Real-Time Embedded Systems

CpE-450 Spring 06

Class 13

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Case Study 4:
The Cellular Phone

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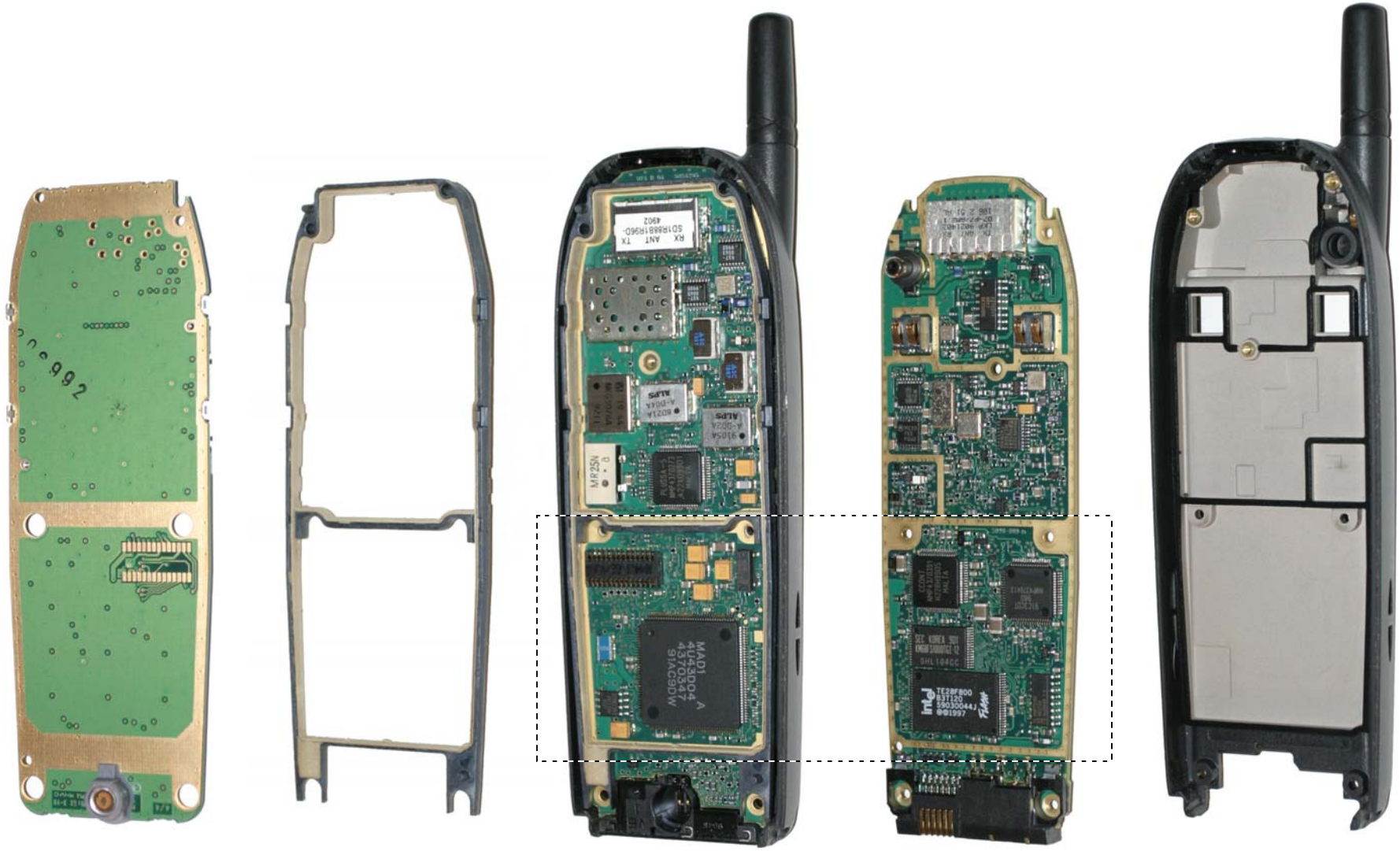
The Cellular Phone

~1996 600 mW
AMPS/TDMA

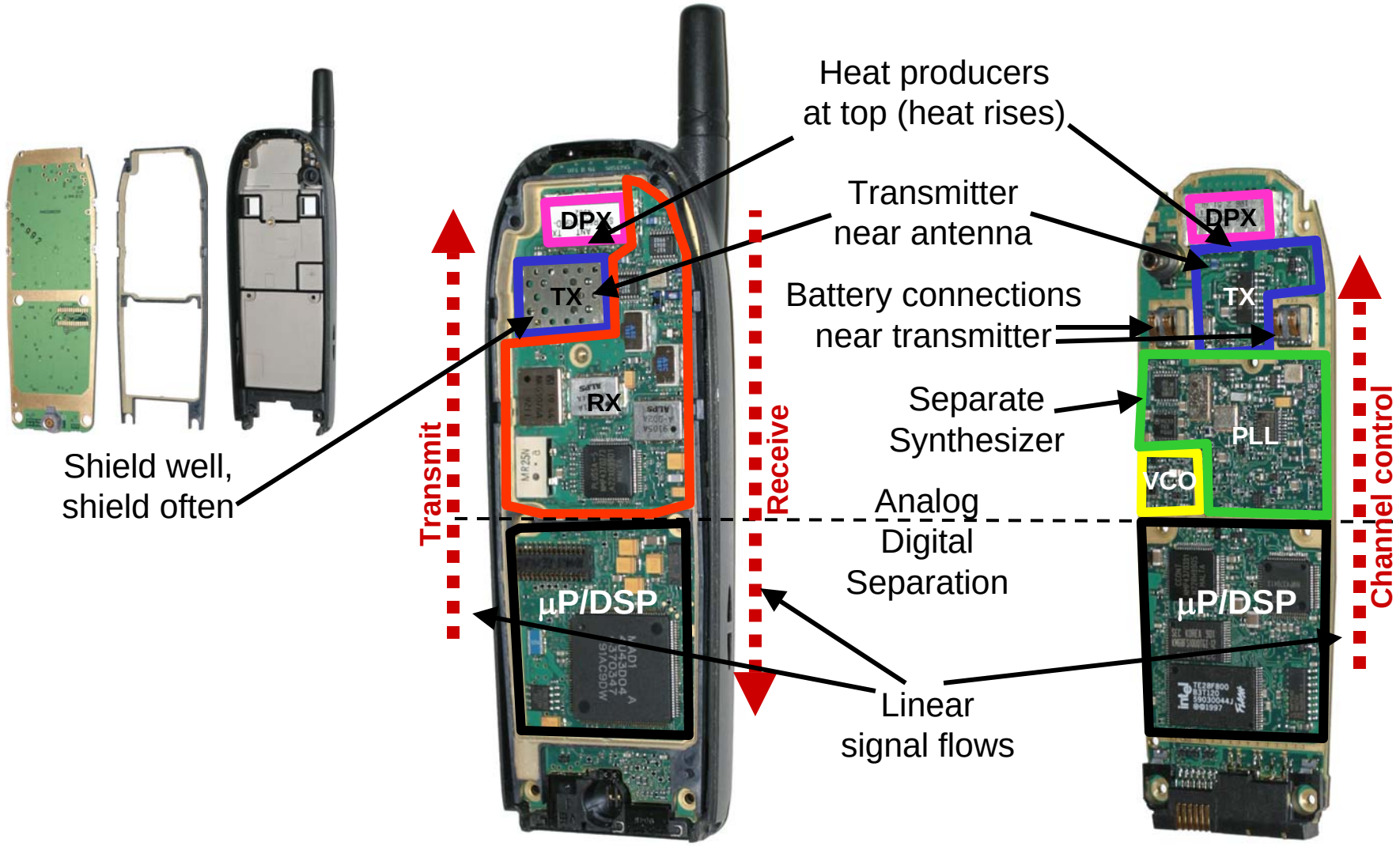
Nokia 6162
850 MHz Analog/
1900 MHz TDMA

