1 – Cable and Phone Networks to the Curb and Wireless Ethernet

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2 – Coaxial Cables

Television Cable signals are carried across coaxial cables (sometimes with a fiber backbone). The Coax cable is a broadcast medium.
Television Cable signals delivered from the head end.
CATV: Cable TV system. Can be coaxial or HFC (Hybrid Fiber Coax).

Cable modem (CM): Client device for providing data over CATV.

CMTS: Cable Modem Termination System. Central device for connecting a CATV network to the internet (at the Head End).

CPE: Customer Premises Equipment (the PC and maybe Modem).

DHCP: Dynamic Host Configuration Protocol. (Dynamic IP addressing)

DOCSIS: Data Over Cable Service Interface Specification, the dominant standard for CMTS and Cable Modems.

Euro-DOCSIS: European flavor of DOCSIS.

Downstream: The data flowing from the CMTS to the cable modem.
• Headend: Central distribution point for a CATV system.

• HFC: Hybrid fiber-coaxial (cable network).
5 – Cable Modem Terminology (M TO Z)

- MAC layer: Media Access Control sublayer.
- MCNS: Multimedia Cable Network System Partners Ltd. (Sponsors DOCSIS).
- Minislot: Basic timeslot unit used for upstream data bursts in DOCSIS.
- MSO: Multiple Service Operator. A cable TV service providing voice and/or data.
- QAM: Quadrature Amplitude Modulation, used downstream.
- QPSK: Quadrature Phase-Shift Keying, used upstream.
- Ranging: The process of automatically adjusting transmit levels and time offsets of individual modems.
- SID (Service ID): DOCSIS standard to define a particular mapping between a cable modem (CM) and the CMTS.
• Subscriber Unit (SU): An alternate term for cable modem.

• Upstream: The data flowing from the CM to the CMTS.
6 – Cable Modem Networks

Typical Cable Systems are HFC (hybrid fiber) setups. The tree like structure may have a single CMTS having say 1000 or more users.
7 – Bandwidth Allocation

The cable company typically uses FDMA to allow many cable modems to share the same media.
8 – Bandwidth on Cable Modems

Typically one television channel can support many users (up to say 2000, depending on their average bandwidth requirements).

The shared data rates on the cable are:

- **Down Stream** - 27-56 Mbps
- **Up Stream** - 3 Mbps

Typically the cable modem has something which looks like a “T” connector at the end called a *power splitter*.

The input is the total signal, the outputs are:

- **TV/VCR Inputs** - Passed through a high pass filter to block out up stream traffic and prevent noise from intruding on the upstream/down stream frequencies. This noise suppression protects both end users and the CMTS/Head End.

- **Modem Input** - This might out the TV signal, but I’m not sure.
Cable modems act as a MAC-layer bridge, with higher end models acting as routers.

The data link layer is IEEE 802.3 compliant (ethernet).

The physical layer differs for upstream and downstream traffic:

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDMA (mini-slots)</td>
<td>TDM (MPEG)</td>
</tr>
<tr>
<td>5-43(65) MHz</td>
<td>42(65)-850 MHz</td>
</tr>
<tr>
<td>QPSK/16-QAM</td>
<td>64/256-QAM</td>
</tr>
<tr>
<td></td>
<td>ITU-T J.83 Annex B(A)</td>
</tr>
</tbody>
</table>

QPSK is typically 2 bits per phase shift encoding.

X-QAM is the number of points in the QAM constellation (X distinct combined phase/amplitude pairs).

DOCSIS control messages support the higher layers.
• Tuner — Shifts the channel to a fixed frequency (6-40 MHz).

• Demodulator — Does A/D conversion, demodulation, ECC and MPEG synch.

• MAC — Converts between MPEG and the local protocol. Filters out signals from other CM and handles timing of bursty traffic.

• Interface — PCI bus for internal modems, or ethernet/USB for external.
11 – DHCP and Address Resolution

• Dynamic Host Configuration Protocol (DHCP) uses a central server to assign network addresses to clients.
  – With mobile systems, clients periodically connect and disconnect.
  – Many clients of ISPs only use the network regularly as clients.
  – Address space is scarce (especially of IPV4)
  – So permit administrators to give temporary addresses to hosts for scalability and ease of management.

• Historical background (bootp), How did it all start?
  – Thin Clients (diskless workstations) popular in late 1980s.
    * Memory/CPUs expensive back then (very different from now)
    * Disks small and expensive to manage
(also very different!)
* Have all work done by beefy servers
  (easier centralized admin)
* Client just do remote display and data
  entry (like Xterminals).
  - Clients needed to retrieve O/S and
    Network ID info
    * So when starting up request boot data
      from server
    * Server sends boot program, and sets IP
      address of clients

• Critical Difference from bootp - lease
  (addresses expire)

• Thomas Narten (ex SUNY CS Prof, now at
  IBM) influential in DHCP design
• Kinds of DHCP messages
  – DHCPDiscover - client broadcast requests a DHCP address
  – DHCPRequest - client requests longer lease
  – DHCPDecline - The client refuses the lease (e.g. the client determines another node is using that address).
  – DHCPOffer - Server offers leased address for a particular duration
  – DCHPRelease - Client terminates existing lease
  – DHCPAck - Server can honor client’s DHCPRequest
  – DCHPNak - Server will not honor client’s DHCPRequest

• Network Design Features
  – Downstream hosts may share a DHCP server
- How to prevent DHCP Request Broadcast Flooding?
  * Use an intermediate DHCP relay
  * Relay receives downstream requests
    broadcast
  * Relay forwards requests as unicast
    messages to DHCP server.
Recall that the phone systems is circuit switched.

