Switching, Mobile Phones, Cable, Beginning Data Link Layer

CS158a

Chris Pollett

Feb 21, 2007.

Outline

- Switching
- Mobile Phones
- Cable
- Start of Data Link Layer

Switching

- We will now examine how the switching part of the phone system works.
- When you make a phone call, the phone systems seeks out a physical path from your phone to the receiver's phone.
- This is called **circuit switching**.
- When a call passes through a switching office, a physical connection is established between the line on which the call came in and one of the output lines.
- This making of a connection was originally done by a phone operator, but was soon automated.
- The alternative to circuit switching is **packet switching**. In this set up the call of data is split into packets and no dedicated connection needs to be set up.
- So there is no set up time in packet switching is faster, but there might be delays on packets after communication starts, which doesn't happen with circuit switching.
- Another switching strategy is to send whole messages to a switch which then stores and forwards them to the next switch. i.e., a **store and forward** network. This is called **message switching** and was used by telegraph.

Mobile Phones

- First-Generation Mobile Phones: Analog Voice.
- Second-Generation Mobile Phones: Digital Voice
- Third-Generation Mobile Phones: Digital Voice and Data

AMPS

- The first real first generation mobile system was called AMPS (Advanced Mobile Phone System) introduced by Bell labs in 1982.
- Its digital successor was called D-AMPS.
- Geographic regions were split into cells typically 10-20km across.
- Each cell has a tower (**Mobile Telephone Switching Office**)which uses some frequencies not used by its neighbors.
- Could support .6 W handsets or 3 W car sets.
- Cells are grouped into units of seven adjacent cells in a hexagonal pattern.
- When a phone signals transmission become weaker the tower notices and asks if anyone of its neighbors can receive it better. In which case, a **hand-off** is done. (This take about 300msec)
- A **soft hand-off**, the new station is acquired before the old station signs off. In a **hard hand-off** the old station sign off first.

Channels in AMPS

The 832 channels are used by AMPS and are divided into four categories:

- Control (base to mobile) to manage the system
- Paging (base to mobile) to alert users to calls for them
- Access (bidirectional) for call setup and channel assignment
- Data (bidirectional) for voice, fax, or data

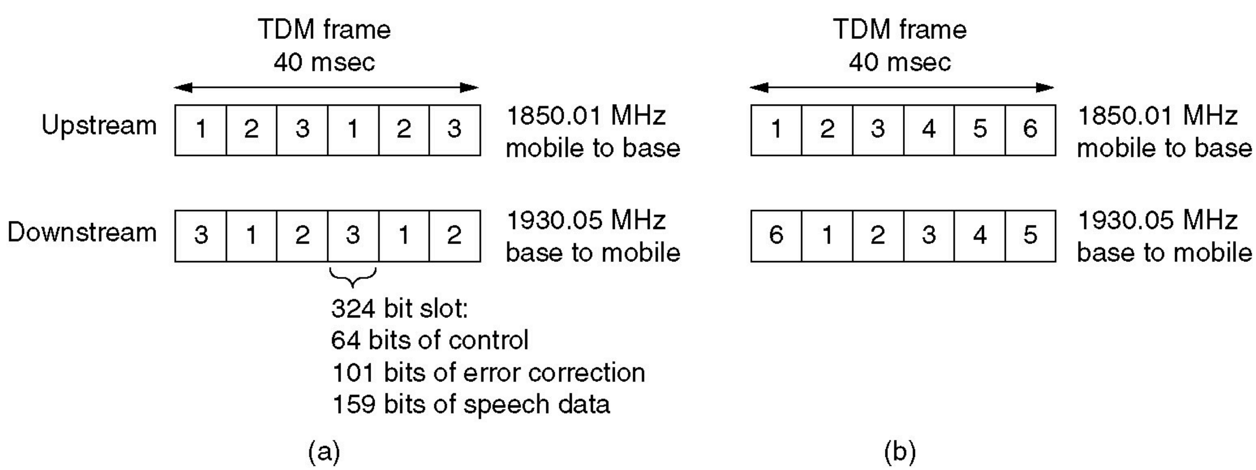
Each phone has a 32 bit serial number and a 10 digit phone number in its PROM.

D-AMPS
Digital Advanced Mobile Phone System

- In D-Amps, the voice data is sample and compressed to an 8kbs stream (PCM in comparison needs 56kbps) by a circuit called a **vocoder**.

•Users can share a frequency using TDM. Each frame is split into 6 slots.

