DSL Technology

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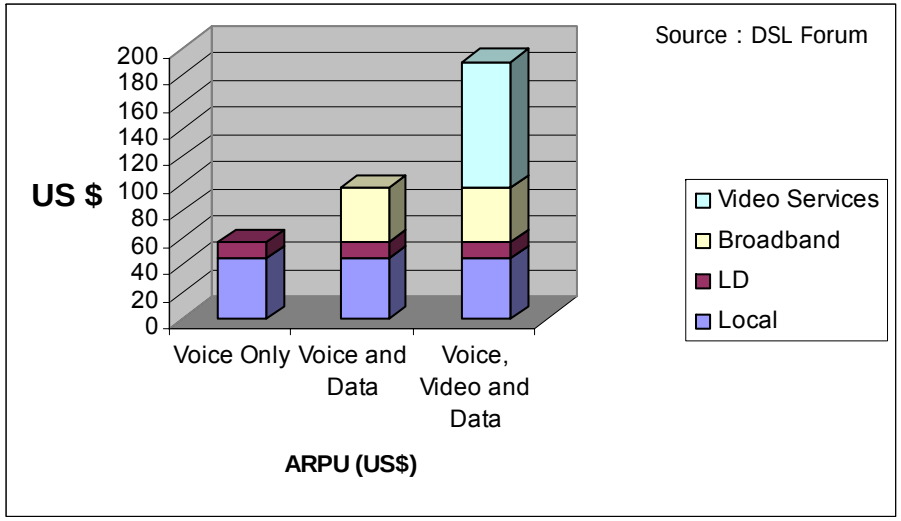
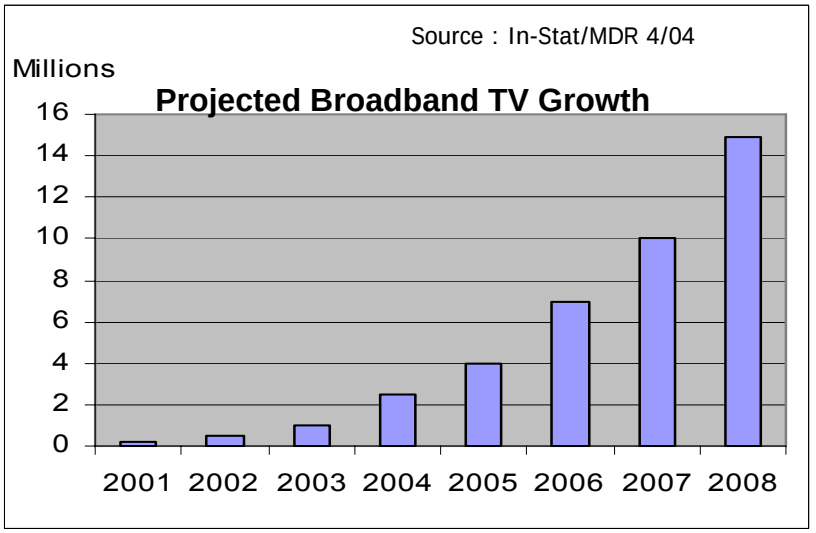
Agenda

