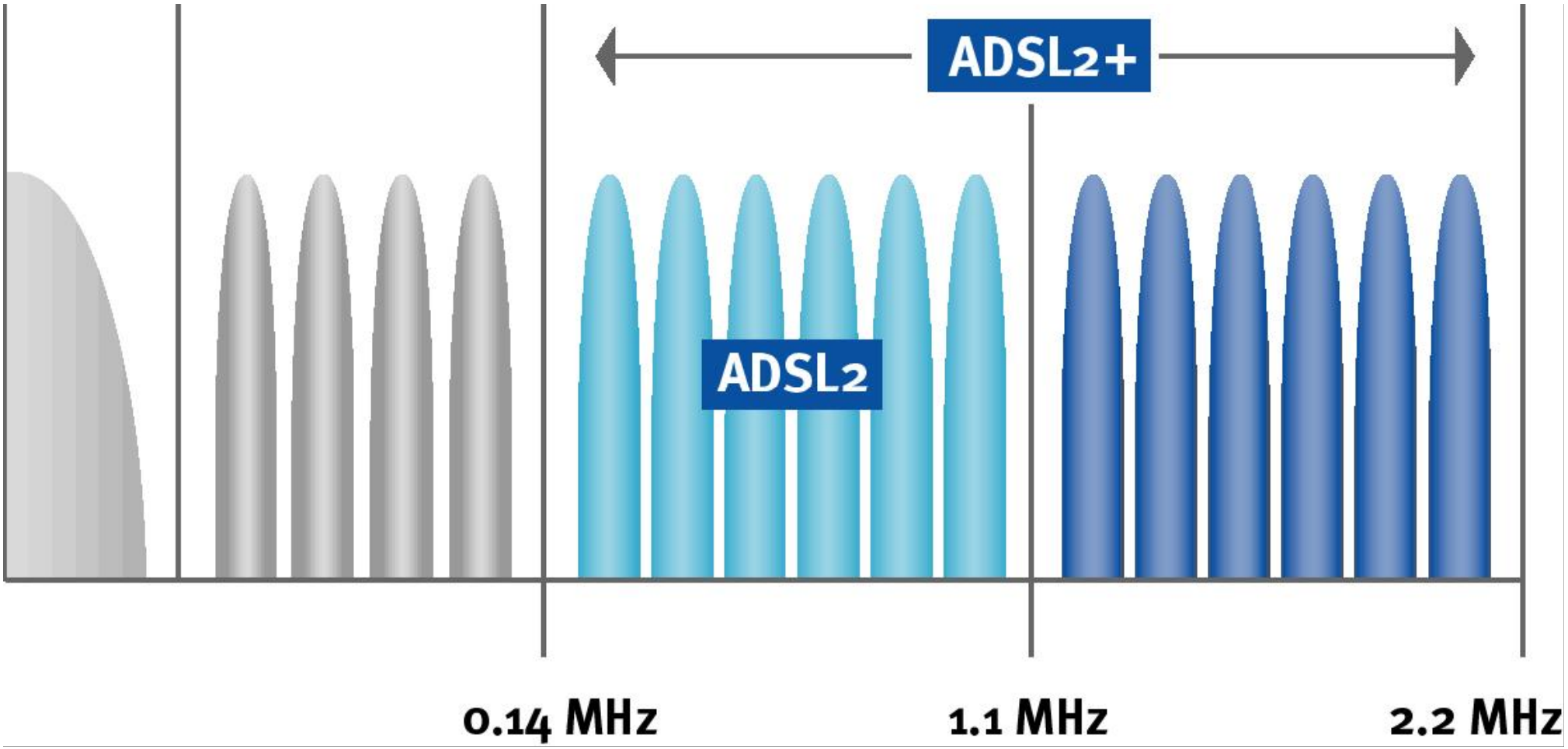
Discrete multi-tone (DMT) modulation has been chosen by the American National Standards Institute (ANSI) as the standard T1.413 line code. DMT, as its name implies, divides the data bandwidth into 256 sub-channels,or tones, ranging from 25 kHz to 1.1 MHz. Upstream data transfer frequencies range from 25 kHz to 138 kHz, and downstream data transfer frequencies range from 138 kHz to 1.1 MHz.

§ Each band is divided into bins.
1 bin = 4.3125 kHz.

