

**UNIVERSITY OF MANCHESTER**  
**School of Computer Science**  
**CS3282: Digital communications**

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**Section 10 (shortened)**

**Multiple access for wireless communications**

## Multiple user access for wireless communications

Allow many users to share given amount of radio bandwidth.

Three main techniques are:

- Frequency division multiple access (**FDMA**)
- Time-division multiple access (**TDMA**)
- Code division multiple access (**CDMA**)

(type of "spread spectrum multiple access" technique).

To these add:

- Space division multiple access (**SDMA**)  
(same band-width is re-used in different places)
- Packet radio (**PR**) is a form of time division multiplexing  
(e.g. '**CSMA/CA**' as used by IEEE802.11).

- **Narrow-band systems**: bandwidth used by a single channel lower than ‘coherence bandwidth’  $B_C$ .
- **Wide-band systems** have bandwidth  $\gg B_C$ .
- $B_C$  is range of frequencies over which fading can be considered flat i.e. all frequencies have same attenuation & delay.
- Sine-waves with freq separation  $\gg B_C$  Hz affected differently.
- If  $B_C < 30$  kHz, analogue mobile phone system with 30 kHz channels works without equaliser.
- 900 MHz GSM with 200 kHz bandwidths requires equalisation.

- **FDMA** divides available frequency range into sub-bands.
  - ‘AMPS’ uses 824-894 MHz band divided into 1664 channels, each 30 kHz with 10 kHz ‘guard-bands’.
  - Narrow-band channels so equalisation not needed
- **TDMA** uses available frequency range by transmitting high frequency bit-stream containing data from many users.
  - Each user allocated cyclically repeating time-slot.
  - GSM divides 890-960 MHz into 200kHz channels by FDMA.
  - Transmits  $\approx 271$  kb/s in each channel by binary GMSK.  
(eight 25 kb/s speech channels)
  - Adaptive equalisation needed as  $200 \text{ kHz} > B_C$

**SSMA** spread transmissions over wide bandwidth by using pseudo-random signals as carriers.

- Different users have different pseudo random carriers .
- **Frequency hopping-SSMA:**
  - Varies frequency of sine-wave carrier in pseudo-random fashion.
  - 'Fast' & 'slow' hopping possible.
  - Provides security & immunity to effects of fading.
- **Direct sequence SSMA (CDMA):**
  - Base-band modulates a 'spreading signal'.
  - Pseudo-random sequence of bits
  - High bit-rate called "chip-rate".
  - 'Soft' capacity limit;
  - Effects of multi-path reduced but power control is a difficulty.

## **Hedy Lamarr (died 2000)**

Patented spread spectrum in early 1940s.

Austrian born.

First nude actress: appeared nude in Czech film 'Ecstasy'.

Before leaving advance of Nazi Germany & Adolf Hitler, married an Austrian arms merchant.

Invented frequency hopping for secure radio communication based on frequencies of piano notes.