- Broadband Trends
- xDSL Technologies
- DSL Network
- Summary

Broadband Business Trend

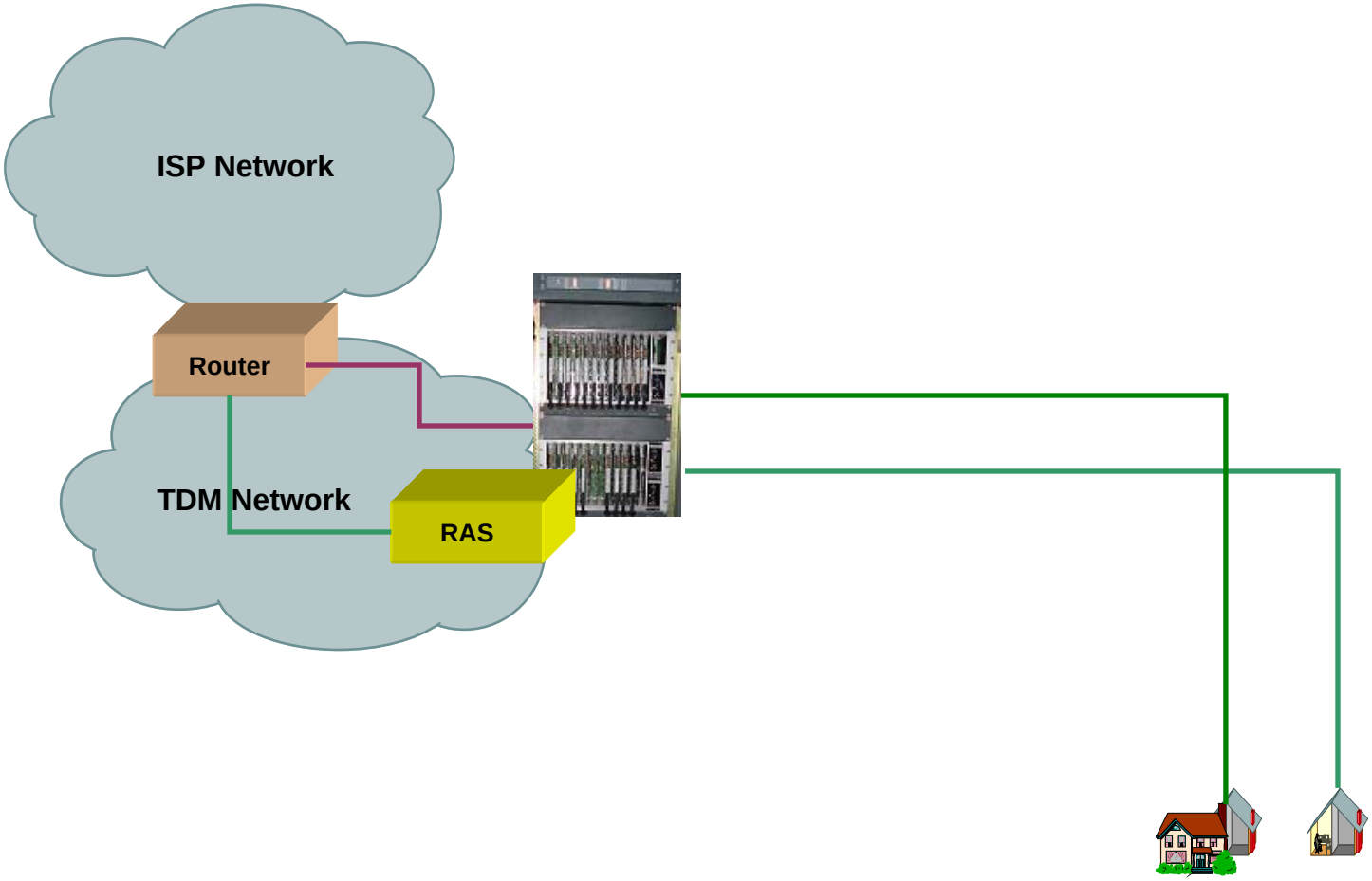




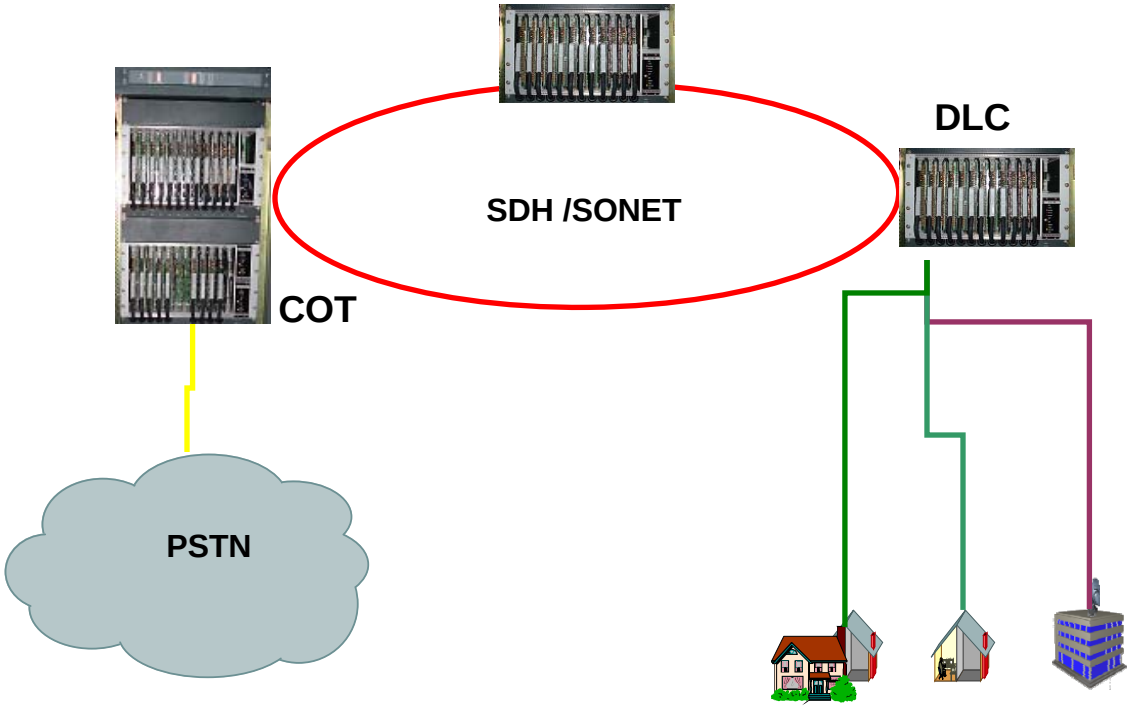
Technology Requirements

- Triple Play Network is essential.
- All components in the network should be triple play aware,
- Fully Packetized network