This means that a telephone call must establish a connection:
14 – Some Notation

The U.S. phone system has a hierarchical infrastructure:

- LATAs — Local Access Telephone Areas
- RBOCs — Regional Bell Operating Companies
- IXC — Interexchange Carriers (Long Distance)

Often there are alternate networks connecting groups of end points.
(a) Routing in a typical metropolitan area

(b) Routing between two LATAs
The *Local Loop* is a twisted pair of wires connecting a phone to the local office.
Recall that echoing occurs because of the use of two wire connections in the phone work.
Digital Cross Connect (DCC) switches are used to handle preexisting calls and traffic (they don’t participate in connection setup).
DCC switches can act as a bridge between two subnets.
• ISDN — Integrated Services Digital Network — Slower, Older form of integrated voice/digital lines

• BISDN — Broadband ISDN

• DSL — Digital Subscriber Lines

• ADSL — Asymmetric Digital Subscriber Lines (have slower upstream rates than downstream).

• ATM — Asynchronous Transfer Mode
20 – Signaling

Signaling is used to support interaction between:

- The user and the network
- Within the network

*Signal Program Control* (SPC) uses stored programs to control switches.
21 – Signaling Networks

Signaling networks provide communication between computers controlling the switches (often packet switched).

- Must have high reliability and availability
- Must be backward compatible.
- *Intelligent Networks* provide a wider range of services.
- *Personal Mobility* directs connections to moving users.

![Signaling Network Diagram]

**Legend:**
- SSP = Service switching point (signal to message)
- STP = Signal transfer point (message transfer)
- SCP = Service control point (processing)
22 – Signaling Systems #7

Signaling System #7 (SS7) is a packet network that: Sets up, Manages and Releases connections.

- MTP 1 — Physical layer (T1, E1, ...)
- MTP 2 — Data Link, ensures correct delivery between neighbors
- MTP 3 — Network Lawyer, ensures remote connections
- TUP — Telephone User Part, Phone Service
- ISUP — ISDN User Part, sets up, manages and tears down phone connections.
- TCAP — Transaction Capabilities Part, provides connectionless database support for connectionless networks.
- SCCP — Signaling Connection Control Part, used by TCAP
Signaling System #7 (SS7) is a packet network that: Sets up, Manages and Releases connections.
Cellular telephone networks consist of:

- Mobile telephones with radio connections
- Fixed *base stations* with connected to each other.
- *Mobile stitching centers* (MSCs) in the base stations.
Cellular Phone Networks have to deal with:

- Reusing limited frequency ranges:
  - The base stations transmit on \textit{forward channels}
  - The mobile users transmit on \textit{reverse channels}

- Coordinating the \textit{handoff} of users moving between cells.

- Roaming Users outside their home areas.

- \textit{Mobile stitching centers} (MSCs) in the base stations.
AC = authentication center
BSS = base station subsystem
EIR = equipment identity register
HLR = home location register

MSC = mobile switching center
PSTN = public switched telephone network
STP = signal transfer point
VLR = visitor location register
26 – Cellular Telephone Standards

The Major Standards for Cellular Phone Systems are:

- Global System for Mobile Communications (GSM) — Europe

- Interim Standard-41 (IS-41) — North America, based on GSM
GSM systems have:

- Base Station Subsystems (BSS)
  - Base Transceiver System (BTS) — Includes signal strength control
  - Base Station Controller (BSC) — Non Radio based equipment
28 – Layering in GSM

- Radio — Physical Layer
- Link Access Procedure D (LAPD) — data link layer, like Asynch Mode
- LAPD_m — mobile LAPD, also data link
- Application Layer
  - Radio Resource Management (RRM)
  - Mobility Management (MM)
  - Connection Management (CM)
29 – Satellite Networks

Satellite networks can use geosynchronous or low earth orbit satellites (LEOS).

- Geosynchronous — Easier to manage, more latency
- low earth orbit satellites (LEOS) - harder to manage
- Iridium — Motorola’s unsuccessful LEOS system
(a) [Diagram of satellite motion]

(b) [Diagram of satellite motion]
Wireless Ethernet now has 3 popular standards:

- **802.11b** — 11 Mbps at 2.4 GHz. (Currently Deployed, WiFi certification) using QPSK (QAM).
- **802.11a** — Emerging Deployment 54 Mbps at 5GHz using OFDM
- **802.11g** — Emerging Standard 20 Mbps at 2.4 GHz.
References