Transceiver Anatomy 101

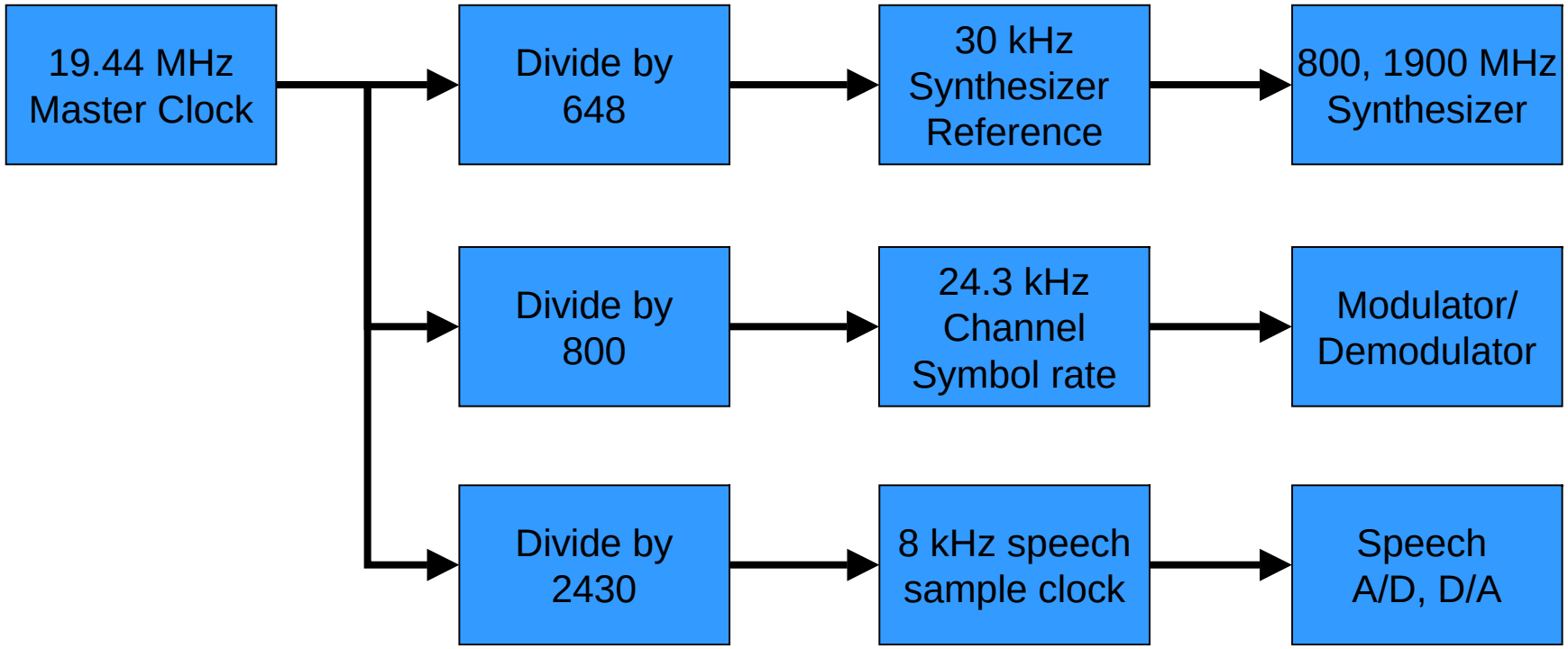
Transceiver Anatomy 102



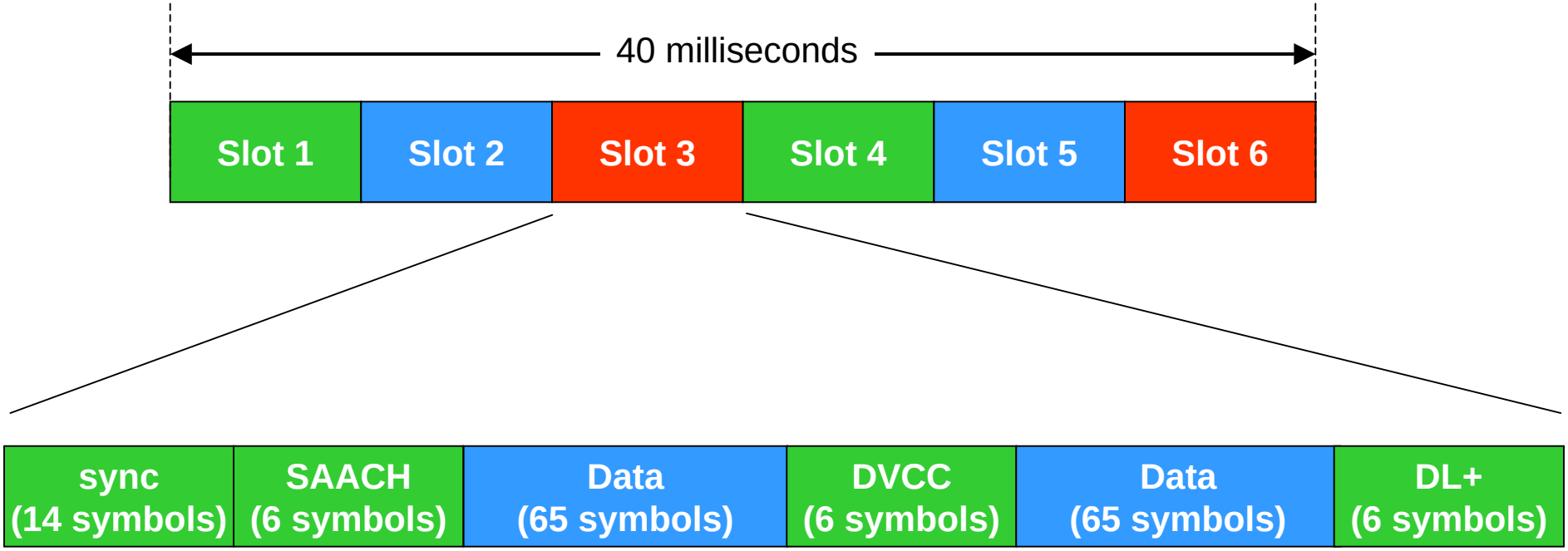
Lessons from Anatomy



Clock Generation



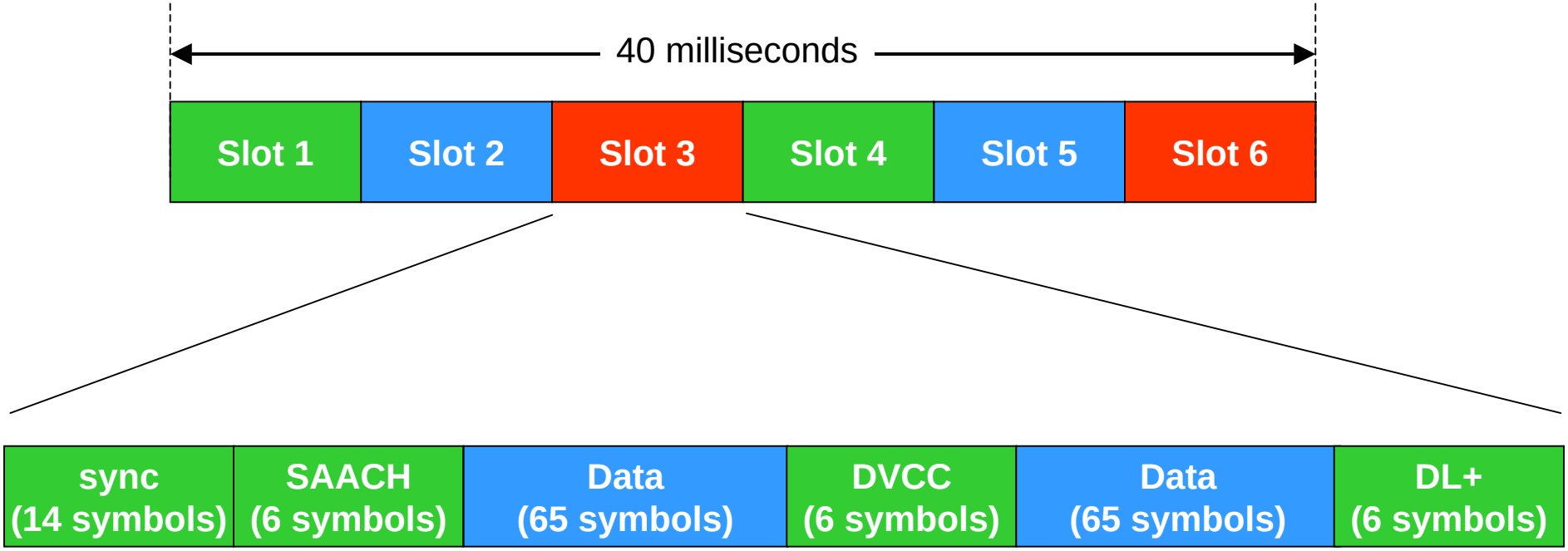