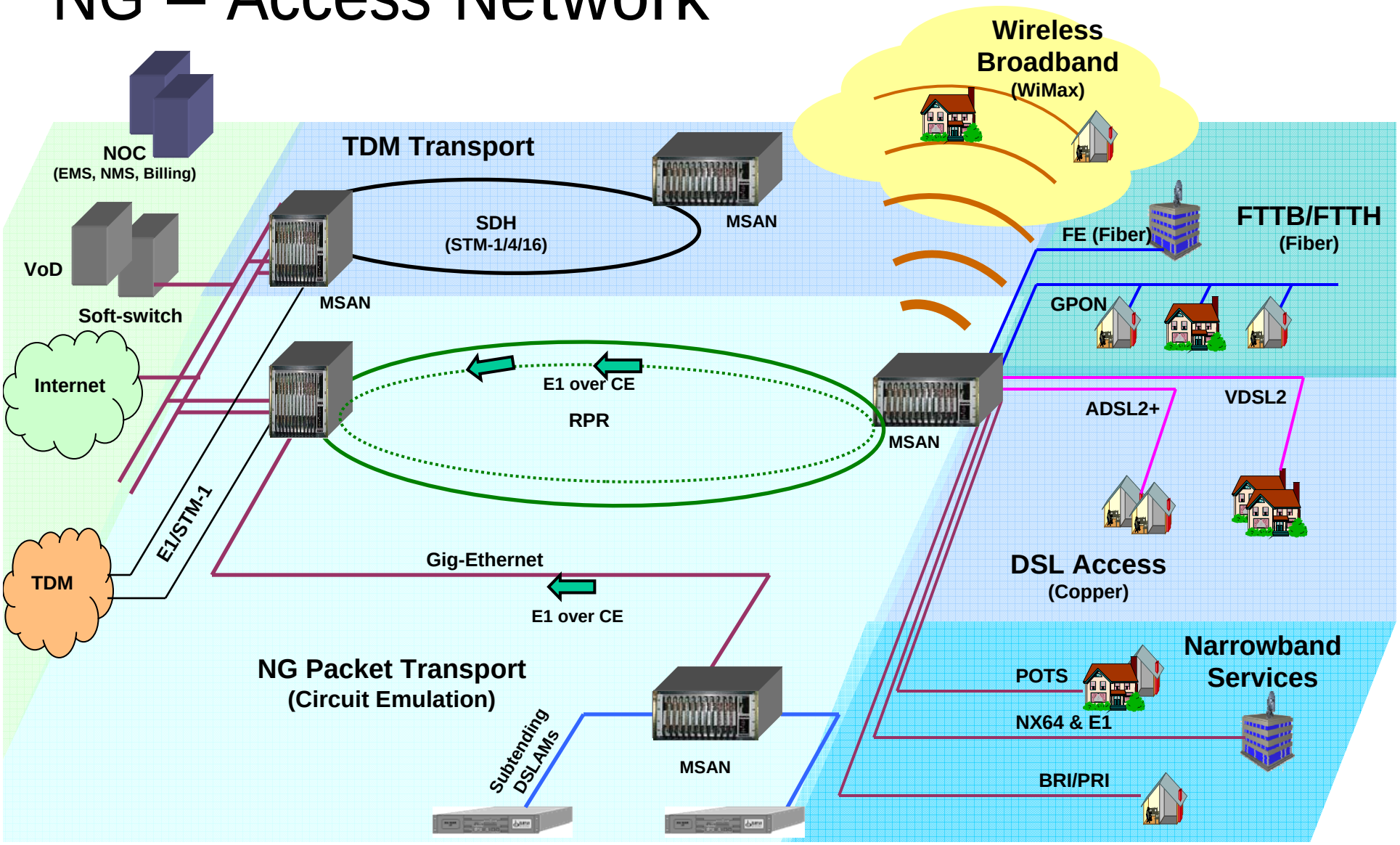
Telephone Network



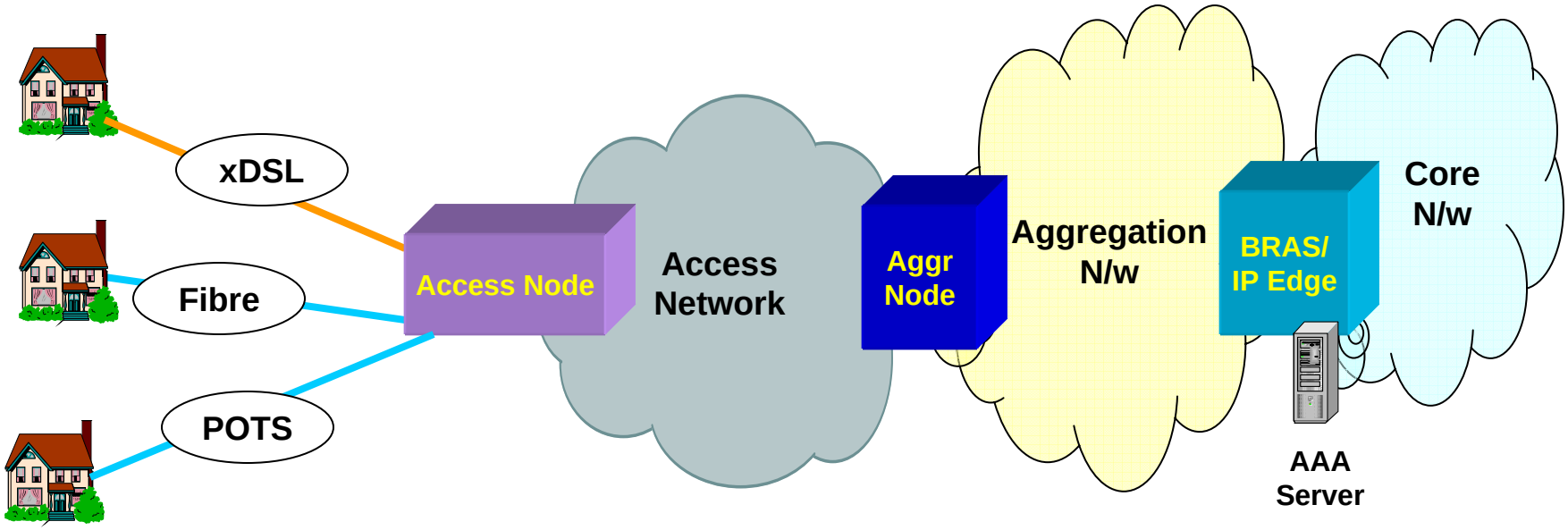
DLC Network



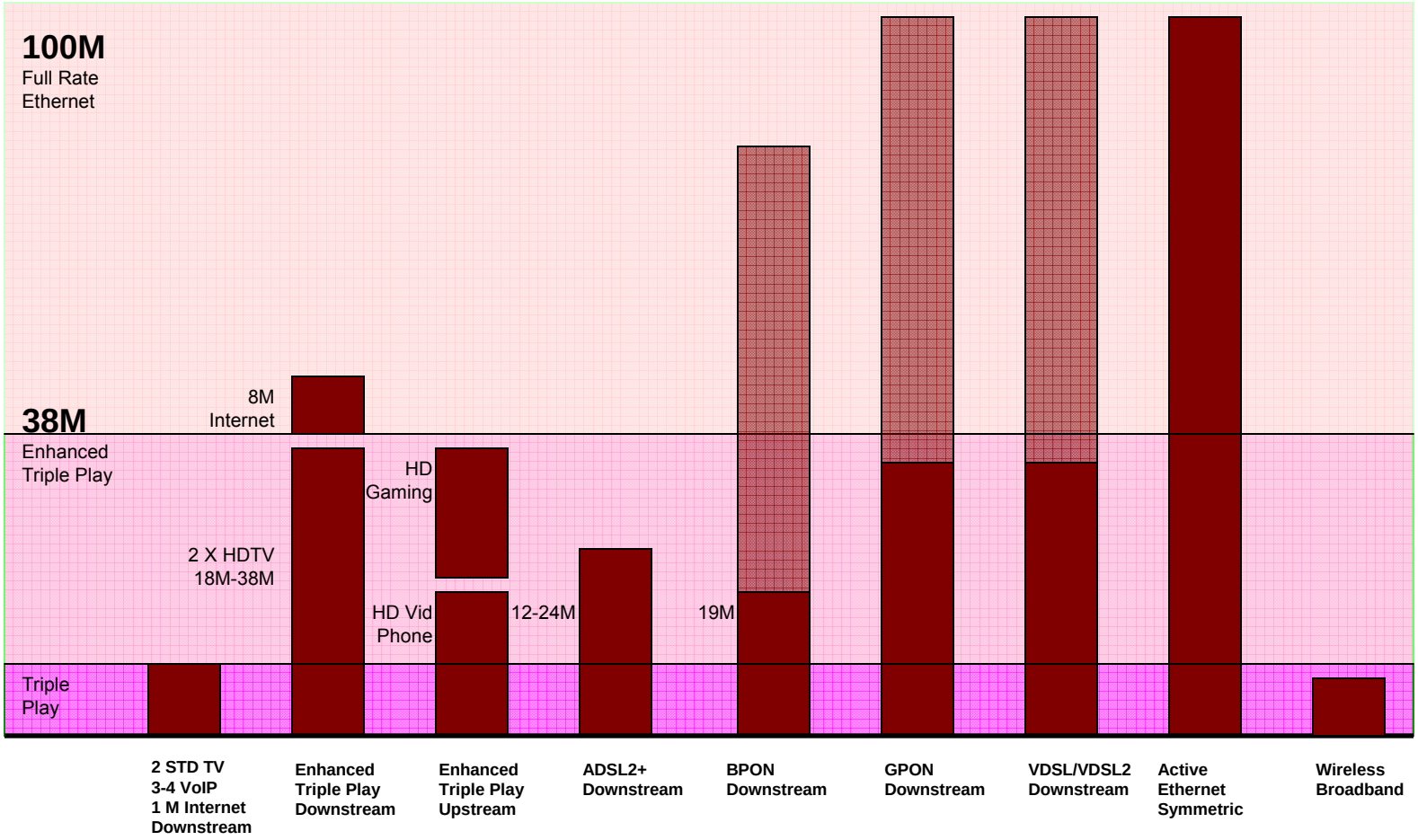
NG – Access Network



Broadband Network Architecture



Triple Play Requirements



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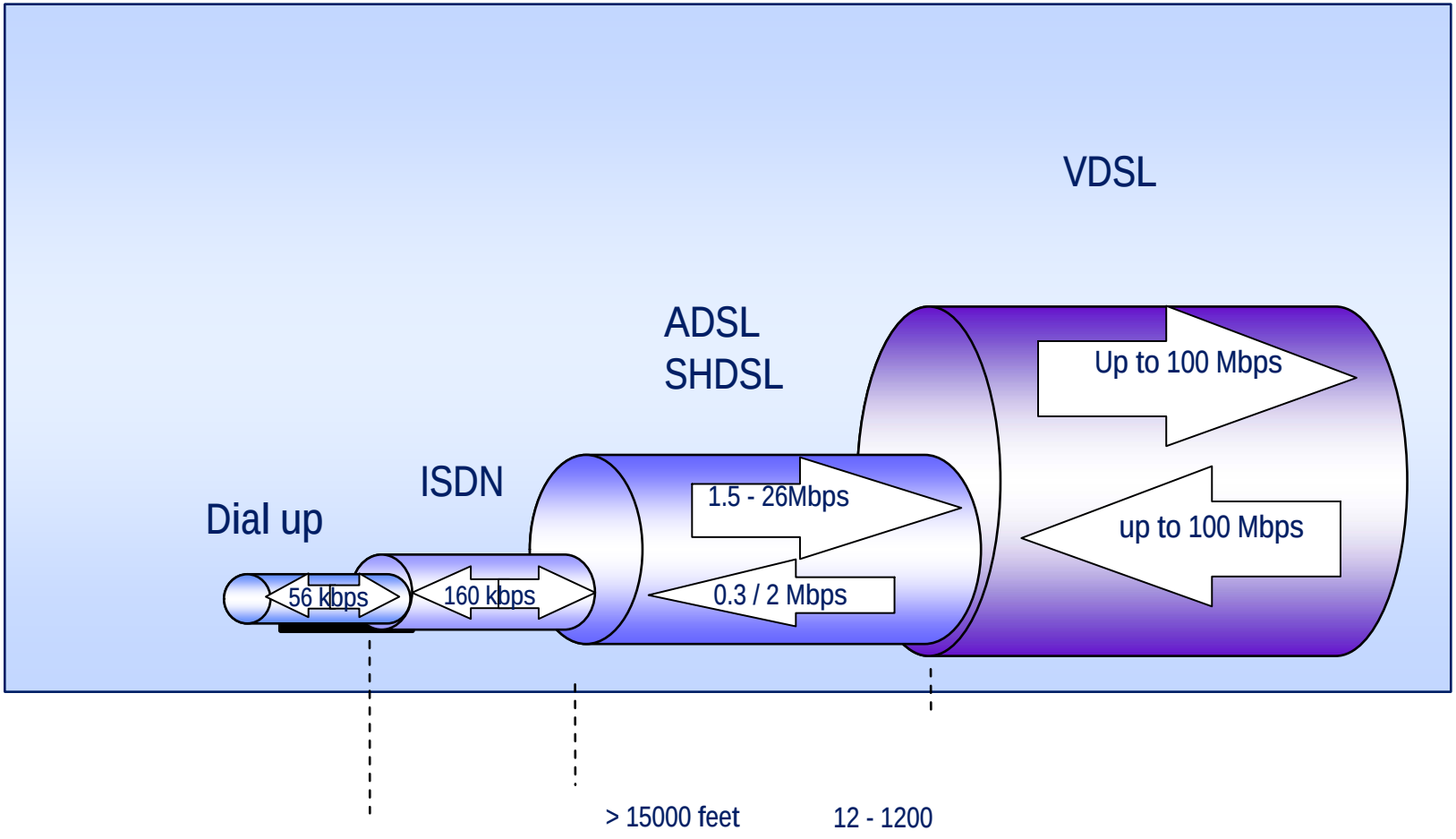
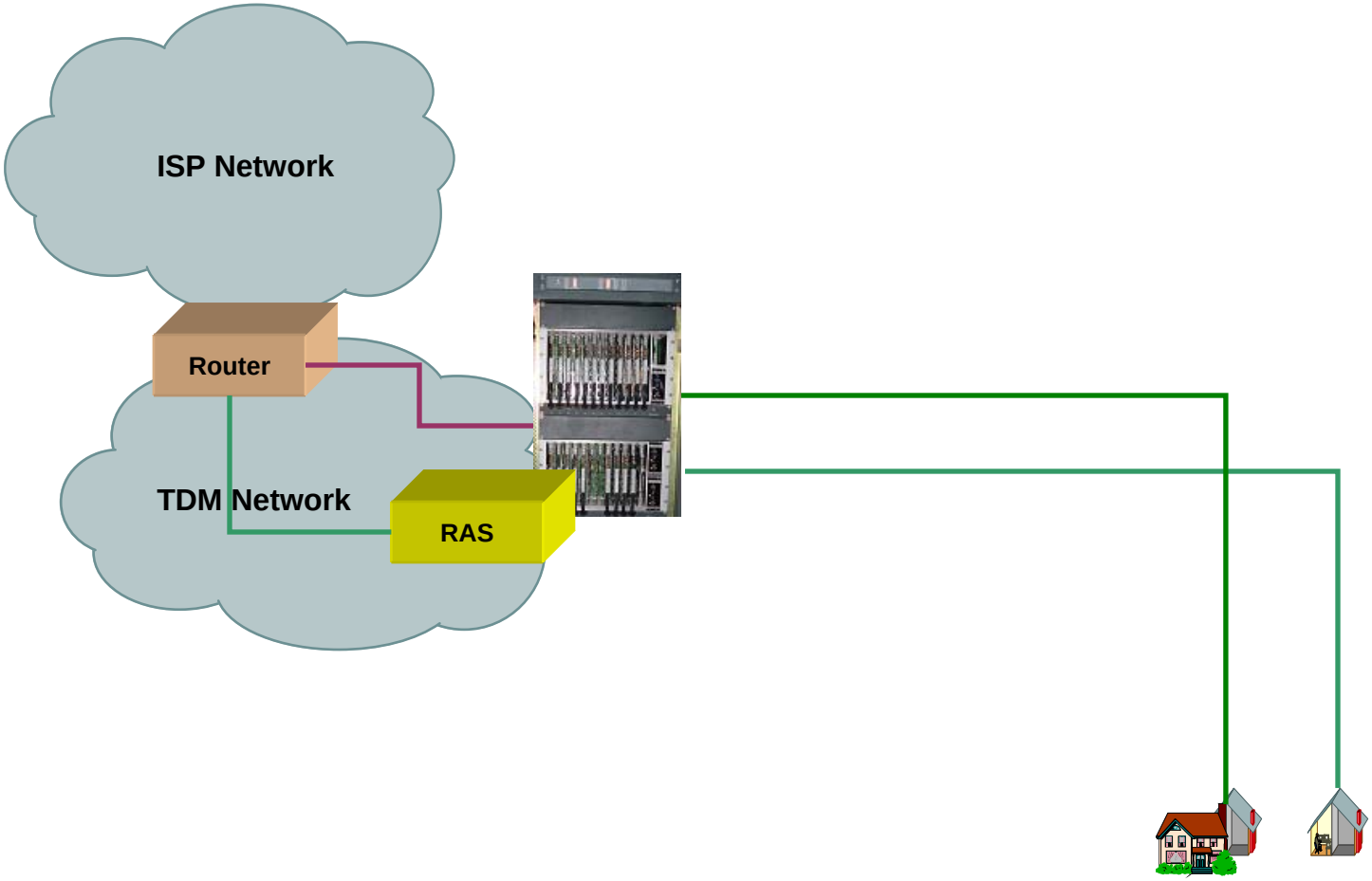
DSL

