

# Competing Methodologies and Future Trend in Residential High-Speed Internet Access

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“A simple solution to the labor shortage: Build broadband to the home...”

Michael Vizard

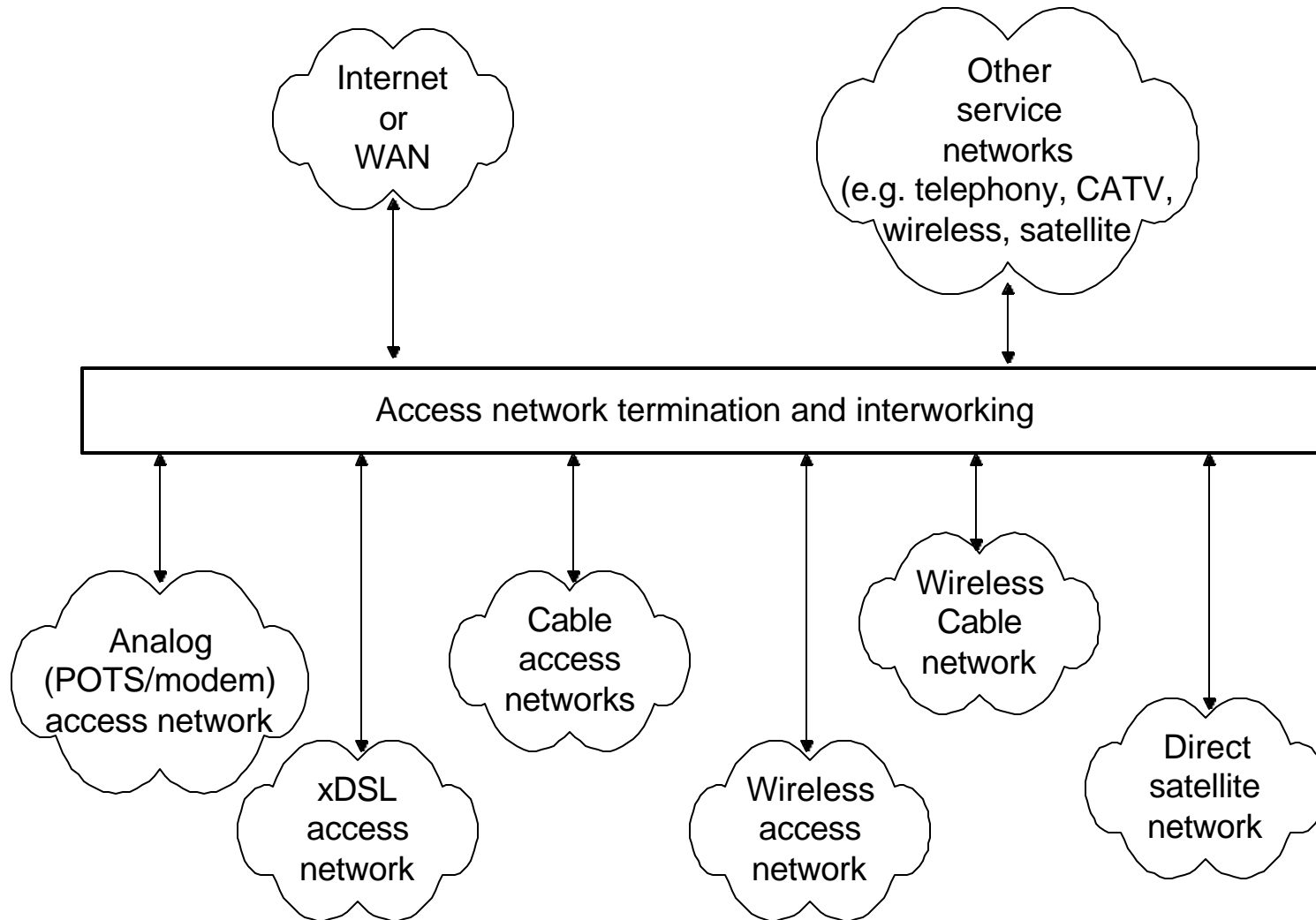
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# The Current Cost of Internet Access

- Second phone line \$25/month+installation with dial-up ISP \$20/month. Total cost is ~\$45/month at <56 kbps.
- Cable modem ~\$40/month plus modem (\$150) and installation (\$100) at 27 Mbps shared with 8 or more neighbors.
- ADSL varies \$50-\$200/month plus modem or router/bridge (\$200) and installation (usually waived) for 144 Kbps to 1Mbps.