IS-136 Channel Structure (Downlink)



(162 symbols/slot * 2 bits/symbol) * 6 slots/frame ➔ 1944 bits/frame

1944 bits/frame * 25 frames/sec ➔ 48.6 kb/s

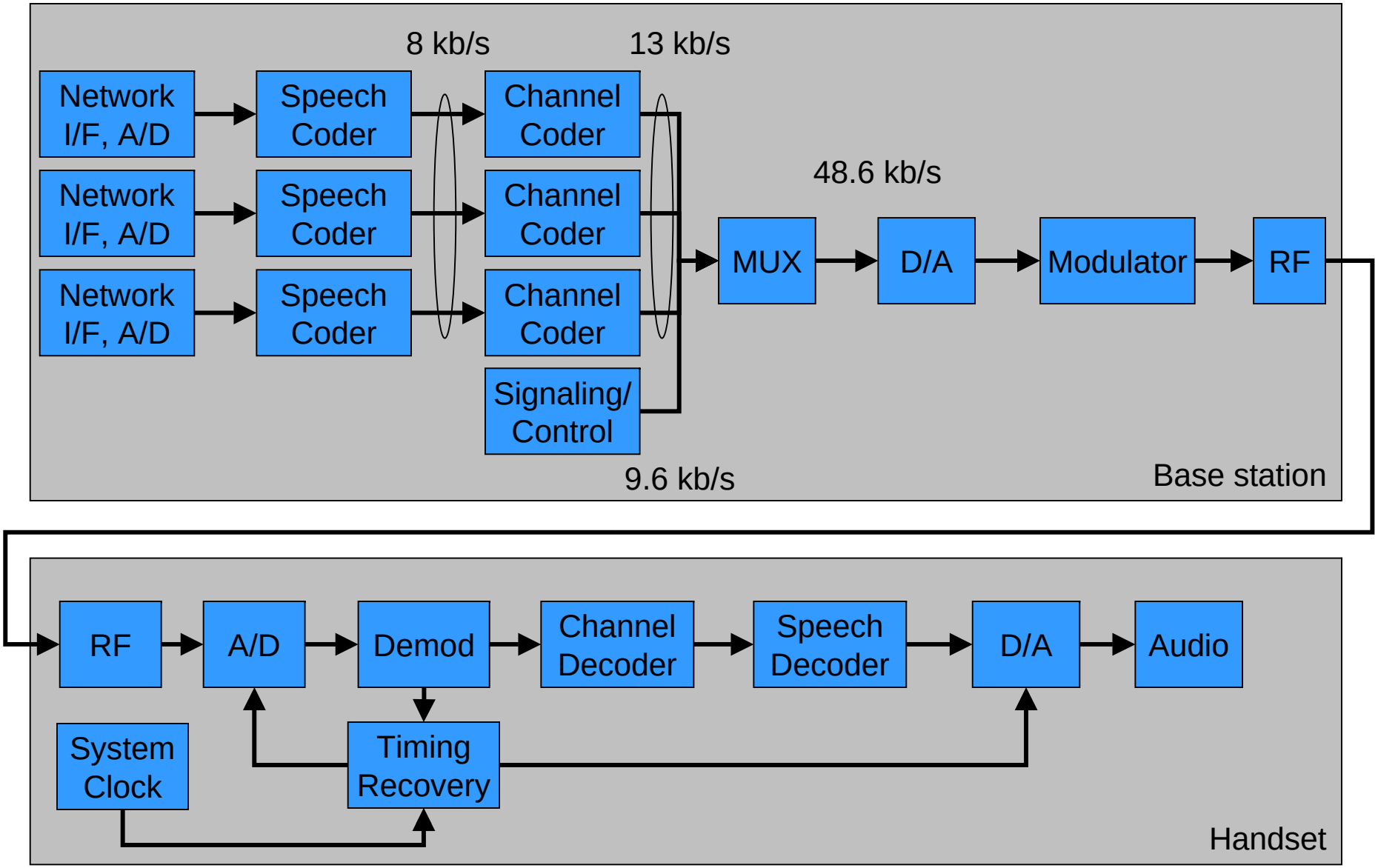
IS-136 Channel Structure (Downlink)