- What is DSL?
  - ***Digital Subscriber Loop Technology - Digital Communication Technique used in the subscriber loop cable to increase the bit rate.***
  - ***The technology that came to uncover the potential of the ubiquitous Copper cable.***
- ***Subscriber Loop - The portion of the cable between Central Office (CO) till the Customer Premises (CP) or homes. This is also called as Last Mile Copper.***

XDSL Technology Evolution



Telephone Network



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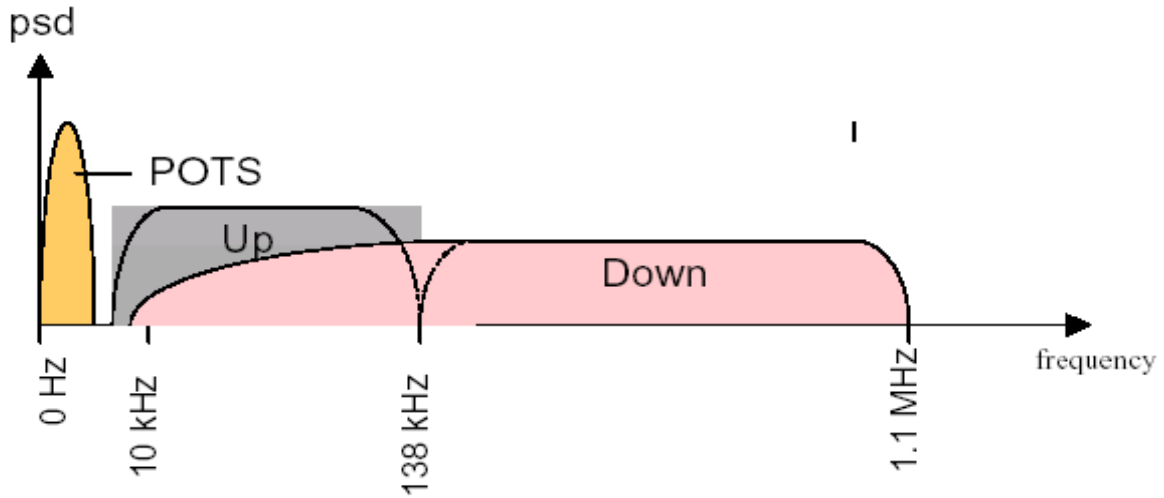
ADSL

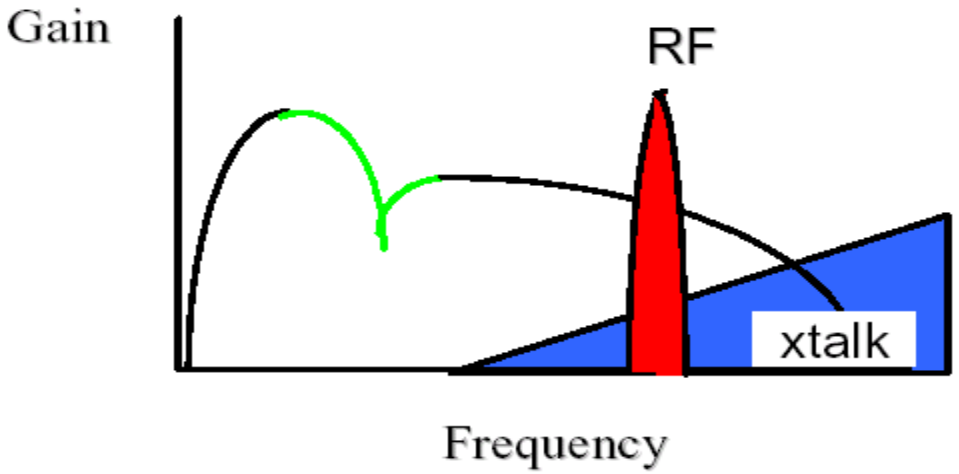
- By far the most heavily used broadband internet delivery method in the world.
- ADSL is worldwide standardized in ITU Standard G.992.1
- Uses DMT with symbol rate 'T' = 250us.
- Annex A (typical ADSL) provides Downstream rate upto 8 Mbps and Upstream rate upto 1 Mbps.
- The Spectrum (0 to 1.104 Mhz) is divided into 256 subcarriers or bins, each 4.3125 Khz wide.
- They can be independently modulated from zero to a maximum of 15 bits/sec/Hz. This allows up to 60kbps per tone.

ADSL



Channel characteristic

- Low frequencies are attenuated, due to DC notching of transformer coupling to the telephone line.
- Attenuation at high frequencies (cable is a LPF)
- Notch caused by a bridged tap - open circuit i.e. unterminated extension phone of line, that branches from the phone line. (Decreases Data Capacity)



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Channel characteristics

- The non-flat response of the channel will lead to ISI (intersymbol interference), as the Nyquist criterion requires it to be flat.
- Any adaptive equalization will be extremely difficult for this kind of channel response, as they only mildly consider that channel impulse response. i.e. The modulator basis functions are fixed.
- In practice, a particular modem may have to work with acceptable performance over a range of variation in transmission channels.
- There are nearly a billion telephone lines worldwide that exhibit significant variation in channel response and noise PSD.