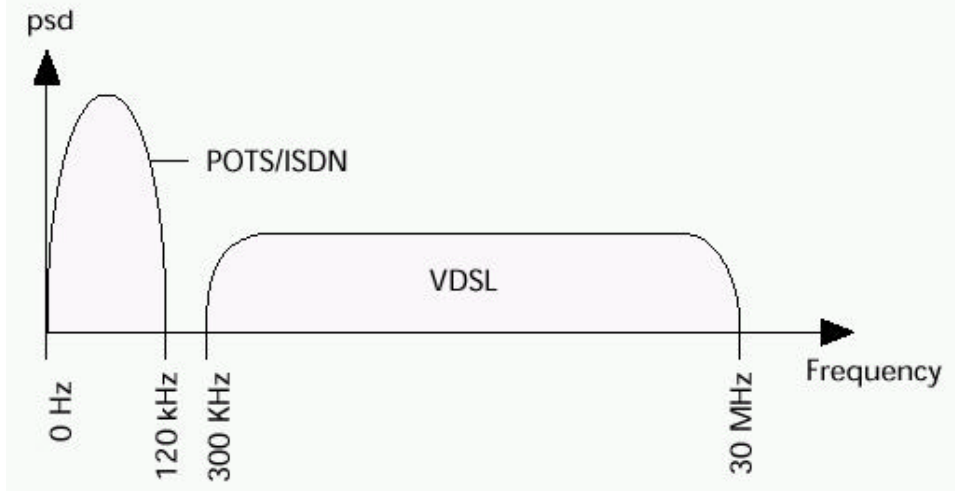
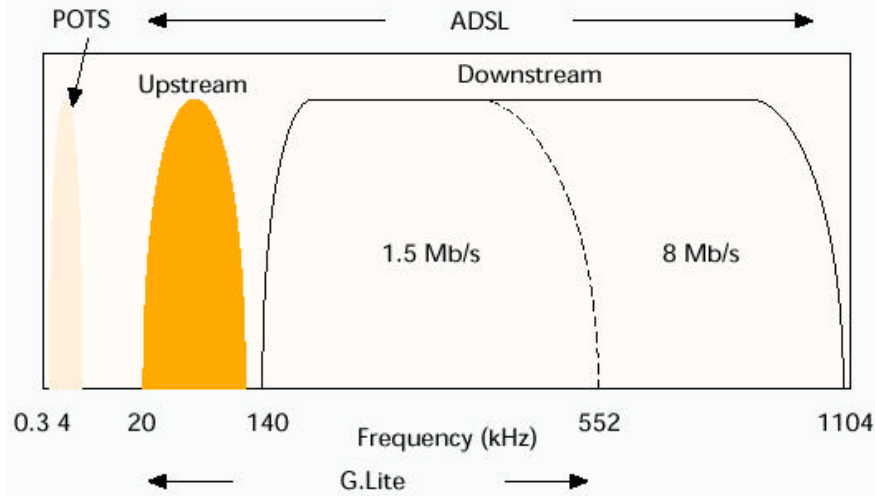
# Current Internet Access Methods



# Summary of xDSL Technology

ACRONYM	NAME	DATA RATE	LINE CODE	MODE	NUMBER OF TWISTED PAIRS
DSL	Digital subscriber line	160 Kb/s	2B1Q	Duplex	One
HDSL	High-data-rate DSL	1.544 Mb/s 2.048 Mb/s	2B1Q	Duplex Duplex	Two Three
SDSL	Single-line DSL	1.544 Mb/s 2.048 Mb/s	CAP DMT	Duplex Duplex	One One
ADSL	Asymmetric DSL	1.5 to 6.144 Mb/s 16 to 640 Kb/s	CAP DMT	Downstream Upstream	One
RADSL	Rate-adaptive DSL	Adaptive to ADSL rates	CAP DMT	Upstream and downstream	One
VDSL	Very-high-data-rate DSL	13 to 52 Mb/s 1.5 to 2.3 Mb/s	CAP DMT	Downstream Upstream	One
(A)DSL Lite (or UADSL)	Asymmetrical DSL Lite Universal ADSL	1.5 Mb/s 512 Kb/s	CAP DMT	Downstream Upstream	One

# xDSL Spectrum



# xDSL - Some Important Abbreviations & Facts

- LEC: Local Exchange Carrier: LBOCs
  - Were the only provider of DSL service
  - Now called Incumbent LEC (ILEC)
- CLEC: Competitive LEC. Most rapid growth industry
- DSLAM: DSL Access Multiplexers
  - OEM: also fast growth due to market demand
  - CO and CPE equipment: Cisco, Nortel, etc...
  - DSL chip maker: Alcatel, ADI, NEC...

# Some xDSL Providers

- Local Bell Operating Companies
- Major ISPs
  - Earthlink.net
  - FirstWorld Communications
- Dsl.net, Speakeasy.net, Megapath.net, etc...
- Freebies: freedsl.com ...
- Information sites
  - <http://whatis.com/dsl.htm>
  - <http://www.dslreports.com/>