•Idle slots are used to measure line quality and assist in handoff. (mobile assisted handoff.

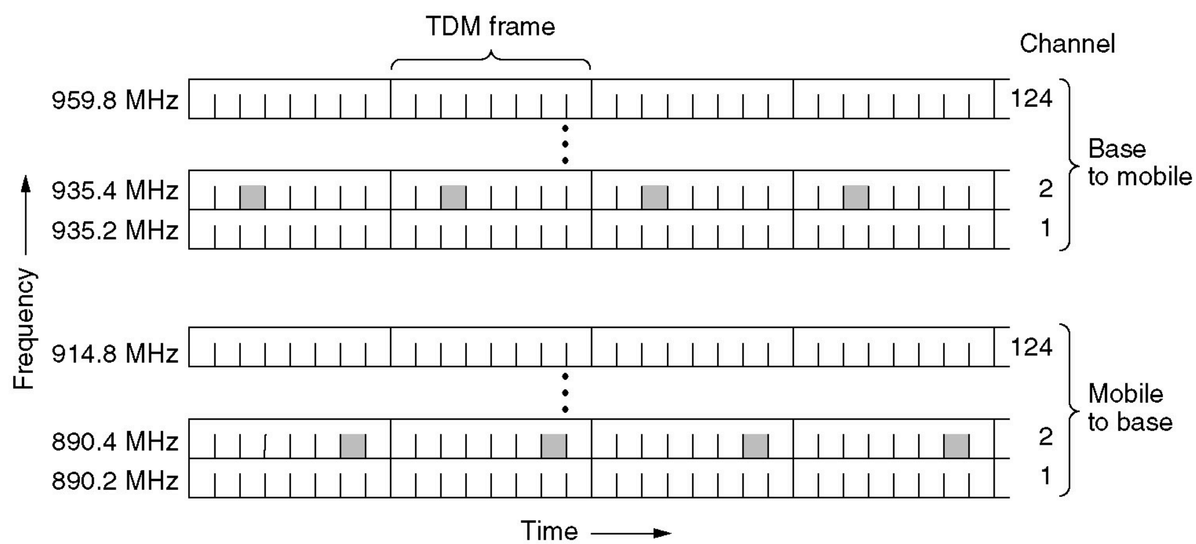


(a) A D-AMPS channel with three users.

(b) A D-AMPS channel with six users.

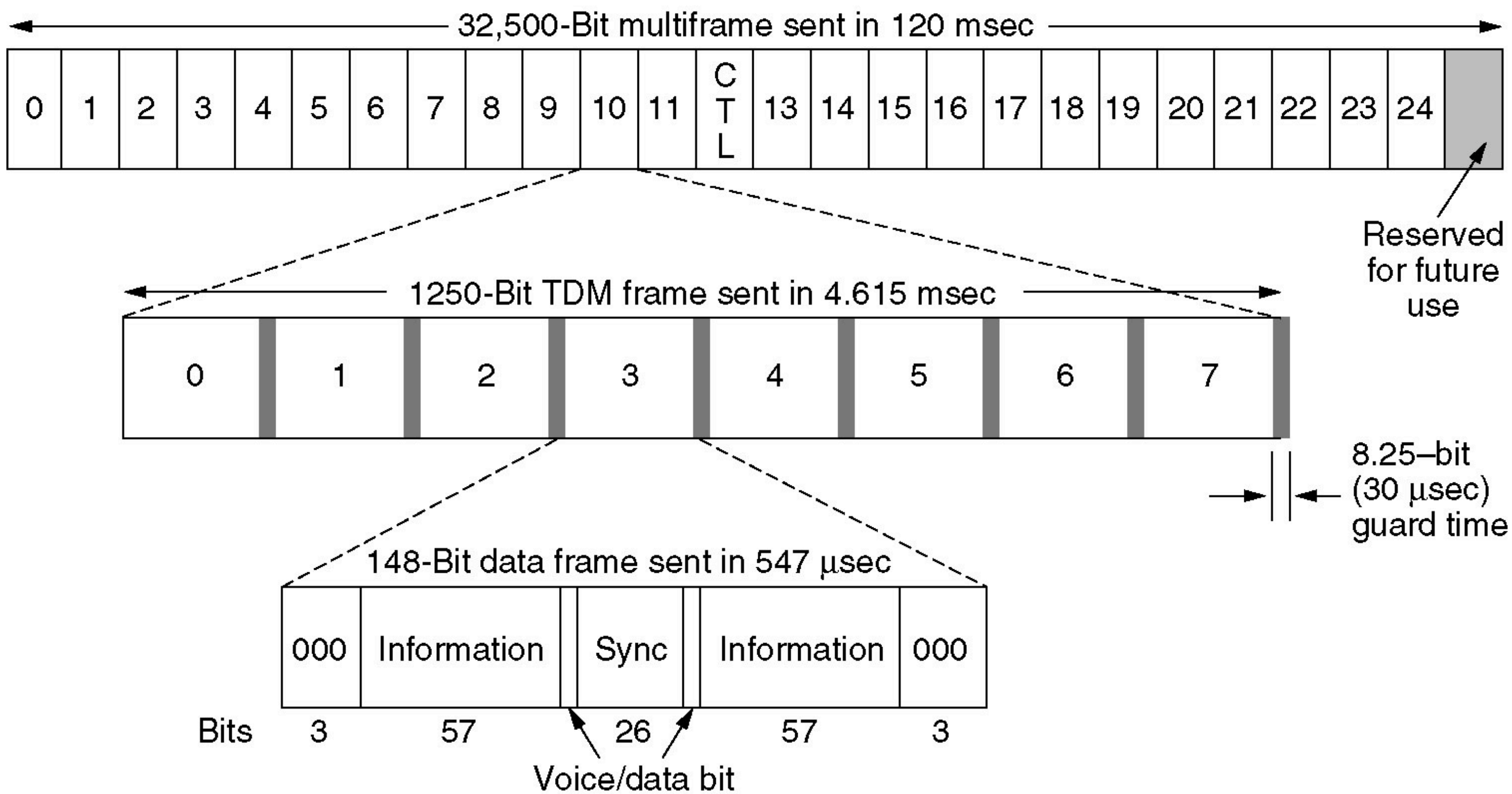
GSM
Global System for Mobile Communications