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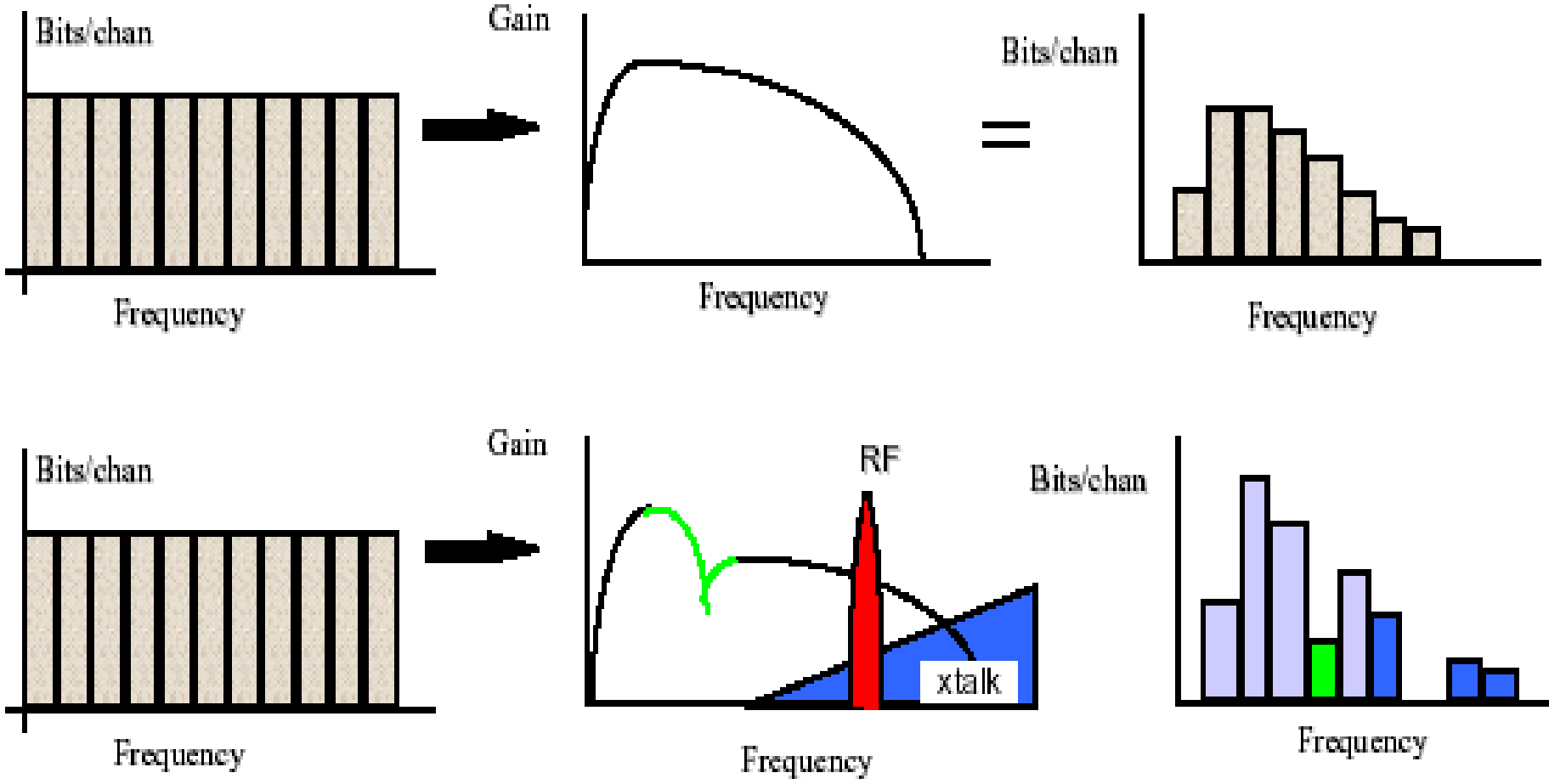
Solution -Multi tone Modulation

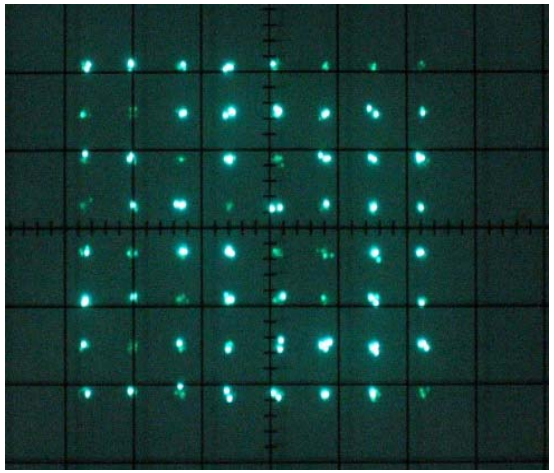
- Large performance improvement can be attained in these applications when the modulator basis functions can be designed as a function of measured channel characteristics.
- Multi-channel modulation methods allow such modulator adaptation to channel.
- The available spectrum is divided into multiple subbands called bins (256 for ADSL).
- Each of the subbands (bins) are modulated with non-overlapping narrowband QAM signals or 'tones'.
- The constellations (number of symbols transmitted) for the various QAMs are a function of the capacity of that particular bin.

Adaptive Multi tone transmission

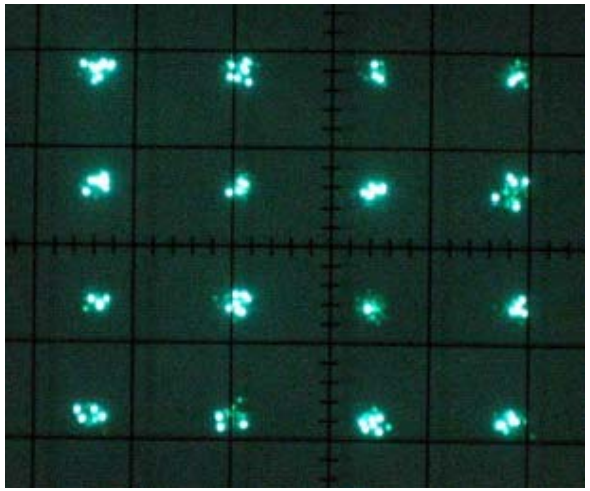


QAM Constellations

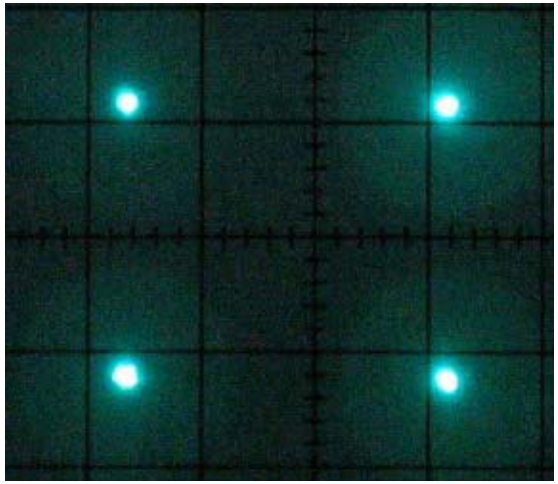
Each of the bins carries QAM constellations with varying number of bits, depending upon the capacity (SNR).



64 QAM
6 bits/symbol



16 QAM
4 bits/symbol .



QPSK
2bits/symbol .

Multi tone Modulation contd.

- Now the energy and the amount of information carried on each QAM channel roughly follows the channel transfer function.
- Multitone designs thus avoid the need for equalization on any 'tone', by making each sufficiently narrow, that the associated channel response appears to be 'flat'. Hence it satisfies the Nyquist's criterion.
- Thus multitone modulation methods extracts maximum capacity or data rate from the copper channel.

Discrete Multitone

- Channel Partitioning methods divide a transmission channel into a set of parallel, and ideally independent, subchannels to which the loading algorithms can be applied.
- Multitone modulation is a kind of channel partitioning.
- Discrete-time channel partitioning, partitions a discrete-time description of the channel, i.e. the sampled channel.
- Continuous time partitioning is difficult to implement, hence ADSL uses a discrete discrete channel partitioning method called – Discrete MultiTone (DMT).

