Residential Broadband (RBB)

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Service Aspects and Applications (SAA)

- Voice and Telephony over ATM (VTOA)
- Residential broadband services (RBB)
- Audiovisual multimedia services (AMS) Phase 1: Video on demand
- AMS Phase 2: Video conferencing
- ATM Name Service (ANS)
- Native ATM Services (API)
- Technologies for high-speed access to home
- ATM over these technologies
- IEEE 802.14 standard
Residential Broadband (RBB)

- Also, Residential and Small Business Broadband (RSB) in the marketing arm of ATM Forum
- High-speed access to homes
- RJ-11 like universal interface to devices
- Existing cable TV has the media but no switching
- Existing phone service has switching but not enough bandwidth
Potential Applications

- Video on demand (VOD)
- Near video on demand (NVOD) - staggered starts
- Distance learning
- Home shopping
- Telecommuting
- Teleconferencing
- Meter reading
- Security
- Telemedicine
Residential Access Networks (RANs)
ADSL

- Asymmetric Digital Subscriber Line
- Asymmetric $\Rightarrow$ upstream $\ll$ Downstream
- Modem technology
- 6 Mbps downstream, 640 kbps upstream
- Using existing twisted pair lines
- No interference with phone service (0-3 kHz) $\Rightarrow$ Your phone isn't busy while netsurfing
- Up to 7500 m
- Being standardized by ADSL forum
- Quickest alternative for Telcos
Very High Speed DSL (VDSL)

- Up to 50 Mbps downstream, 5 Mbps upstream
- Up to 1500 m
- Larger bandwidth for shorter distances and vice versa
- 51.84 Mbps at 300 m, 25.92 at 1000 m, 12.96 at 1500 m
- Reuse existing telephone twisted pair wiring
- Point-to-point topology ⇒ Bandwidth not shared
- Co-exist with POTS or ISDN on the same pair
- Twisted pair ⇒ EMI ⇒ withstand legal 400W radio transmissions at 10 m
Hybrid Fiber Coax (HFC)

- Reuse existing cable TV coax
- Replace trunks to neighborhoods by fibers
- 500 to 1200 homes per HFC link
- 45 Mbps downstream, 1.5 Mbps upstream
- MAC protocol required to share upstream bandwidth
- Several homes share the cable TV
- Sharing $\Rightarrow$ Security issues
- IEEE 802.14 is standardizing MAC and PHY
HFC Spectrum

- Use 0-50 MHz for upstream, 50-450 MHz for analog broadcasts, 450-750 MHz for downstream
- Can use phone, TV, and Internet simultaneously
- Low upstream band $\Rightarrow$ more noise
- Broadband $\Rightarrow$ frequency multiplexing $\Rightarrow$ Each home tunes to its channel
- Quadrature amplitude modulation (QAM-64) can give 27 Mbps over 6 MHz channel
Fiber to the Curb (FTTC)

- Also known as switched digital video (SDV)
- Coax and twisted pair for the last 100-300 m
- Coax is used for analog video, TP is used for POTS
- Baseband $\Rightarrow$ No frequency multiplexing
- Passive optical network $\Rightarrow$ signal is optically broadcast to several curbs $\Rightarrow$ Time division multiplexing
- Up to 50 Mbps downstream, Up to 20 Mbps upstream
- Co-exist with POTS or ISDN on the same cable pair
- Twisted pair $\Rightarrow$ EMI $\Rightarrow$ withstand legal 400W radio transmissions at 10 m
FTTC MAC

- Downstream uses periodic frames
- Upstream should consist of fixed size slots containing one ATM cell
- One upstream slot per n downstream frames
- Some slots are reserved, others are for contention
- Contention slots are used by devices undergoing activation
Cable Modems

- Modulate RF frequencies into cable
- Signal received at the headend and converted to optical
- Cost $395 to $995
- Internet access at 500 kbps to 4 Mbps
- If cable is still one-way, upstream path is through POTS
- $30 to $40 per month flat service charge
- Successful trials in Canada using 500 kbps modems
- After the trial 75% users decided keep the service and pay
- TCI formed @Home http://www.home.net
- Servers at headend to avoid Internet bottleneck
- Plans to create high-speed cable backbone across the US
Fiber to the Home (FTTH)

- Fully optical ⇒ No EMI
- Initially passive optical network ⇒ Time division multiplexing
- Upstream shared using a MAC
- 155 Mbps bi-directional
- Need new fiber installation
Passive Optical Networks (PONs)