- GSM uses 124 frequency simplex channels, each of which uses an eight-slot TDM system
- It achieves higher data rates than D-AMPS



GSM (2)

A portion of the GSM framing structure.



CDMA – Code Division Multiple Access

A: 0 0 0 1 1 0 1 1
B: 0 0 1 0 1 1 1 0
C: 0 1 0 1 1 1 0 0
D: 0 1 0 0 0 0 1 0

(a)

A: (−1 −1 −1 +1 +1 −1 +1 +1)
B: (−1 −1 +1 −1 +1 +1 +1 −1)
C: (−1 +1 −1 +1 +1 +1 −1 −1)
D: (−1 +1 −1 −1 −1 −1 +1 −1)

(b)

Six examples:

– – 1 –	**C**	S_1 = (−1 +1 −1 +1 +1 +1 −1 −1)
– 1 1 –	**B + $\overline{\mathbf{C}}$**	S_2 = (−2 0 0 0 +2 +2 0 −2)
1 0 – –	**A + $\overline{\mathbf{B}}$**	S_3 = (0 0 −2 +2 0 −2 0 +2)
1 0 1 –	**A + $\overline{\mathbf{B}}$ + C**	S_4 = (−1 +1 −3 +3 +1 −1 −1 +1)
1 1 1 1	**A + B + C + D**	S_5 = (−4 0 −2 0 +2 0 +2 −2)
1 1 0 1	**A + B + $\overline{\mathbf{C}}$ + D**	S_6 = (−2 −2 0 −2 0 −2 +4 0)

(c)

$S_1 \bullet C$ = (1 +1 +1 +1 +1 +1 +1 +1)/8 = 1
$S_2 \bullet C$ = (2 +0 +0 +0 +2 +2 +0 +2)/8 = 1
$S_3 \bullet C$ = (0 +0 +2 +2 +0 −2 +0 −2)/8 = 0
$S_4 \bullet C$ = (1 +1 +3 +3 +1 −1 +1 −1)/8 = 1
$S_5 \bullet C$ = (4 +0 +2 +0 +2 +0 −2 +2)/8 = 1
$S_6 \bullet C$ = (2 −2 +0 −2 +0 −2 −4 +0)/8 = −1

(d)

(a) Binary chip sequences for four stations
(b) Bipolar chip sequences
(c) Six examples of transmissions
(d) Recovery of station C's signal (1 indicates 1 sent, -1 a 0, and 0 indicates nothing sent)

2.5 and 3rd-Generation Mobile Phones:
Digital Voice and Data

Basic services an IMT-2000 network should provide:

- High-quality voice transmission
- Messaging (replace e-mail, fax, SMS, chat, etc.)
- Multimedia (music, videos, films, TV, etc.)
- Internet access (web surfing, w/multimedia.)