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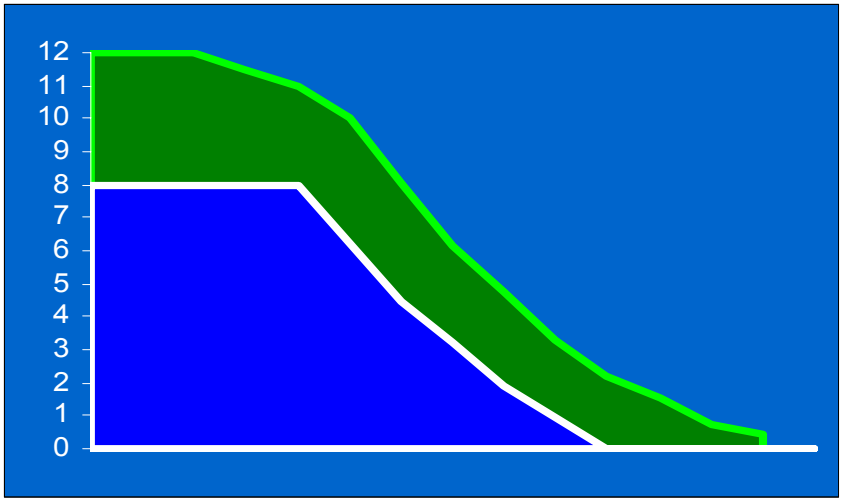
Bin Loading

- In digital modulation, the energy of a modulated signal is related to the number of bits it carries.
- Total number of bits carried by the multitone system is the sum of bits carried by the individual tones.
- Hence the total date rate of the multitone system is sum of the individual data rates in each of the bins.
- The Loading Algorithms compute the optimal number of bits to be carried in each of the bins.
- One such loading algorithm is the 'Waterfilling Algorithm'

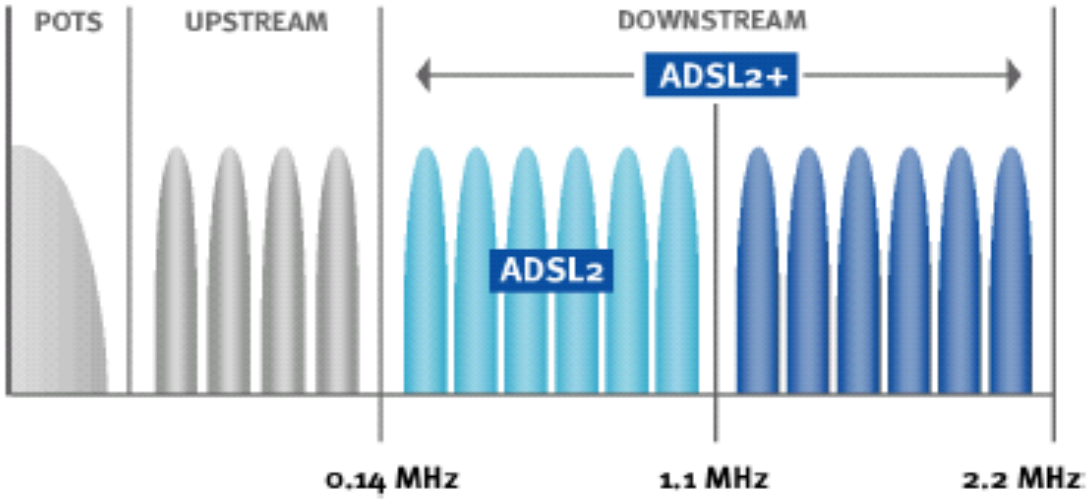
ADSL2

ADSL2 enables service providers to extend existing rates plans at longer loop lengths using rate enhancement technologies



ADSL2+

Double spectrum uses 512 bins of 4.3125 kHz each.



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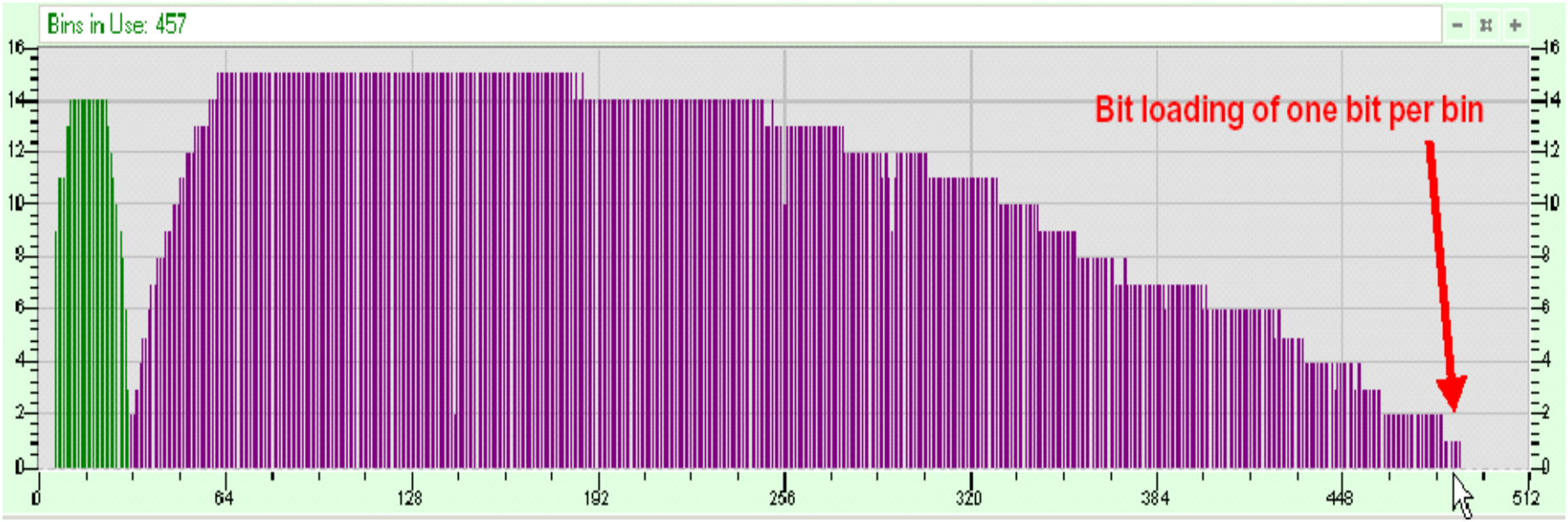
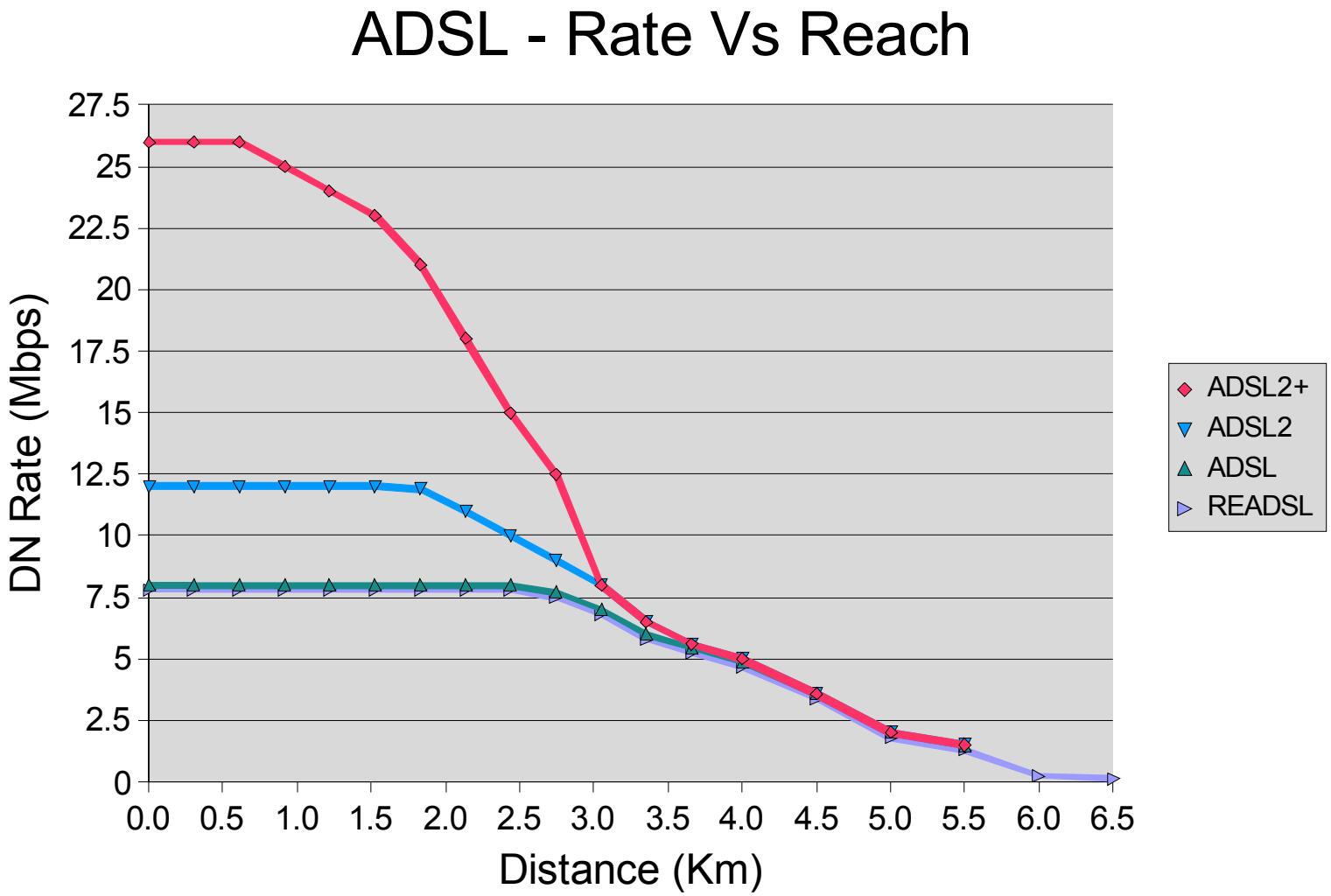
ADSL2+

- Higher rates through many small changes.
- Improved and flexible framing.
- SRA.
- New line diagnostics (DELT and in datamode).
- Improved initialization for improved rates and interoperability.
- Power Management to reduce power dissipation at CO.
- Improved reach with 1 bit/bin and READSL2.