# 2B1Q Line Code: 4-level PAM

BITS	QUATERNARY SYMBOL	VOLTAGE LEVEL
00	-3	-2.5
01	-1	-0.833
10	+3	+2.5
11	+1	+0.833

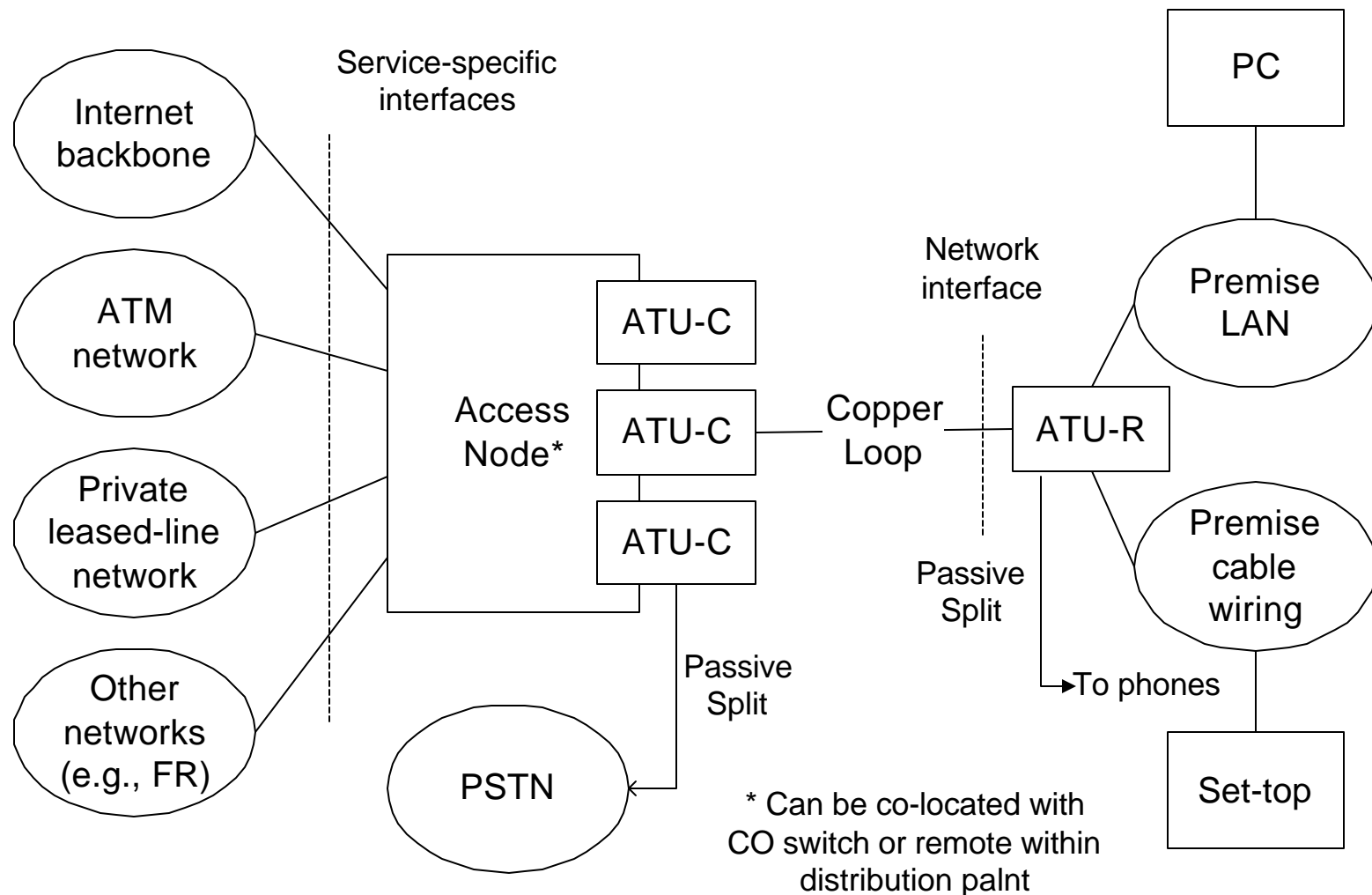
# CAP - Carrierless Amplitude and Phase

- CAP is closely related to QAM (Quadrature Amplitude Modulation)
- The I&Q (inphase and quadrature) in QAM generated by sine & cosine mixer and combined in analog domain
- The I&Q in CAP generated digitally, combined and then digital-to-analog converted => precise matching between I and Q.

# DMT - Discrete Multi-Tone

- DMT employs many sub-carriers (up to 256) & transmit in parallel.
- All sub-carriers are orthogonal to each other. Use of FFT and IFFT
- Each sub-carrier can have amplitude and/or phase modulation for that sub-band.
- Similar to OFDM (orthogonal frequency division multiplexing) in wireless communication.