Some proposed 3rd generation systems are W-CDMA and CDMA-2000.

Some 2.5 generation systems with higher data rates such as **EDGE** (enhanced data rates for GSM evolution) and **GPRS** (general packet radio service) are now being used.

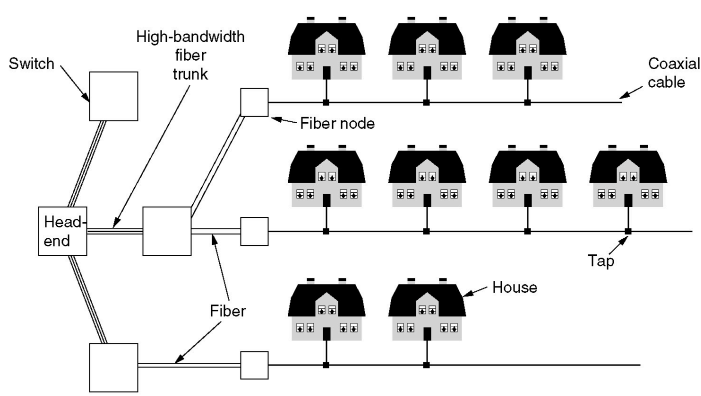
GPRS is an overlay to D-AMPS and GSM that allows on to send and receive IP packets.

Cable

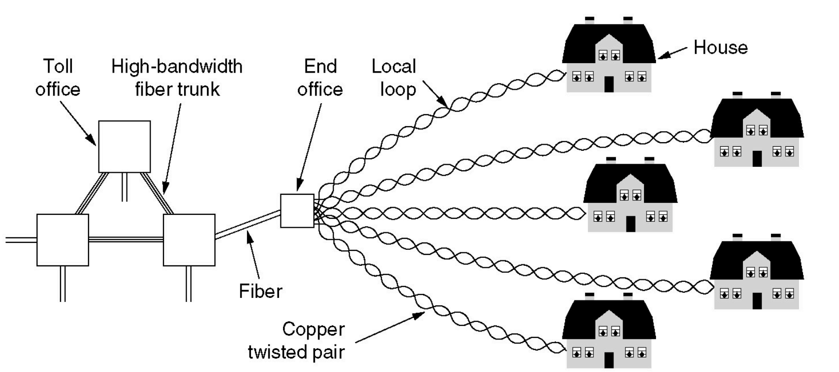
- Cable was developed in the 1940s.
- Initially, systems consisted of a big antenna on top of a hill, an amplifier, called the **head end**, and a coaxial cable to deliver it to people's houses in the valley below.
- In the early days this was sometimes called **Community Antenna Television (CAT)**.
- With time, cable only channels such as HBO (the first in 1974) were also fed into the coax.
- Cable was also laid between cities and eventually, the initially one way communication from the head end was converted into a two way channel by replacing amplifiers with two way amplifiers.

Internet Over Cable

- Cables between cities were eventually replaced by the cable companies by fiber for long hauls.
- The new systems were called **Hybrid Fiber Coax**.
- The interface between the fiber and electrical parts are called **fiber nodes**.
- The system now looks somewhat similar to the phone system, except that rather than every house having its own local loop, there is one cable which is tapped by many houses.
- Older systems with long cables only for broadcast to up to 10,000 home have been split in recent times to handle 500-2000 homes to make upstream traffic manageable.

