2 G Architecture– GSM, GPRS and Others

Lesson 05

GSM Radio Interface, Data bursts and Interleaving

Space Division Multiple Access of the signals from the MSs

- A BTS with *n* directed antennae— covers mobile stations in *n* distinct cell-sectors
- Each cell-sector defines a space within a cell

Channels allotted at a given instant to a BTS

- Maximum 10
- The mobile service provider reserves one channel per BTS for transmission to MS or BSC

GSM system station Channels

- Total number of channels assigned to a BTS is 11
- A GSM system station is permitted use the ch2 to ch123 only
- 122 channels are available in GSM 900
- Total number of reserve channels can be 32 for the data transmission of mobile service provider

TDMA and FDMA both in GSM system

- $Cell_i$ with two radio-carrier channels ch_m and ch_n using FDMA (Up to 124 permitted)
- Each MS in each channel transmitting bursts in 577 μs time-slots using TDMA

BTSs

- All the BTSs taken together can communicate over 90 channels (ch0, …, ch89) available in GSM band

Data Frame in a Channel

- Each channel transmits data frames of 4.615 ms (8 time-slots) each

Data Frame in a Channel

- The frequency-slot for each channel is 200 kHz
- A set of maximum 8 MSs (out of *I* MSs) can be assigned (by BTS_j) to a radio carrier channel frequency for uplink
- Downlink frequency is greater than the uplink frequency of a radio-carrier channel by 45 MHz

Data bursts in a data frame

- A set of data bits in an SL
- A set of 8 data bursts defines a data frame
- Each frame uses different channel (radio carrier frequency)

Example of three mobile stations, MS1, MS2, and MS3

- Assume B1, B2, and B3 the data bursts of MS1, MS2, and MS3, respectively)
- Using the same radio-carrier channel ch_m
- Assume B1 assigned SL0
- B2 assigned SL1, SL4, and SL7
- B3 assigned SL2 and SL6

Data frame

- At an instant, a data frame can have bursts B1, B2, B3, X, B2, B3, X, B2 transmitted in 8 time slots SL0–SL7, respectively
- X represents unassigned slots for access by either BTS_j or other MSs that are using the same radio carrier channel

Time for data burst and frame

- Since an SL = 577 μs, data burst period = 577 μs
- Each data frame transmits in 8 ×577 μs = 4.615 ms

Half Duplex Transmission

- The transceiver of a mobile device can function in half duplex mode when the uplink time slot t_u and downlink time slot t_d are assigned separately by a BTS
- *tu* – *td* is constant = 3×577 μs

Frequency Hopping in Data Frames

- Specific frequency values result in signal fading at an instant
- Do not provide expected signal strengths
- A data frame frequency channel assigned to an MS by the BTS can be changed (hop) these select frequencies at a certain rate according to a predetermined sequence

Frequency Hopping

- This helps in ensuring better signal quality for most of the period
- GSM hopping rates are 207.6 hop/s

Delays in Data burst during transmission

- Variable delays during transmission— the reflected signals take different amounts of time
- Original signals — reconstructed using a digital signal processor (DSP)
- The DSP spends computational time in processing the signals

Format of a Data Burst– Guard space in time slot

- At the beginning and end of every data burst of 577 μs, a guard spaces of 15.25 μs (equal to 4.125 bit transmission time interval) each reserved to account for delays in the reflected signal and computational time

Format of a 577 μs TDMA burst

- The effective transmission time for the data bits is, therefore, [577 – (2 ×15.25)] = 546.5 μs
- 148 bits– transmitted in 546.5 μs
- Data transmission rate = (8 × 148) bits/4.615 ms = 256.555 kbps
- Transmission by GMSK modulation and at 256.555 kbps (3.898 μs/bit)

Division among 148 bits

- Six bits, 3 at the head (*H*) and 3 at the tail (*T*) [called tail bits (TB)]
- At H, bits– 000
- At T, bits = 000

Division among 142

- 26 bits in the middle of the burst are transmitted as training (*TR*) bits
- The TR bits enable the receiver to (a) synchronize using *H*, *TR*, and *T* bits and (b) select the strong components of the signals
- Direct path or wide reflection angle signals are the strongest ones as they travel the least distance between the transmitter and the receiver

Division among (142 – 26)/2 = 58 bits each after H and before T

- Data in the burst can be of two kinds—MS data or mobile-service NSS control data
- On either side of the *TR* bits, an S bit can be placed to specify whether the source is the MS or NSS control data
- Meaningful data bits are 57 after H and 57 before T

Division among 57 bits each between H and TR, and TR and T

- Assuming that only one time slot used in a data frame of 8 slots when transmitting voice and assuming that the only data bursts are voice data bursts
- Total 114 bits (57 + 57) for the user data in a data burst (timeslot)
- Total number of bits per second = 114/4.615 bit/ms = 24.7 kbps

User and Other than user slots

- 12 slots for user data
- User data followed by one slot for control signals data
- The voice data (user data) rates ≠ 24.7 kbps but 12/13 × 24.7 kbps = 22.8 kbps

User and Other than user slots

- Additional slots required for the frequency correction and synchronization bursts
- The control data slot is replaced by an empty slot X in every alternate set of 13 frames

Traffic multiframe

- Total 26 data frames in one in which there are one control data, one empty, and 24 user data frames
- Traffic multiframes transmit TCH, FACCH, and SACCH data

Control channel capacity

- Within a traffic multiframe one control channel
- Capacity = (1÷26) × 24.7 kbps = 950 bps

Traffic multiframe

- Transmits in 26 × 4.615 ms = 120 ms interval

Interleaving in a Traffic Multiframe

- Interleaving means inserting in-between
- The packets, each consisting of 456 bits in a 20 ms time slot, are interleaved in a traffic multiframe for voice traffic

Example

- Assume two MSs, MS_i and MS_j multiplexed in TDMA slots
- There are 57 bits after *H* and 57 bits before *T* in the data bursts
- TCH/F (traffic channel full rate) transmission rate = 22.8 kbps
- Therefore, there are 456 (= 8 × 57) bits per 20 ms in voice traffic from two MSs

Example

- When 20 ms packets of MS_i and MS_j interleave, then all the 57 bit time-slots after *H* in each data burst are used by MS_i and all the 57 bits before *T* in each data burst are used by MS_j
- Interleaving distributes the effects of channel characteristics variations with time on multiple MSs

Summary

- Space division multiplexing to increase user capacities, FDMA to provide 124 uplink and 124 down link channels and TDMA in 8 time slots of each = 577μs
- Guard space between radio carrier channels
- Each slot carrying a data burst
- Data frame has 8 data bursts of 4.6 ms

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... Summary

- Guard interval in each time slot to account for delays in reflected signals
- 3 H bits, 3 T bits, 26 TR bits, 1 S bit and total 57 after H and 57 before T for user data
- After 12 user slots one control data slot or empty slot in traffic multiframe of 26 frames in 120 ms

End of Lesson 05

GSM Radio Interface, Data bursts and Interleaving