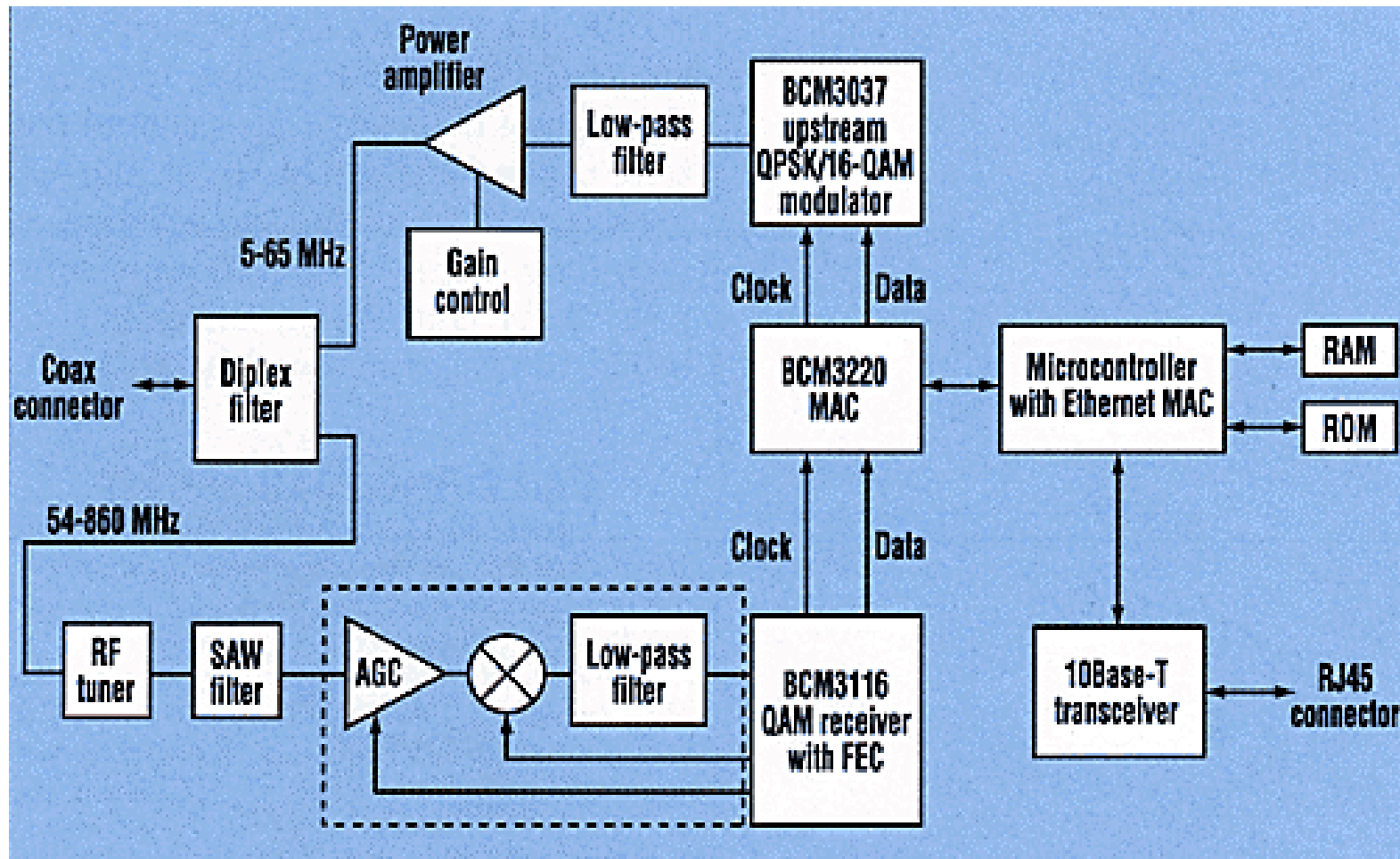
# ADSL Network Access Architecture



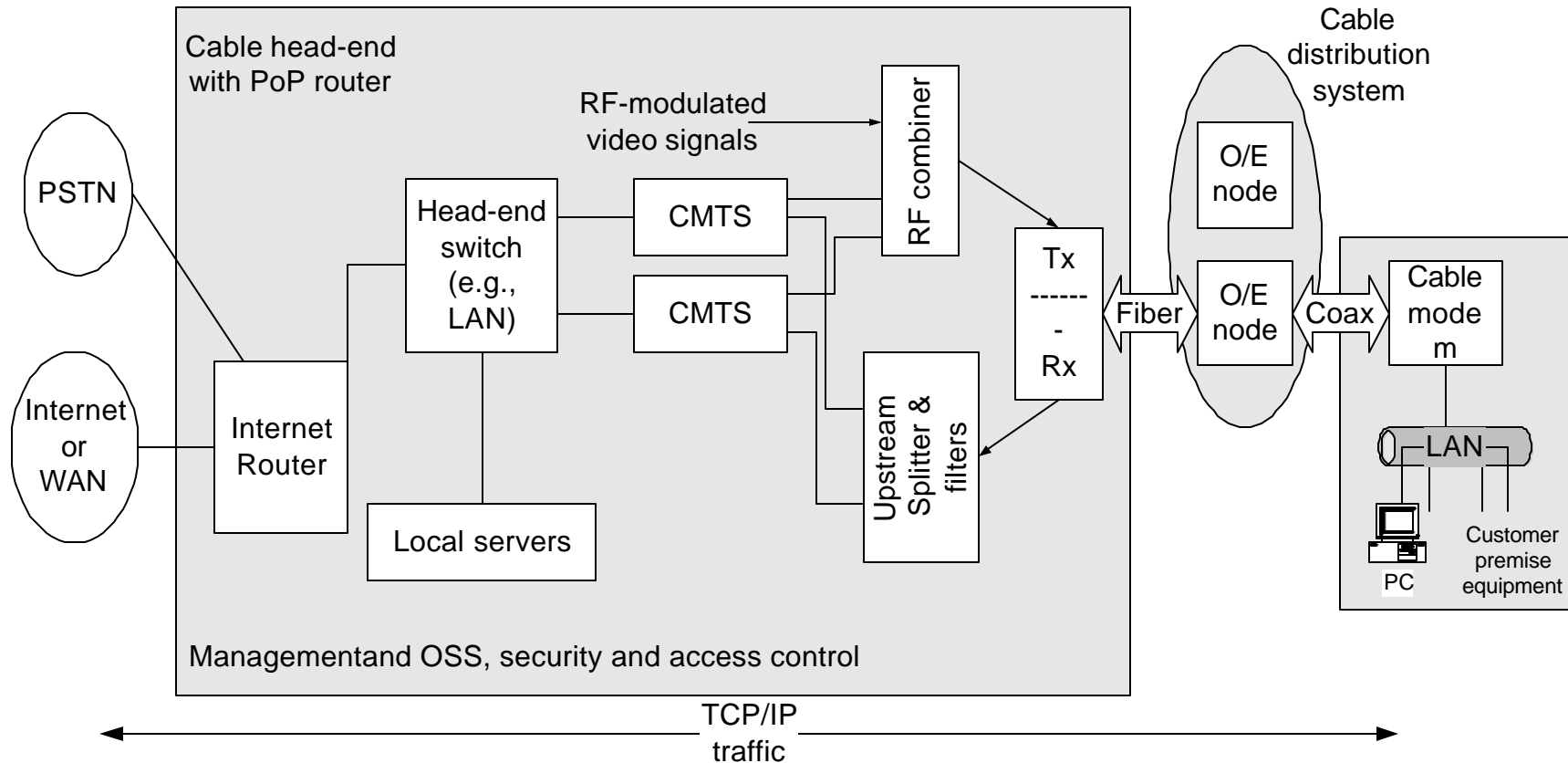
# Key MCNS DOCSIS Technical Specifications