(130 data symbols/slot * 2 bits/symbol) * 2 slots/frame ➔ 520 data bits/frame

520 data bits/frame * 25 frames/sec ➔ 13 kb/s (data)

IS-136 Transmitter/Receiver Structure



Handset Receiver Software Structure

```
main()
{
initialize();
while(1)
  {
  sleep();
  switch(alarm)
    {
    case 40ms:
      demod_frame(!FB#);
      decode_frame(!FB#);
      if(detect_signal(!FB#))
           act_on_sig();
      adjust_timing();
      decode_speech(!FB#,!SB#,P);
      break;
    case user:
      x=decode_command(UIB);
      act_on_command(x);
      break;
    }
  }
}
```

Interrupt on IS-136 frame

```
bit frame_buffer_nr=0;

40ms_frame_int()
{
read_a_frame(frame_buffer_nr++);
wake_BG(40ms);
}
```

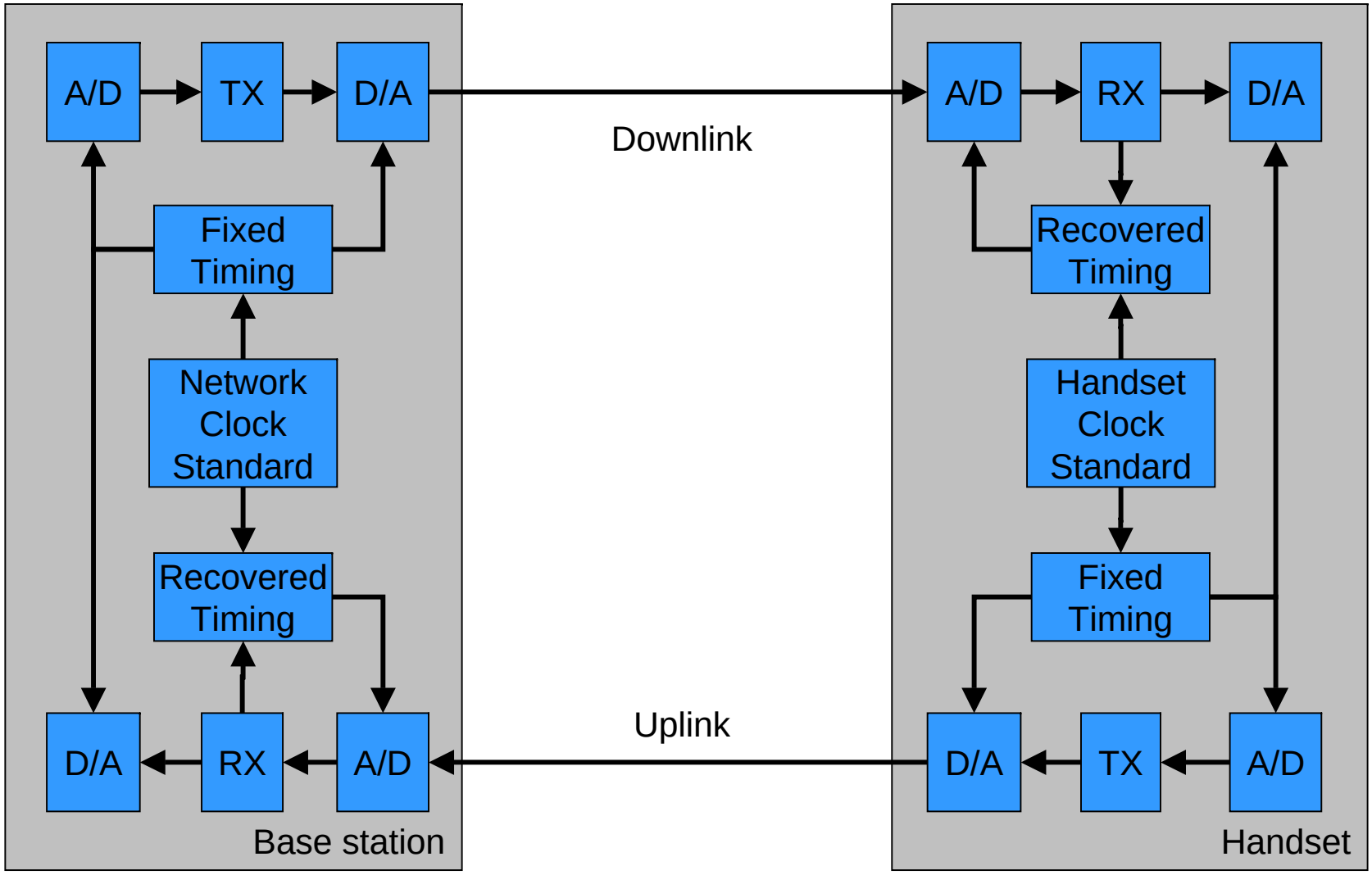
Interrupt at 8 kHz

```
bit speech_buffer_nr=0;
int position;

speech_DA_int()
{
write_DA(speech_buffer_nr,position);
if(position>length)
   {
   SB#++;
   position=0;
   }
}
```