BIN Loading in ADSL2+



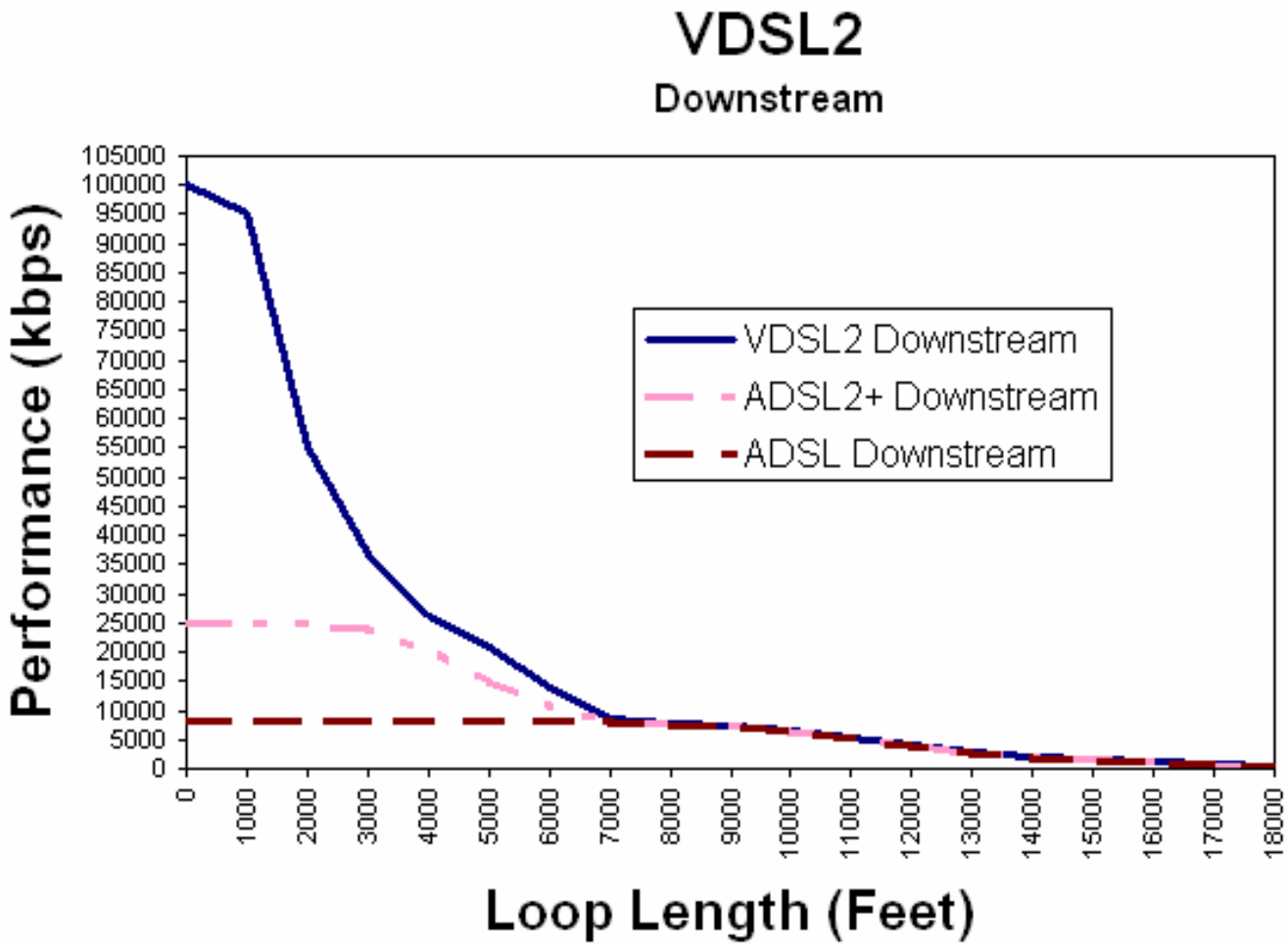
Rate Vs Reach in ADSL2+



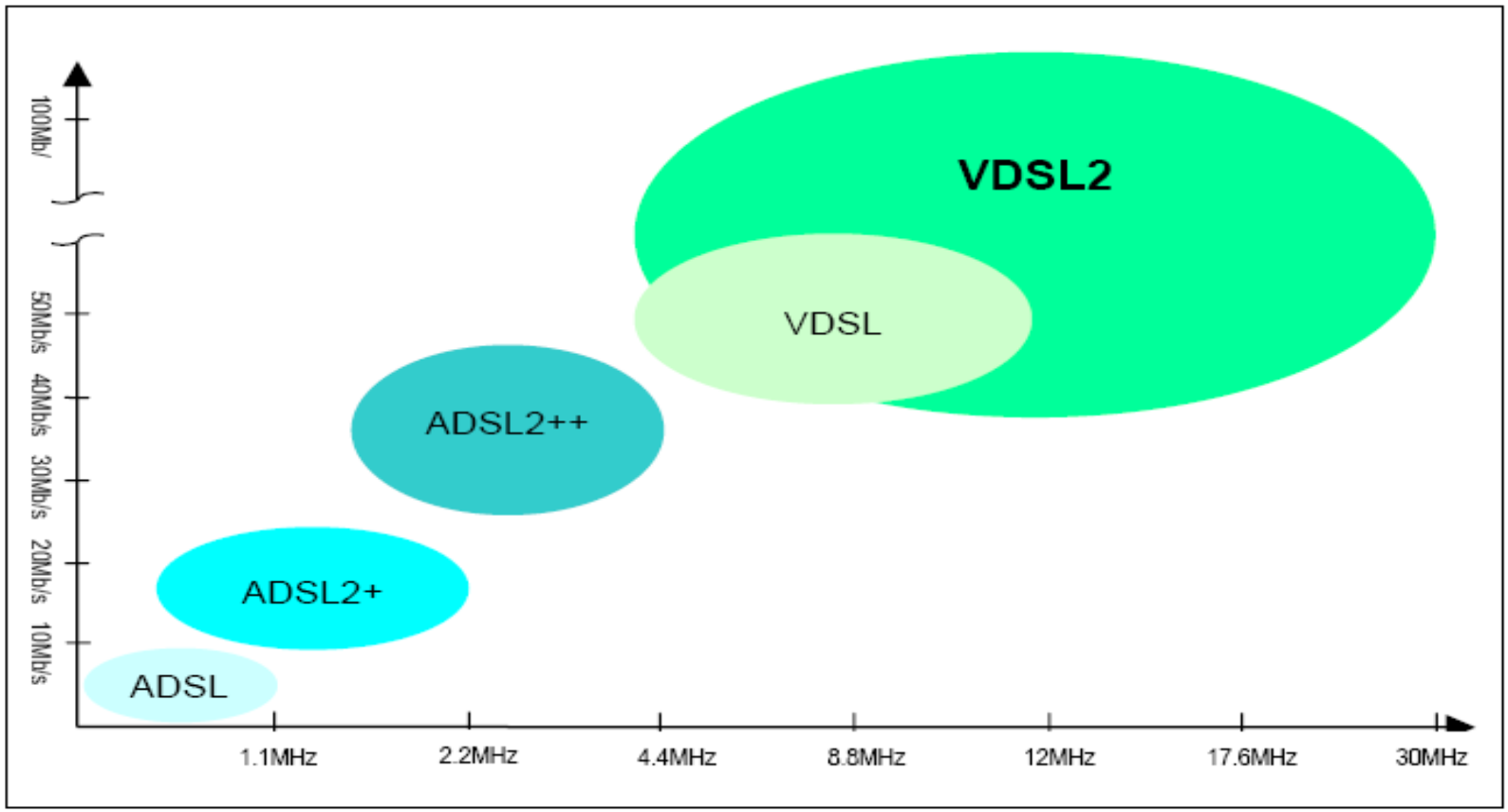
VDSL

- Very high-speed Digital Subscriber Line2
- Latest DSL standard (VDSL2) from ITU (G993.2)
- Transmission rates up to 100/100 Mbps over a single copper pair.
- Supports both Asymmetric and Symmetric Data rate
- Bandwidth upto 30 Mhz
- Supports seamless Ethernet Backbone
- Backward compatibility to all DMT based xDSL

VDSL2 Rate Vs Reach



DSL data rate Vs Frequency



Issues faced in DSL deployment

- Crosstalk Noise due to other ADSL and POTS lines in the same binder cable.
- Presence of Bridged taps - i.e. open-circuit unterminated extension phone lines, that branch from the main line.
- Background Noise in the copper line and RF Interference.
- Load Coils inserted in order to increase the POTS reach, affect the ADSL data rate.
- Patching of copper cable and use of split-pair (separated Tip & Ring).

