Lesson 02
Medium Access using SDMA, TDMA, FDMA and CDMA
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Medium Access Problem

• Medium access so that wireless stations (WSs) transmit at any instant without interference with signals from other WSs
• WS—can be a mobile terminal (TE) at a mobile station (MS), a base transceiver system (BTS), or a wireless LAN node
Four ways to eliminate interference between the signals at any instant $t$

- SDMA
- TDMA
- FDMA
- CDMA

- Facilitate access to the medium by multiple sources or channels of same source when each one is using a distinct set of physical space, time, frequency, and code at each instant.
SDMA (space division multiple access)

• WSs that are distantly located access the medium by transmitting at the same $f_{c0}$ as well as in the same time-slot SL ($t' \leq t \leq t''$) in different spaces (cells) only.

• WSs located at suitable distances from each other are then said to transmit using SDMA.
Four wireless stations, in four distinct cells, simultaneously transmitting with the same $f_c$.
TDMA (time division multiple access)

- \( m \) time slots in a communication system
- When the WSs (\( \leq m \)) located in the same space (cell \( c \)), then the WSs access the medium in \( m \) different time-slots, \( SL_0 \) to \( SL_{m-1} \)
TDMA in GSM 8 transmitting WSs

- Distinct time-slots SL0, SL1, ..., SL7 using the same radio-carrier frequency $f_c$ using TDMA
- A limit to the number of wireless stations that can be served using different slots
TDMA in GSM 8 transmitting WSs

- Transmission slots for a WS repeated after small intervals (called frame intervals)
- Total data throughput from each WS does not become too small
8 WSs transmitting in distinct time-slots SL0, SL1, ..., SL7 using the same $f_c$ using TDMA
GSM system

- Provides for 8 time-slots of 577 µs
- Transmitting WS channels allotted a fixed pattern by the BTS
- If there are two WSs in place of 8 WSs, then the BTS reserves each alternate slot for each WS
- 8 WSs then the BTS reserves each alternate frame slot for each WS
GSM system

- Maximum transmission interval that a WS has between successive slots (frame interval) = 4.615 ms in TDMA
- Guard space of 15.25 µs at the beginning and at the end of each 577 µs slot
- Collisions avoided due to drifts in receiver and transmitter clock frequency or computational delays in placing the data in a slot
GPRS

- $k = 4$ receiving time-slots in successive data bursts for packet transmission in a class 10 mobile station
DECT WSs medium access control by TDMA

- Half of the TDMA slots are used for uplink and half for downlink.
- The transmitting WS channels allotted a fixed pattern by the BTS.
- Each of the $m$ stations can transmit with a maximum delay interval equal to the frame interval $m \times (t' - t'')$. 
DECT WSs medium access control by TDMA

- Data bursts transmit in time-slots of 417 µs
- Total 12 uplink and 12 downlink channels in 24 slots in a total duration of 10 ms
- After each successive 10 ms interval, the slots in a frame are repeated
- Uplink and downlink frequencies can now be kept identical, as the time-slots used for them are distinct
FDD (frequency division duplex) Uplink and downlink accesses of the WSs

- In different time-slots or in the same slots (shifted by a constant delay), SL0 to SL_{m-1}
- The uplink and downlink frequencies of the radio carrier, f_c, are distinct
- Example—fc and fc + 45 MHz for FDD access to the medium
- Different uplink–downlink frequency-pairs are assigned distinct f_c s (out of the n values from f_{c0} to f_{cn-1}) in a cell
Cell $i$ with 124 radio-carrier channels using FDMA and $f_c$ for uplink and $f_c + 45$ MHz for downlink.
FDMA (frequency division multiple access)

- Access to the medium by distinct $f_c$ at any given instant $t$, when there are many WSs ($n > m$) accessing the medium simultaneously.
- $m = 0$ for only FDMA
- $m \neq 0$ for FDMA-TDMA simultaneous use
Radio-carrier channels in GSM 900

• A set of maximum 124 radio-carrier channels
• Each separated by 200 kHz
• Used in the GSM 900 downlink channel
• Another set of 124 in the uplink channel
TDMA-FDD-FDMA for medium access control

- GSM
- GPRS
- HSCSD
CDMA (Code Division Multiple Access) based system

- When the WSs using the same space (cell), same time-slot, and same frequency $f_c$, then there is the CDMA alternative to access the medium
- Each WS uses a distinct code between $C_0$ and $C_{p-1}$ when accessing the medium
- $p$ values from $C_0$ to $C_{p-1}$
Summary

- SDMA
- TDMA
- FDMA
- FDD
- CDMA
End of Lesson 02
Medium Access using SDMA, TDMA, FDMA and CDMA