DOWNSTREAM	UPSTREAM	ACCESS CONTROL	MANAGEMENT	SUBSCRIBER INTERFACE	NETWORK INTERFACES
64 and 256 QAM with variable interleaving	QPSK and 16 QAM	MCNS	SNMP	10Base-T	10Base-T 100Base-T ATM FDDI
6 MHz carrier	200 KHz to 3.2 MHz carrier	Packet-based, contention and reservation slots, QoS hooks	MIB definitions provided	USB and IEEE 1394 planned	
27 or 36 Mbps data rate	320 Kbps - 10 Mbps data rate				
Reed Solomon FEC	Reed Solomon FEC				
DES Encryption	DES Encryption				

# Broadcom Cable Modem Block Diagram



# Data Over Cable Architecture



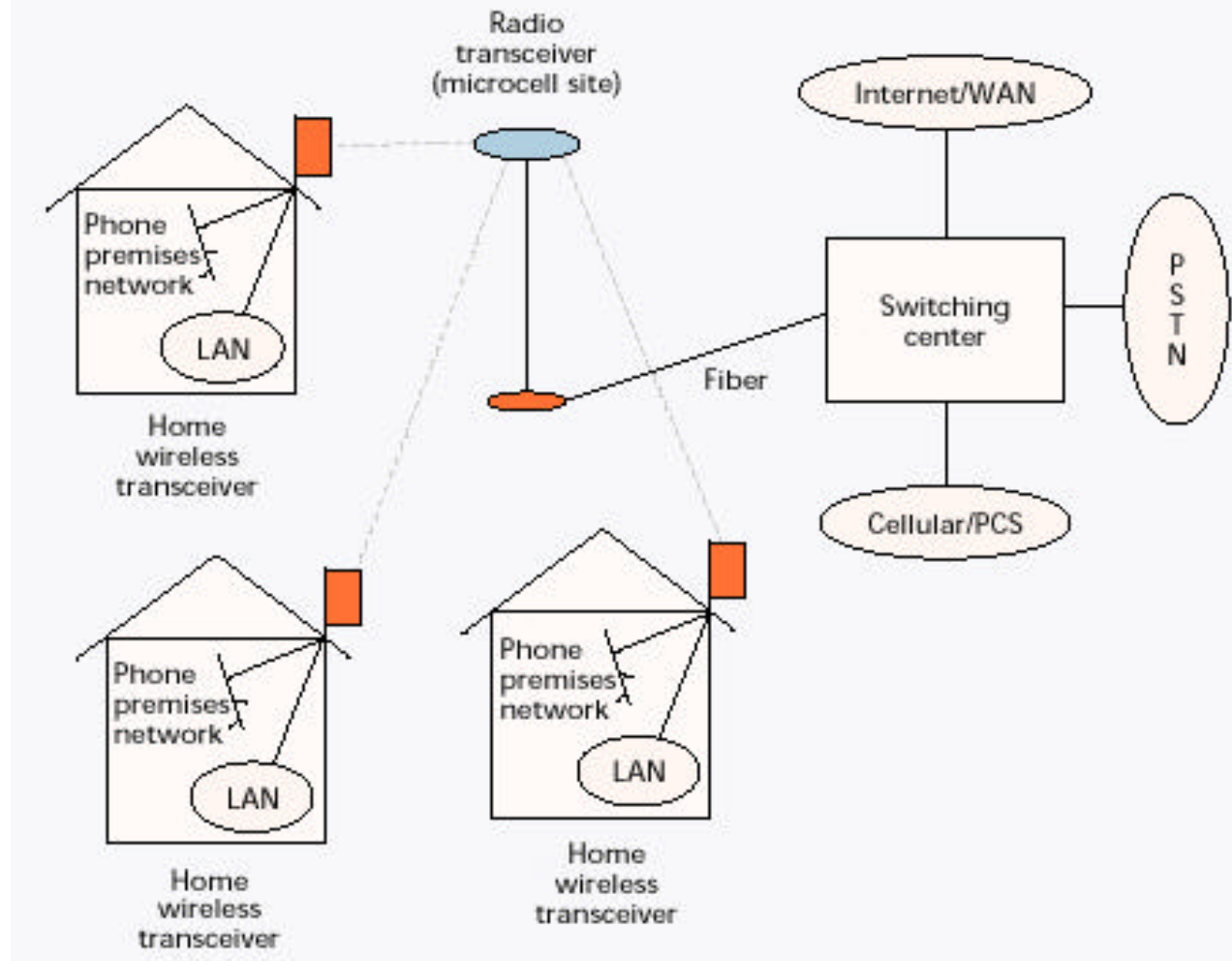
CMTS: cable modem termination system  
 O/E: optical to electrical conversion