- Optical part of HFC, FTTC, FTTH
- Up to 10 km
- 150 Mbps or more downstream
- 50 Mbps or more upstream
- Downstream signal is broadcast to all NTs
- Downstream traffic has a destination address
- Upstream transmission is controlled by optical line terminal (OLT)
- Upstream bandwidth shared using a MAC
- Timing reference transmitted downstream
## Comparison of RANs

<table>
<thead>
<tr>
<th>Technology</th>
<th>Typical Downstream Rate</th>
<th>Typical Upstream Rate</th>
<th>Maximum Distance</th>
<th>Homes Per Optical Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC</td>
<td>45 Mbps Shared</td>
<td>1.5 Mbps Shared</td>
<td>N/A</td>
<td>500</td>
</tr>
<tr>
<td>FTTC</td>
<td>25-50 Mbps</td>
<td>25-50 Mbps</td>
<td>100 m</td>
<td>10-50</td>
</tr>
<tr>
<td>FTTH</td>
<td>155 Mbps</td>
<td>155 Mbps</td>
<td>N/A</td>
<td>10-200</td>
</tr>
<tr>
<td>ADSL</td>
<td>6 Mbps</td>
<td>640 kbps</td>
<td>4000 m</td>
<td>1,000</td>
</tr>
<tr>
<td>VDSL</td>
<td>13-50 Mbps</td>
<td>1.6-5 Mbps</td>
<td>2,000 m</td>
<td>100</td>
</tr>
</tbody>
</table>
RBB Reference Configuration

ATM Core

ATM Access Network

Distribution

Final Drop

UNI_w  UNI_x

NT

Home ATM Network

UNI_y

Adaptor

TII

TE
RBB Charter

- To define:
  - Home UNI (HUNI)
  - UNI<sub>x</sub> (where x = HFC, FTTC, FTTH, ADSL, ...)
- Support end-to-end ATM
- Point-to-point and point-to-multipoint VCs
- All TM4.0 services: CBR, VBR, ABR, UBR
- CATV MAC and PHY Protocol working group
- Started November 1994
- Defining PHY and MAC for 2-way HFC
- 17 MAC protocol proposals have been submitted
- Downstream PHY: 1-to-n broadcast
- Upstream PHY: n-to-1
- Up to 50 miles (80 km) ⇒ 400 microsecond one-way
IEEE 802.14 MAC Requirements

- Support both connectionless and connection-oriented services
- Support QoS
- Support CBR, VBR, ABR
- Support Unicast, multicast, broadcast services
IEEE 802.14 PHY

- 500 homes as a reference design point
- Support sub-split (5-40 MHz upstream), mid-split (5-120 MHz upstream), and high-split (800-1000 MHz upstream)
- Frequency reuse in upstream
- Decided to use Quadrature Amplitude Modulation (QAM) 64 for downstream.
- QAM-64 gives 6 bits/Hz $\Rightarrow$ 30 Mbps on 6 MHz $\Rightarrow$ 27 Mbps after FEC
- Quadrature Phase Shift Keying (QPSK) may be selected for upstream to sustain high noise $\Rightarrow$ 1.5 to 3 Mbps on 2 MHz
- Several upstream channels per downstream channel
## IEEE 802.14 Protocol Stack

<table>
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<tr>
<th>Layer</th>
<th>Description</th>
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<tbody>
<tr>
<td>802.2</td>
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IEEE 802.14 Issues

- ATM based?
- Which forward error correction algorithm?
- Size of slots?
- Upstream sharing requires ranging of homes. How precise?
- Security and encryption
- Error handling by MAC
- Station addressing
Home ATM Network (HAN)
Home ATM Network

- Allow intra-home device communications
- Access network not required for intra-home communications
- 20-50 Mbps, symmetric, full-duplex
- Reach of 50 m
- At least 128 addressable devices
- Position independent operation
- Allow firewall between HAN and access network
Summary

- High Speed Access to Home: HFC, FTTC, FTTH, ADSL, VDSL
- 6 to 155 Mbps downstream, 1.5 Mbps upstream
- Both cable and telecommunication companies are trying to get there with minimal modification to their infrastructure
Acronyms: RBB

- ADSL: Asymmetric Digital Subscriber Line
- ANI: Access Network Interface
- CATV: Cable TV
- EMI: Electromagnetic Interference
- FTTC: Fiber to the curb
- FTTH: Fiber to the home
- HAN: Home ATM Network
- HFC: Hybrid Fiber Coax
- NT: Network termination
- ONU: Optical network unit
- **STB**  Set top box
- **TII**  Technology independent interface
- **VDSL**  Very high speed digital subscriber line
- **VOD**  Video on demand
References: RBB

References: IEEE 802.14