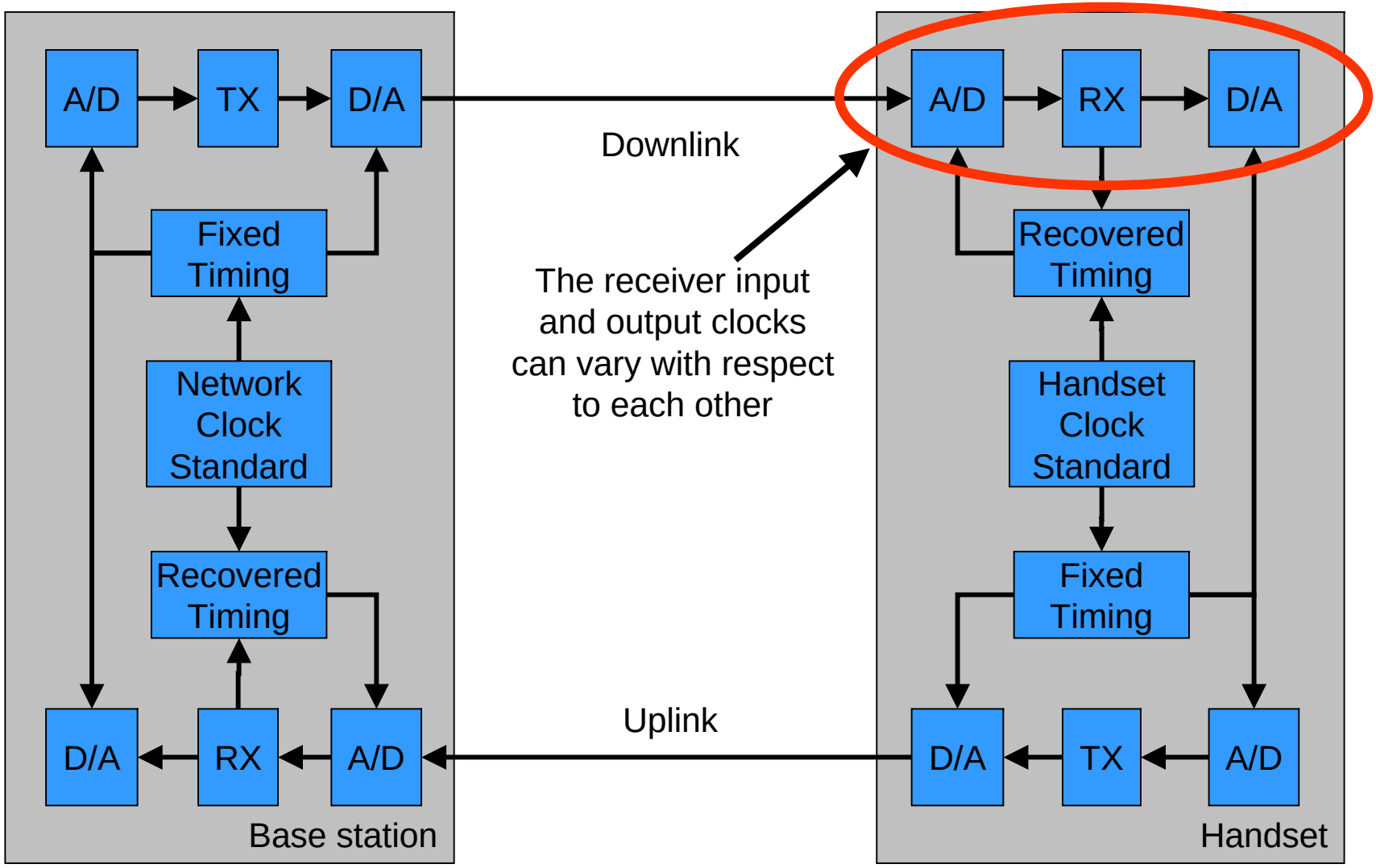
Interrupt on user input

```
char UI_buffer_nr[N];

user_int()
{
scan_UI(UI_buffer_nr++);
wake_BG(user);
}
```