# Multi-point Distribution System Local (LMDS) & Multi-channel (MMDS)

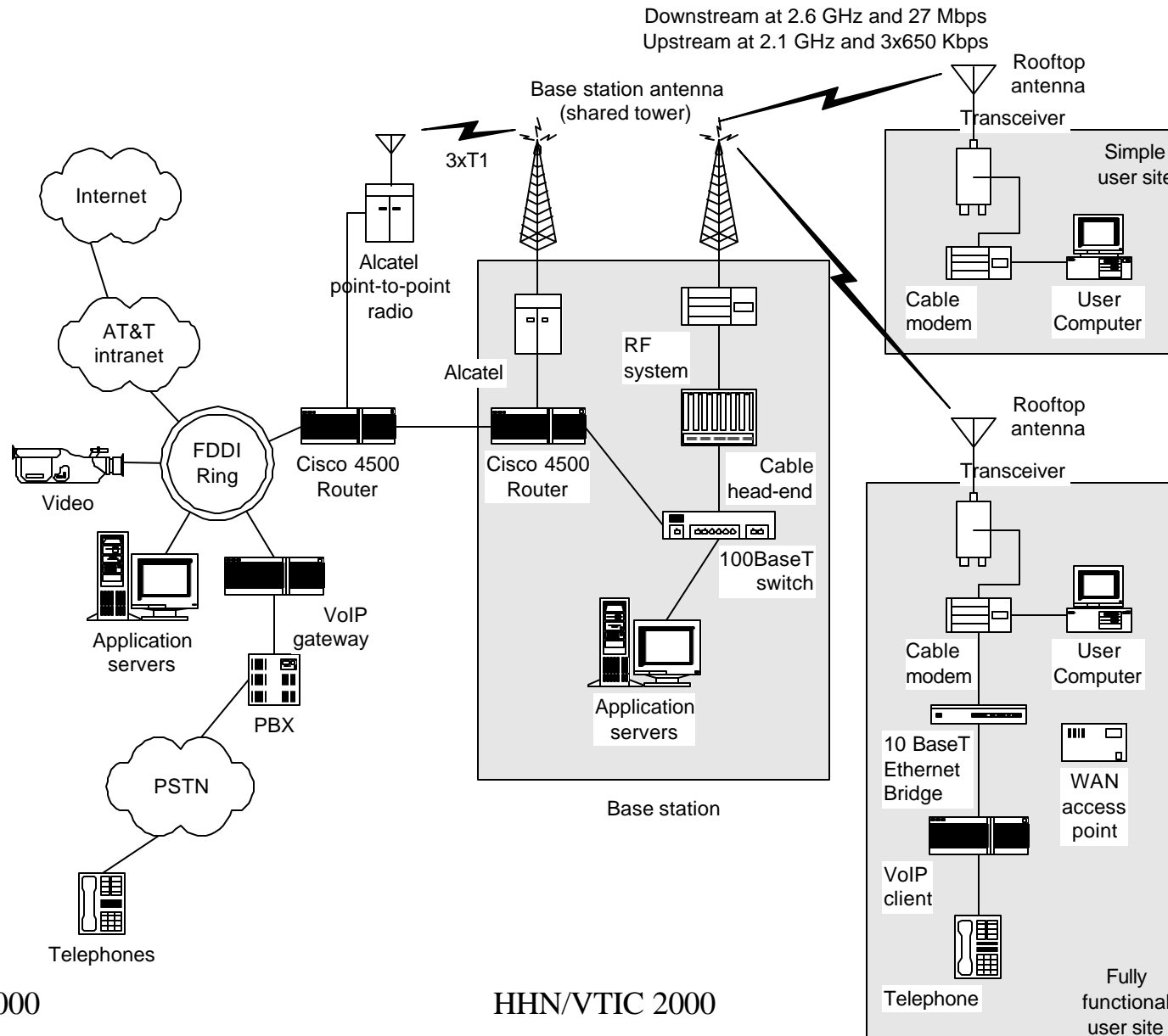
- Analog video distribution from base station to households. Line-of-sight operation.
- MMDS: 2.5-2.7 GHz, 33 analog channels of 6 MHz within 50 km radius. Upstream may be via phone line.
- LMDS: at 28 GHz to promise 1,300 MHz bandwidth with bi-directional & interactive data services.