§ The frequency layout is :-
- 0-4 kHz - voice.
- 4-25 kHz -unused guard band.
- 25-138 kHz - 25 upstream bins (7-31).
-138-1104 kHz - 224 downstream bins (32-255).

§ No. of Bits Encoded/ Bin – 2 to 15 depending on the **attenuation** and **signal to noise ratio** for that bin .




ADSL2+
ADSL2
0.14 MHz
1.1 MHz
2.2 MHz

Different ADSL Standards :

ITU-T Rec. G.992.1: G.992.1 specifies the characteristics of the ADSL interface to metallic loops. G.992.1 supports a minimum 6.144-Mbps downstream and 640-kbps upstream net data rate. It will be referred to as G.DMT.

ITU-T Rec. G.992.2: G.992.2 specifies the physical layer characteristics of splitterless ADSL.
G.992.2 supports a maximum 1.536-Mbps downstream and 512-kbps upstream net data rate. It will be referred to as G.Lite.

ITU-T Rec. G.992.3:Transmission System and Media Digital System & Network for ADSL2 Describes Asymmetrical subscriber Line (ADSL) Transceivers on a metallic twisted pair.
Downstream and Upstream data rates up to 12Mbps and 1Mbps .

ITU-T Rec. G.992.5 :Transmission System and Media Digital System & Network for ADSL2+. Describes Asymmetrical subscriber Line (ADSL) Transceivers on a metallic twisted pair.

Downstream and Upstream data rates up to 24Mbps and 1Mbps .

Supported Data Rates

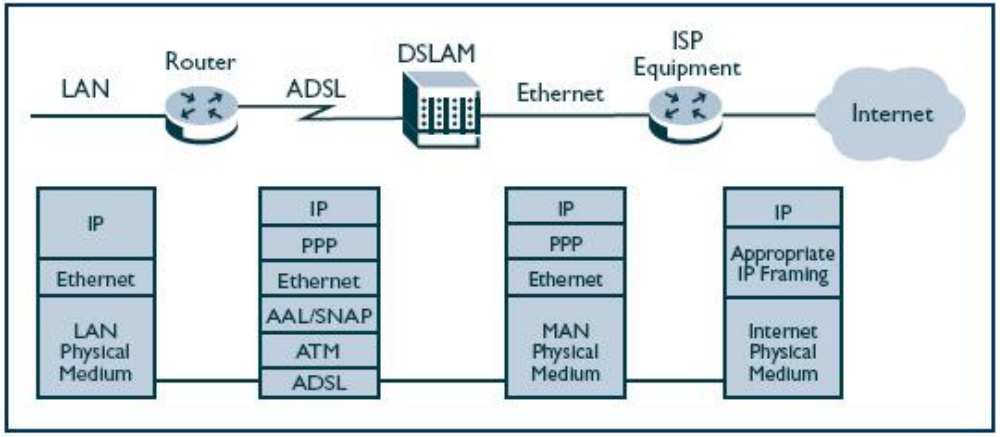
Standard	Downstream rate	Upstream rate
G.992.1 ADSL	8Mbit/s	1Mbit/s
G.992.3 ADSL2	12Mbit/s	1Mbit/s
G.992.3 ADSL2 (Annex M)	12Mbit/s	2.5Mbit/s
G.992.5 ADSL2+	24Mbit/s	1Mbit/s
G.992.5 ADSL2+ (Annex M)	24Mbit/s	2.5Mbit/s

ADSL :- Upper Layers

- RFC 1483/2684 defines two encapsulation methods:-

Ø VC Mux :-Create Multiple VC's and send different protocols each VC.

Ø LLC/SNAP :- Send multiple protocols on single VC. The header includes a protocol type field to identify type of data .



Advantages of DSL Technology

- DSL is more cost-effective because it eliminates the need for extensive and expensive infrastructure upgrades.
- Increased Bandwidth capacity in the existing infrastructure.
- The speed is much higher than a regular voice band modem.
- Voice and data can be transmitted at the same time.
- Very Secure and reliable.

Disadvantages of DSL Technology

- The bandwidth capacity is inverse to cable distance.
- More sensitivity with the Quality of the transmission media.
- Better connection if closer to the provider's
- Faster receiving than sending data

BROADBAND Technologies implemented in MTNL Delhi

- Ericsson
- Huawai (Sterlite)
- Alcatel Lucent