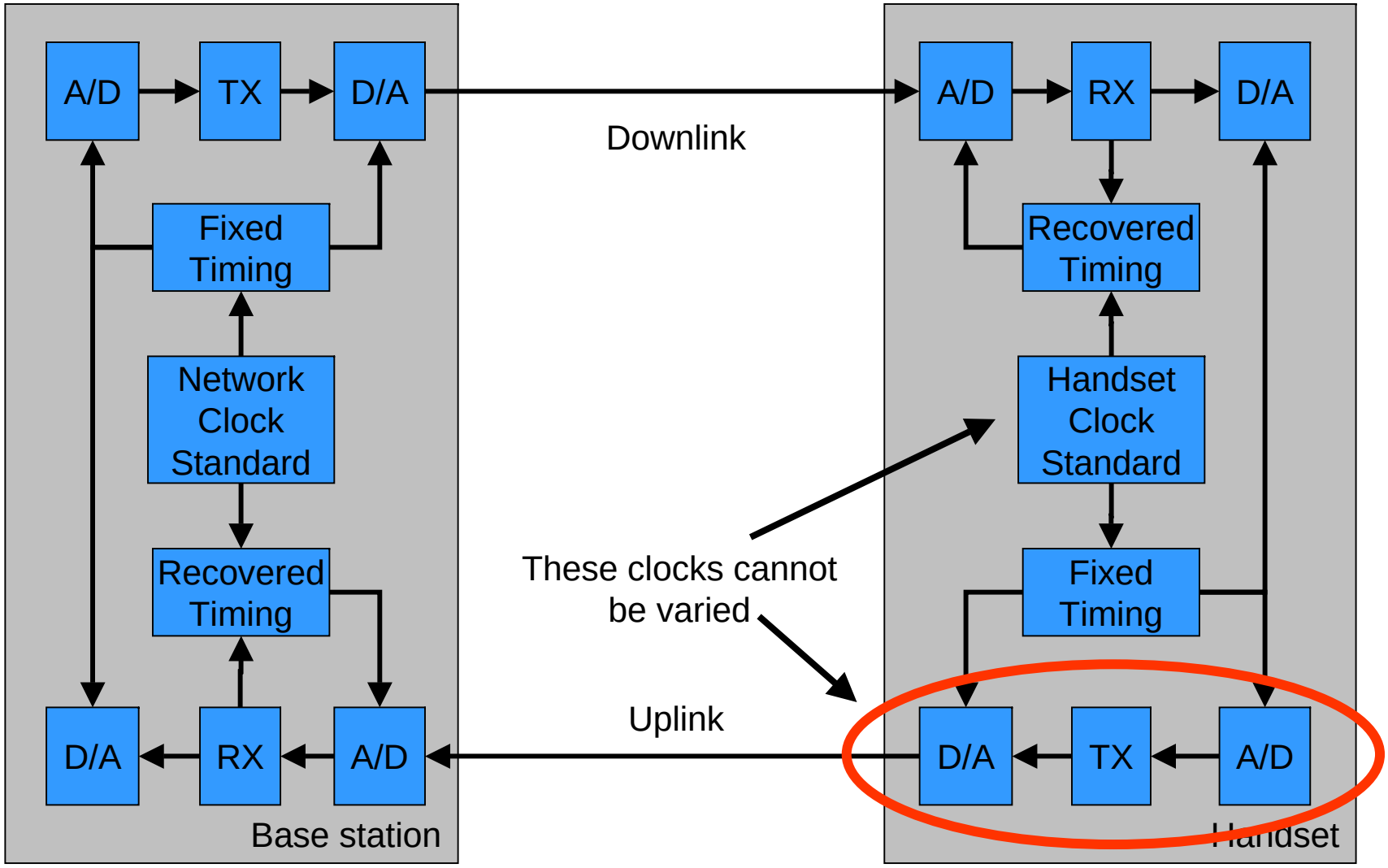
Timing adjustment



Timing adjustment

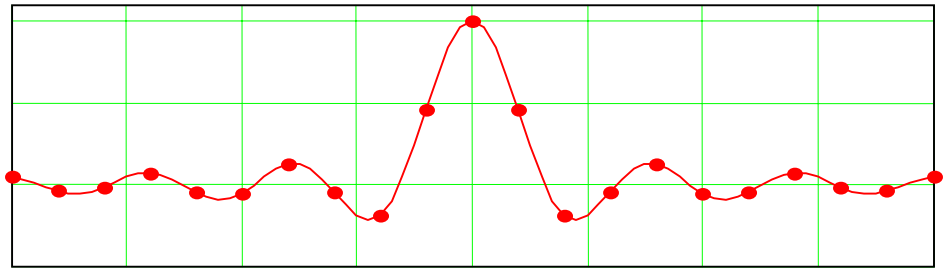


Timing adjustment



Timing adjustment in digital receiver

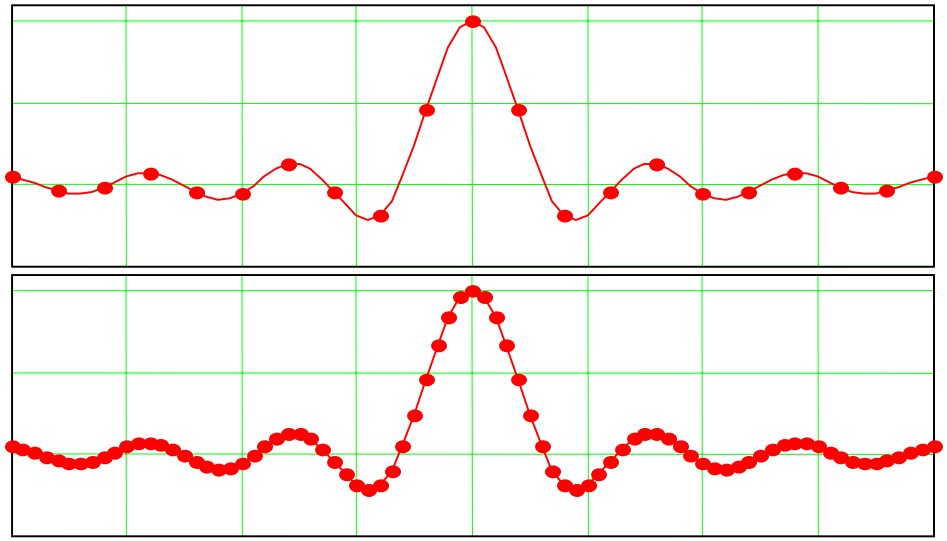
Desired channel response



Timing adjustment in digital receiver

Desired channel response

4X oversampled channel response

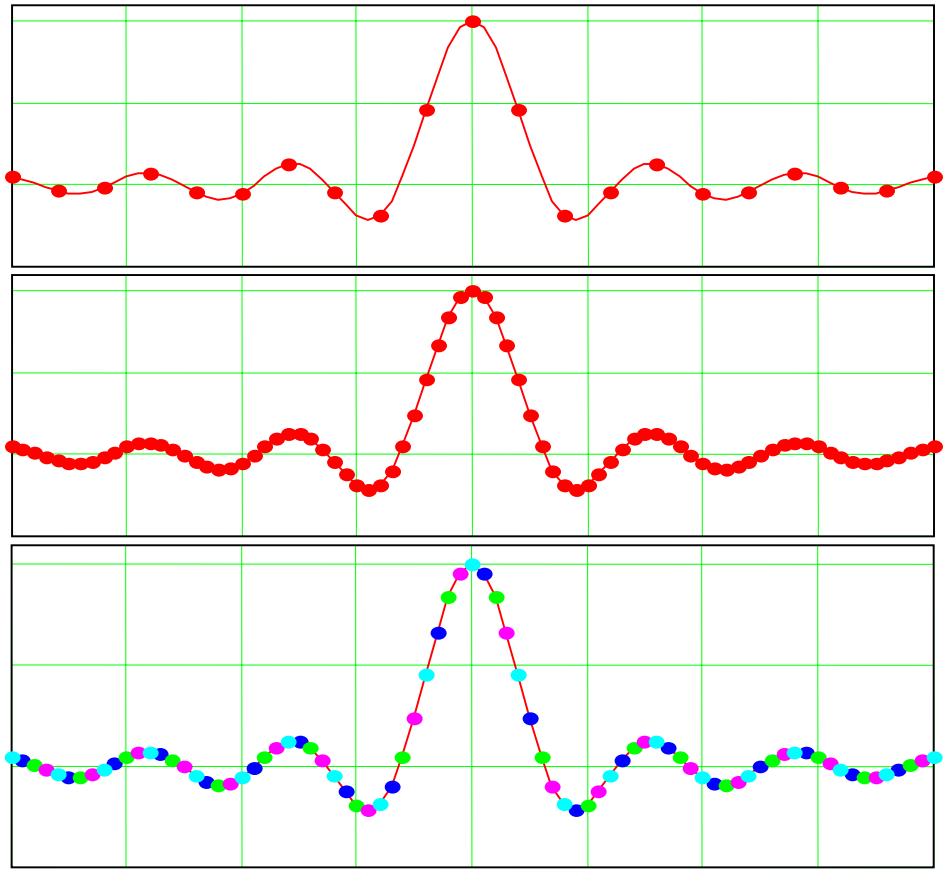


Timing adjustment in digital receiver

Desired channel response

4X oversampled channel response

4X oversampled channel response separated into 4 different filters