# Wireless Local Loop (WLL) Multi-point Distribution System



# An MMDS Experimental System



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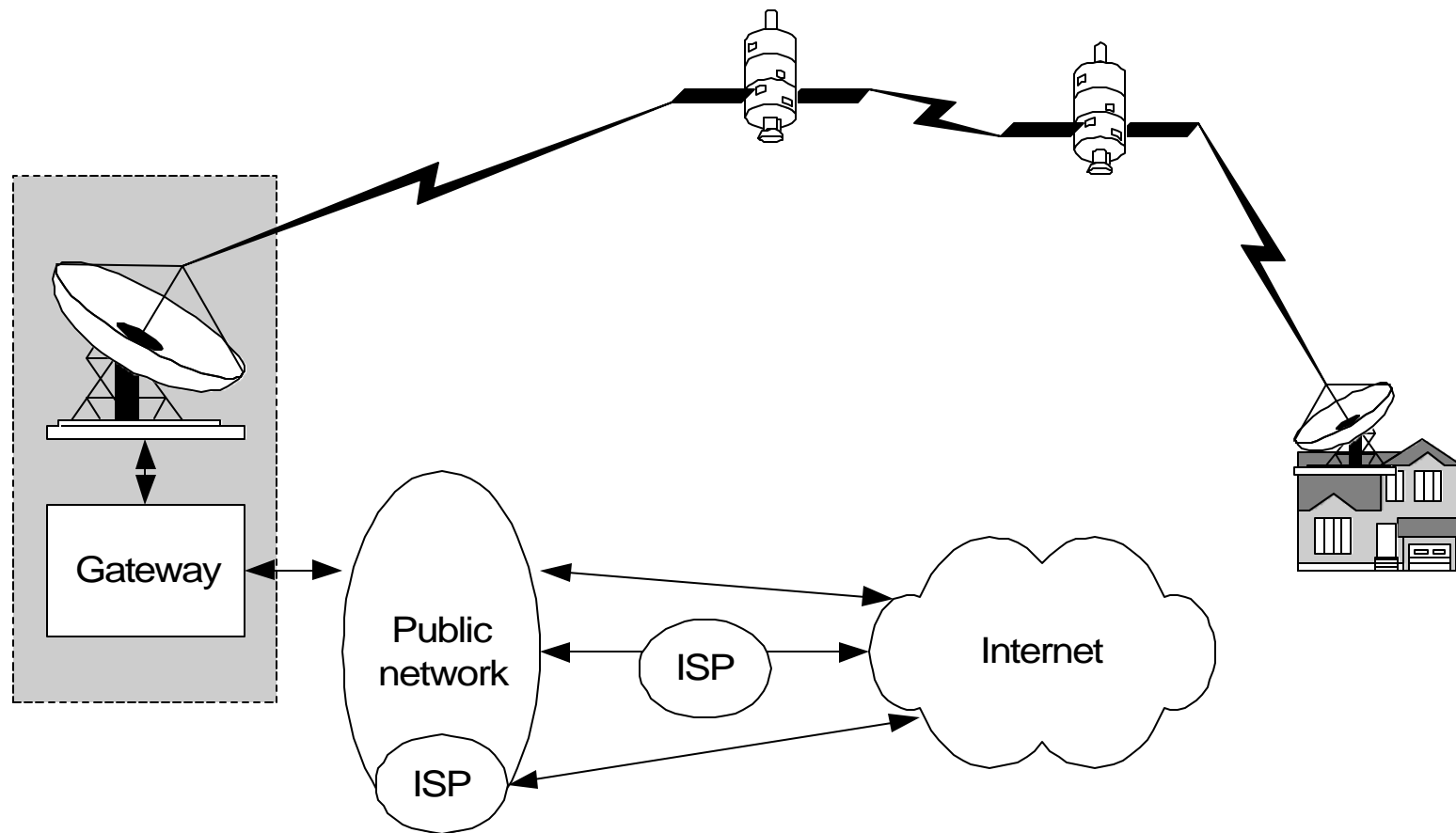
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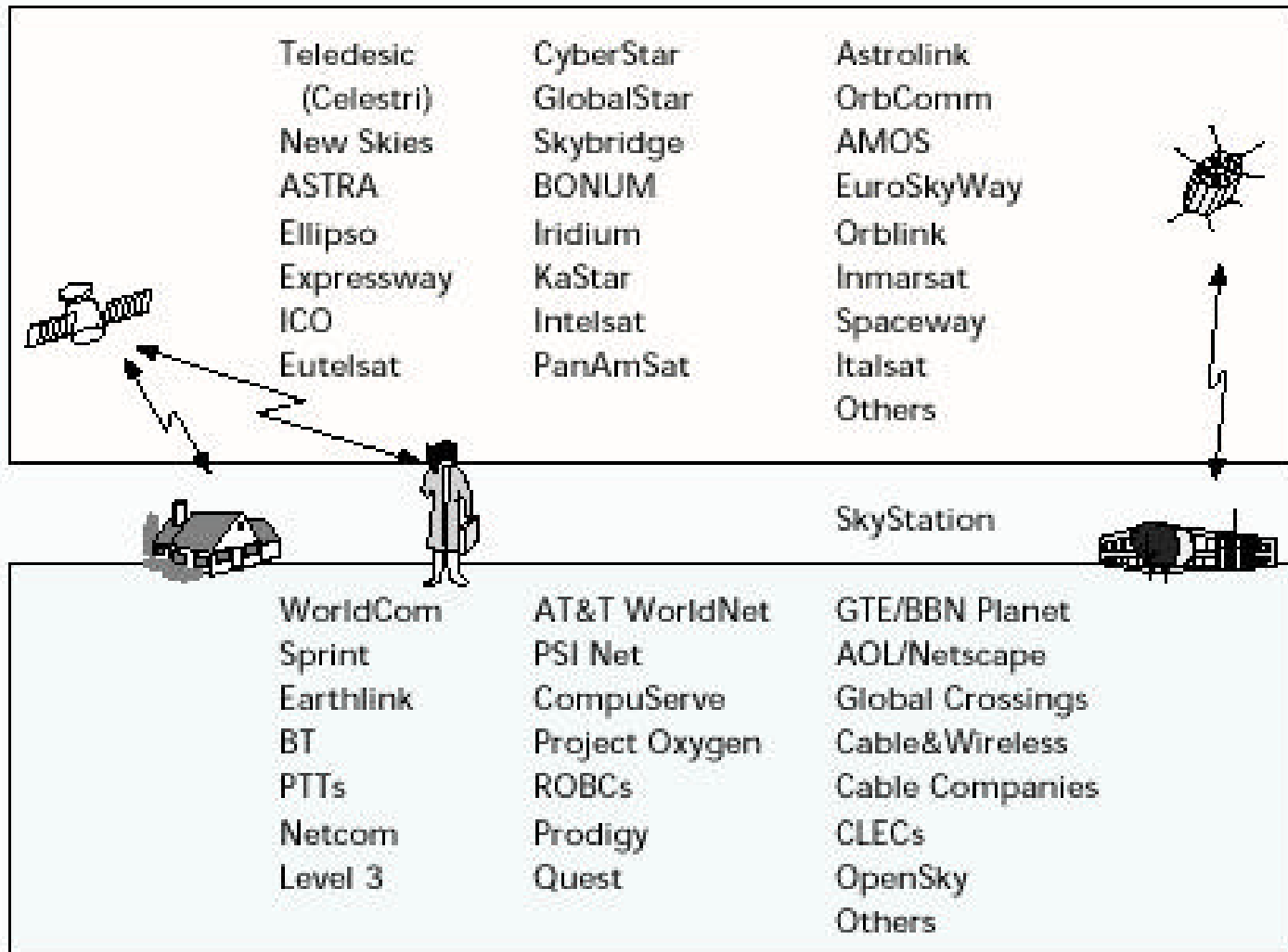
# Current LMDS Providers