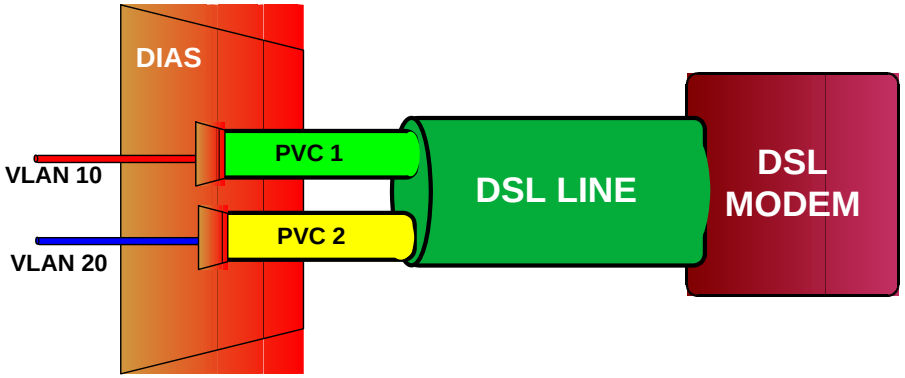
Issues faced in Deployment

- Use of muti-gauges of wire in a line (using both 0.5mm and 0.4mm)
- Water seeping into the cable causes longitudinal imbalance.
- Bunching of spectrally incompatible services in the same binder cable.
- Stacks overheads, in Ethernet service over ADSL.

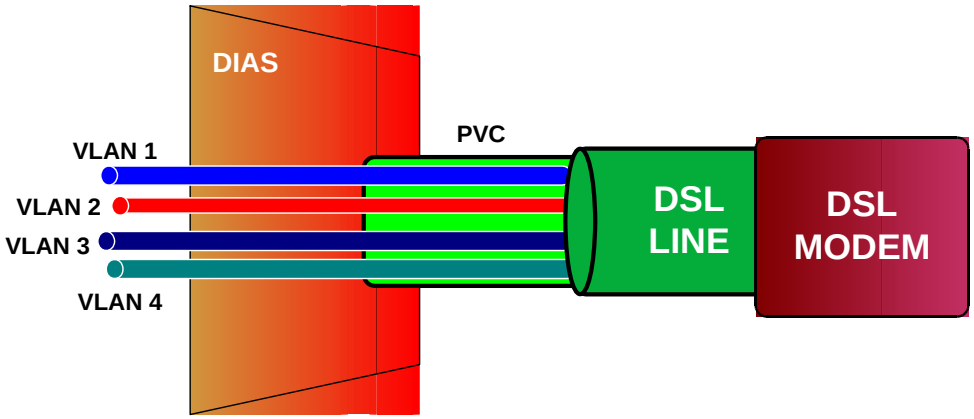
DSL Fault Isolation

- The ADSL impairments are isolated by executing Line Evaluation by using SELT/DELT Tests
  - Estimated loop length.
  - Loop termination and wire gauge.
  - Upstream and Downstream capacity.
  - Inband Noise.
  - Termination Response, which helps in isolation of bridged-taps.
  - DMT SNR Margin vs Rate.

Subscriber/Service Identification

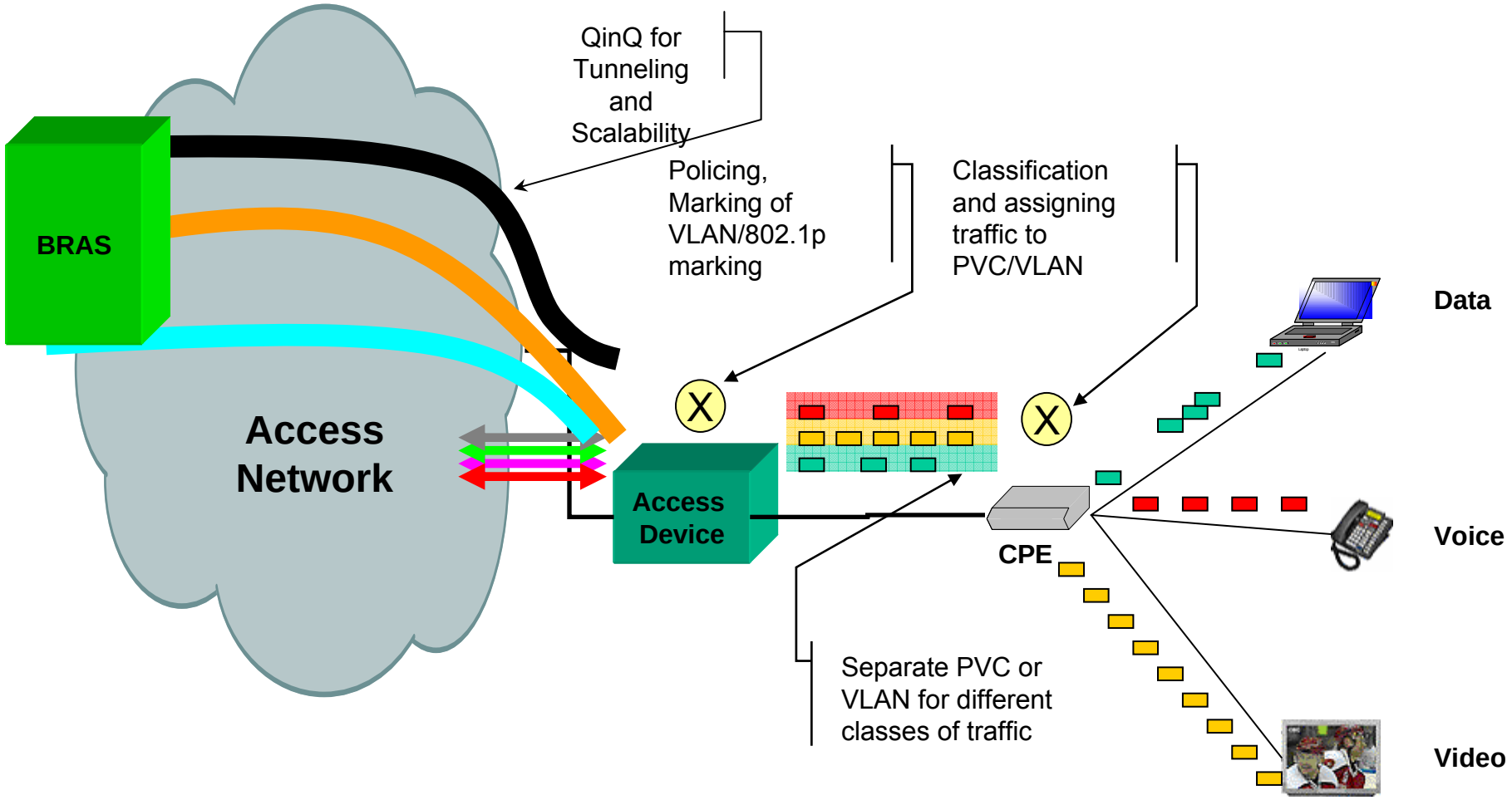


- Multiple PVCs
  - Each PVC can be alloted to carry different services
  - In upstream, CPE classify and transmit traffic to different PVCs



- Single PVC, Multiple VLAN
  - Each VLAN is alloted to carry different services
  - In upstream CPE separate traffic onto separate VLAN's

Triple Play Network



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Thanks...