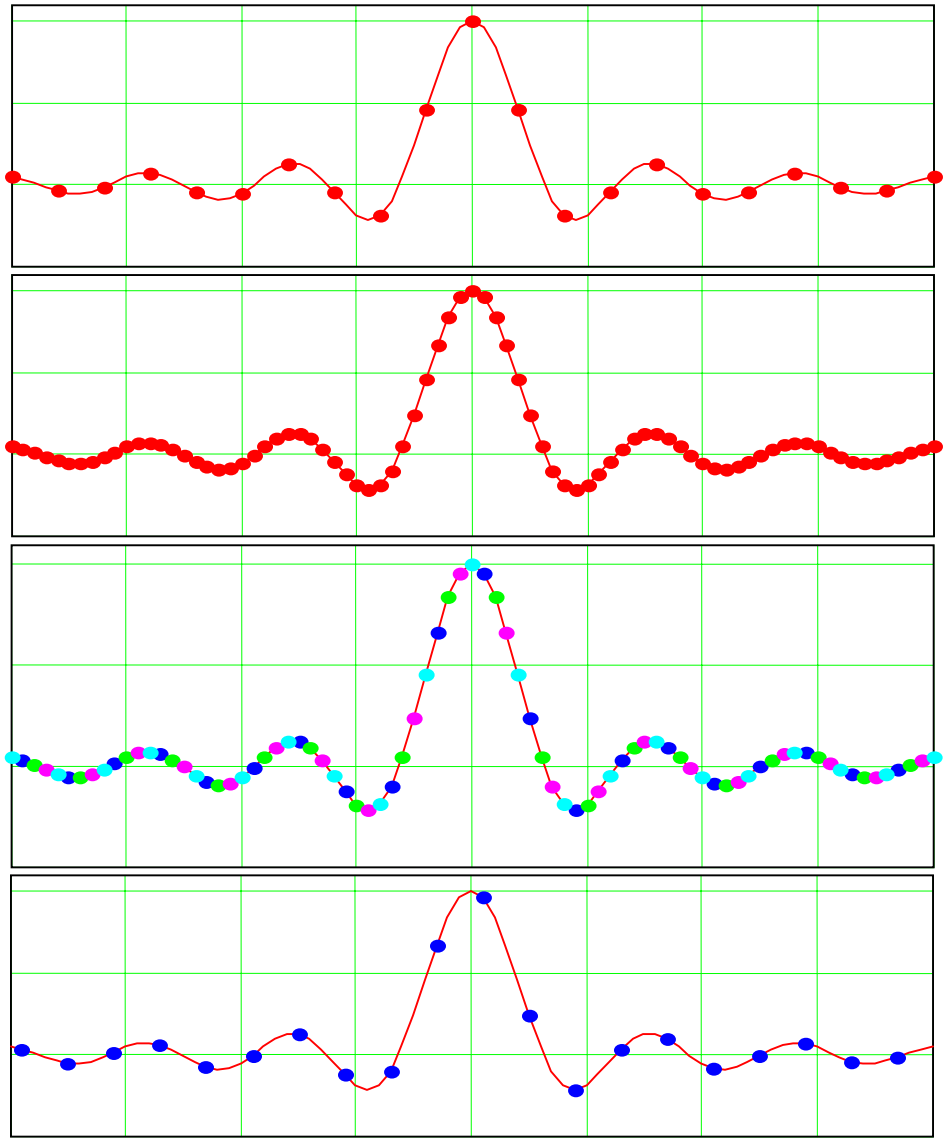
Timing adjustment in digital receiver

Desired channel response

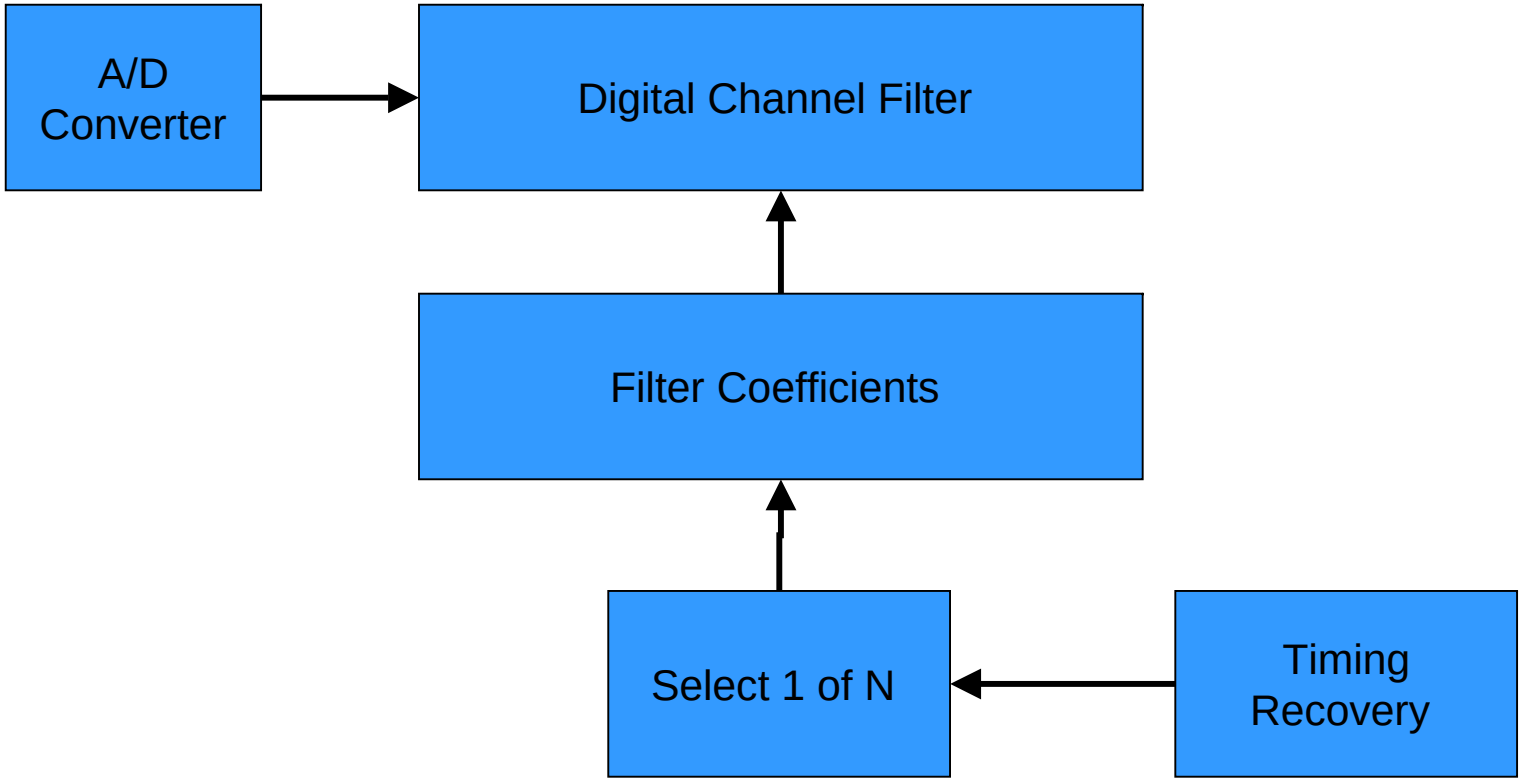
4X oversampled channel response

4X oversampled channel response
separated into 4 different filters

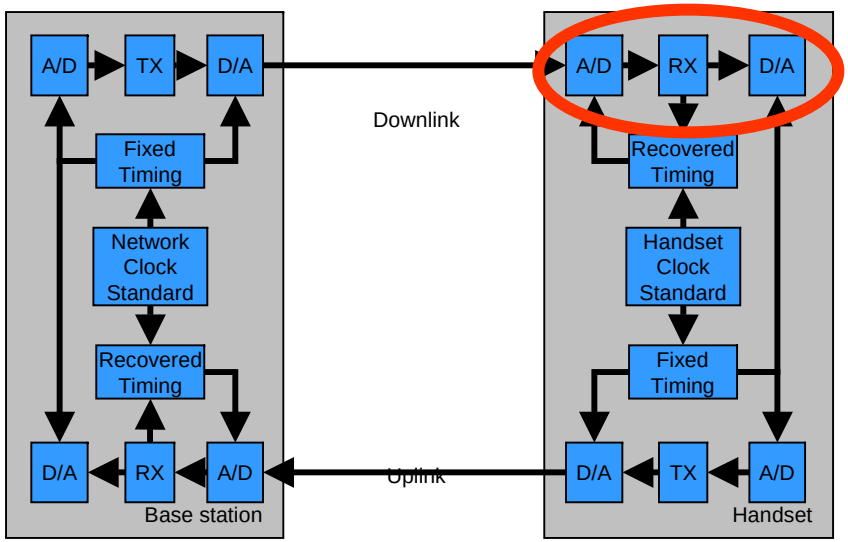
channel response
from 1 sample delay filter

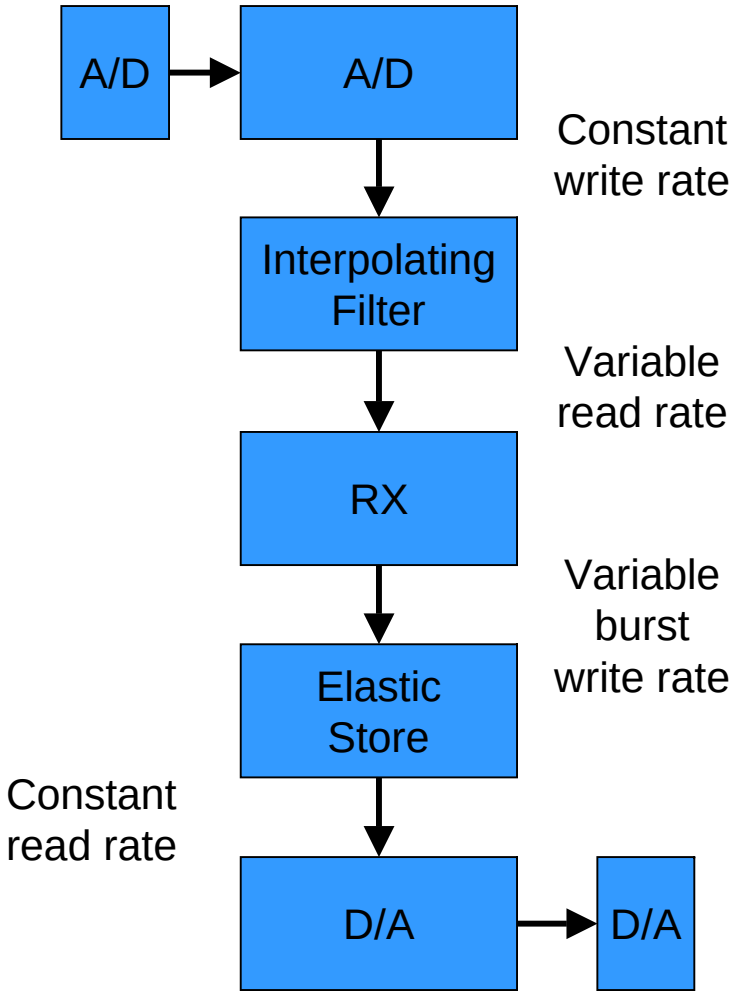


Timing adjustment in digital receiver



Digital output buffering





References

- McNair, B., Gupta, S., Kostic, Z., Sollenberger, N., "*Experimental Results for Extensions to the IS-136 TDM Standard Based on Higher Level Modulation, Coherent Detection, and Equal Gain Antenna Combining*," Proc. IEEE Vehicular Technology Conference, VTC99, Houston, TX, May 1999. (available at http://www.novidesic.com/pubs/vtc99-361a.pdf)
- Kostic, Z., McNair, B., Sollenberger N., "*Experimental Performance Results of an Indoor Wireless Extension of IS-136 Based on pi/8 D8PSK, Coded Modulation, and Antenna Diversity*," Proc. IEEE Vehicular Technology Conference, VTC98 Ottawa, Canada, May 1998. (available at http://www.novidesic.com/pubs/vtc98%20-%20paper%2034-2.pdf)

Homework #10

- Final due next week