

Access Networks:



**Connecting the 'final mile'
to homes and small
businesses**

Ian Pratt

University of Cambridge

Computer Laboratory

Requirements



- more bandwidth & reduced latency
 - avoiding the world wide wait
 - e-commerce
 - better quality audio/video
 - VOD, special interest TV
 - IP telephony/video conferencing
- “always-on”
 - remote access to home servers
 - instant messaging

Connectivity options



- conventional modems / ISDN
- xDSL
- cable modems
- fixed wireless
- fiber
- satellite
- *mobile wireless*

Telephone Network



- conventional modems
 - digital-analogue-(digital)-analogue-digital
 - more advanced modulation techniques
 - 9.6, 14.4, 28.8, 36.4 Kbps
 - use direct digital connection at ISP
 - 56Kbps downlink (still 36KBps uplink)
- ISDN digital telephone line
 - 64+64 Kbps with rapid connection setup
 - requires fairly good quality line

xDSL: Digital Subscriber Line

- Use existing twisted pair copper plant
 - point-to-point link
- but, not a great transmission medium:
 - single pair, long, gauge & material changes
 - high freq loss, bridge taps and load coils
- interference sources
 - RF pickup/egress, thermal noise, reflections
 - Near End crosstalk (NEXT), Far End (FEXT)
- Throw DSP at the problem...

xDSL variants



- HDSL: 1.5Mbps, symmetric, 2 pair, no POTS, up to 12kft
 - T1/E1 delivery (old)
- SDSL: 1.5Mbps, symmetric, 1 pair, up to 18kft
- ADSL: 640-8Mbps ds, 64-800kbps us, 1 pair, POTS/ISDN, up to 18kft
- ADSL G.Lite: as above but 1.5Mbps ds, 512Kbps us
 - "self install" splitter-less ADSL
- VDSL: 6-52Mbps ds, 2Mbps us, 1pair, POTS, 1-16Kft
also 1,2,4,6,8,12Mbps symmetric
- Bandwidth negotiation and noise monitoring
- Asymmetric variants to reflect current traffic patterns

xDSL technology



■ CAP/QAM

- single carrier
- lower symbol (baud) rate by encoding multiple bits per symbol

■ SDMT

- many carriers e.g. ADSL has 249 x 4kHz channels with 15bit QAM = 249 x 60kbps
- poor channels can be discarded

xDSL regulatory issues



- Incumbent Local Exchange Carrier (ILEC)
e.g. BT vs. Competitive LEC (CLEC)
- How to 'open-up' the market?
 - Physical level vs. DSL level vs. ISP level
 - issues of maintenance responsibility, exchange access etc
- Maintaining 'life-line' phone service

Cable Modems



- Uses CATV coax *tree* from Head End
 - serves 1000's of customers
 - rapid rollout -- can split tree later
- 30-40 Mb/s shared ds bw
 - single 6MHz channel (same as a TV station)
 - 64/256 QAM encoding,
 - head-end scheduled

Cable Modems



- Upstream channel is harder (320-10Mbps)
 - need MAC protocol for Collision Detect and retransmission, fair bandwidth sharing
 - large distances require *ranging* optimizations
 - DOCSIS 1.1
- Encryption necessary for both channels
 - DES block cipher

Fixed Wireless



- Microwave and free-space laser
 - line-of-sight between rooftop antennas
 - avoids multi-path interference, lower power
- Free-space laser systems
 - 2-155Mbps and up
 - relatively narrow beam requires stable fixtures
 - Wavelength Division Multiplex systems

Fixed Wireless



■ Microwave

- point-to-point and multi-point systems
- MMDS: 2GHz, 20-50km, 0.2-2Mbps
- LMDS: 28GHz, 5km, 1-20MBps
- MVDS: 40GHz, 3km, 100MBps+

■ Free spectrum above 5GHz

- but, limited propagation, 'rain-fade', requires high-speed electronics...

Satellite



- GEO stationary
 - 36,000km orbit
 - e.g. 2x 120ms RTT
- LEO constellations
 - 20+ in 1,500km orbits (2hr)
 - latency typically sub 100ms, 300Mbps+
 - interconnect options:
 1. forward to ground station
 2. Uplink to a GEO network
 3. LEO to LEO laser

“Near-satellite”



- Avoid LEO roll-out costs
 - target your market audience
- Fuel efficient planes
 - 55,000 ft, 2 pilots on 8hr shifts
- high-altitude balloons
 - above most weather systems
 - use ion engines to stay in place

Fibre to the kerb / home



- A reasonable solution for new properties
 - fiber is cheap, termination costs dropping
- Digging up the street is too expensive
- Fiber to the 'kerb-side box'
 - remaining short length of existing copper good for 100's of Mbps.
- Fibre is not necessary yet...

Mobile wireless



- GSM currently provides 9600 and 14400bps data service
- upcoming “3G” services optimized for data
 - 144kbps vehicular
 - 384kbps pedestrian
- mobile b/w capabilities look set to remain poor in contrast to fixed