- Spectrum auctions completed March 1998.
- Field trials and service roll-out
- Some LMDS vendors:
  - Alcatel (was Newbridge)
  - Harris (was WavTrace)
- Some service providers:
  - LMDS Communications Inc. Competed field trial (New Castle, PA) for small & medium business.
  - Home Telephone Inc., Charleston, SC

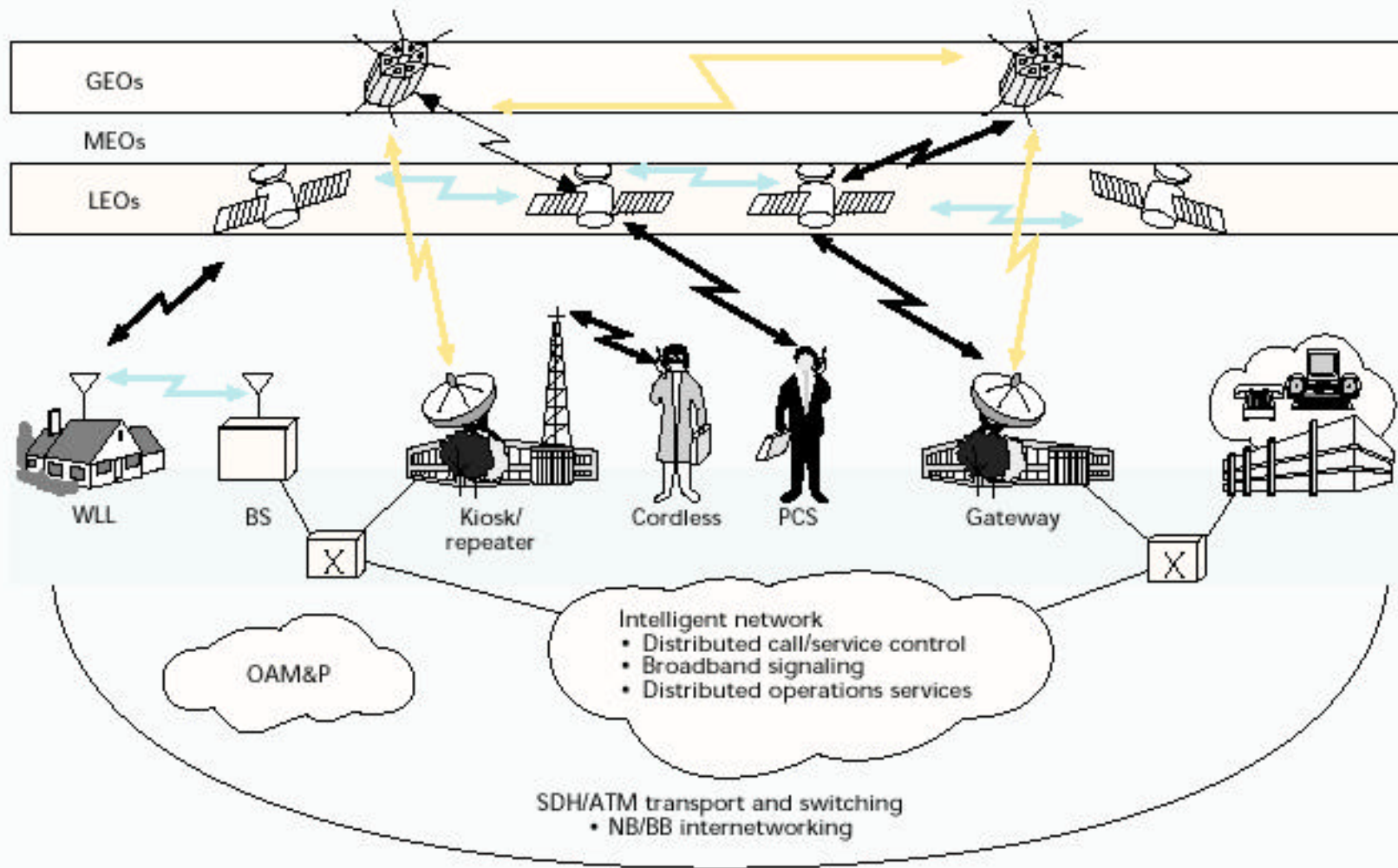
# Internet Access Using Satellite



# Space-Borne Internet Access Providers



# Global Access in Telecommunications



# Conclusions

- xDSL & cable modem are 2 leading contenders.
- Fewer cable modem providers, more visible in big cities, backed up by large corporations.
- More xSDL providers, smaller & less well-known, recently public with negative profit.
- Satellite Internet access could dominate but will have to clear the initial insertion & cost
- LMDS is rolling out and could be extremely competitive due to the wireless technology