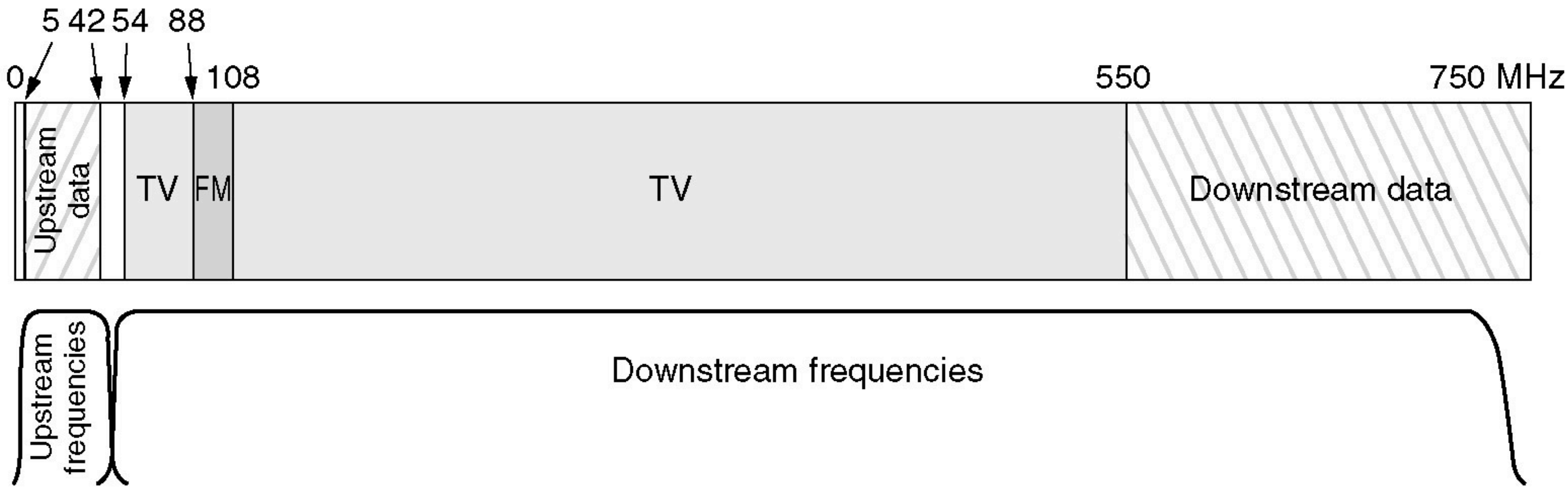


(a)



(b)

Spectrum Allocation



- The downstream bandwidth is typically split into 6MHz or 8MHz channels which use QAM-64 or QAM-256. This gives a net data rates of either 27Mbps or 39Mbps.
- QPSK is used for upstream traffic because of noise issues.

Cable Modems

- These were standardized in **DOCSIS** (Data Over Cable Service Interface Specification).
- So one should be able to buy a cable modem from a third party and have it work with your system.
- The modem-computer interface is not too complicated. It normally 10Mbps ethernet which is output.
- How the input from cable end of the modem is handled is more complicated. The modem scans the downstream channel looking for a special packet periodically sent out from the head end.
- Upon seeing this packet the modem announces itself on one of the upstream channels. The headend then assigns the modem a specific upstream and downstream channel.
- The modem then does **ranging** to determine how far it is from the headend. This is so it can do the timing right for the upstream traffic which is divided into so-called **minislots**.
- Each modem is assigned by the headend a minislot it can use for upstream traffic, and the headend periodically sends out a signal to indicated a round of minislots is going to begin.
- An exponential backup is used to handle contention.
- All traffic over modems is also encrypted.

Introduction to the Data Link Layer

- The data link layer has the following functions:
  (1) Provides a well-defined service interface to the network layer
  (2) Deals with transmission errors
  (3) Regulates the flow of data, so that slow receivers are not swamped by fast senders.
- To do this the data link layer takes the packets it gets from the network layer, breaks these up into smaller units as needed, and adds a header and a trailer to these units to produce **frames** which can be transmitted to the physical layer.

Services Provided to the Network Layer

- Depending on the actual system, the data link layer may provide the following services to the network layer:
  - Unacknowledged connectionless service
  - Acknowledged connectionless service
  - Acknowledged connection oriented service

Framing

- The physical layer provides to the data link layer the ability to deliver or accept a raw bit stream.
- When the data link layer creates a frame it computes a checksum of its data contents and send this as part of the frame.
- At the other the data link layer must be able to break the raw bit stream into frames.
- For each frame, it must compute a checksum, and then check it against the checksum that was sent to see if the frame contains errors.
- To deal with the error this layer discards the frame and may send an error report back to the sender.

More on Framing

- To break the bit stream into frames is actually fairly challenging.
- Inserting time gaps between frames gaps is unreliable because networks rarely guarantee timing.
- Typical techniques include:
  - **Character count** (first char says how many characters in the frame, use this to figure out where frame ends).
  - **Flag byte with byte stuffing** (Use a special character to indicate a state of frame. Say @. If @ appears in the data then add the escape char \ before it. i.e., \@)
  - **Starting and ending flags with bit stuffing**. For example, one starts and ends a frame with 01111110. If 11111 appears in the data instead output 111110.
  - **Physical layer coding violations**. If the physical layer sends 01 for a 0 and 10 for a 1, then if you see 00 or 11 you assume it is the start or end of a frame.