

Exam 2011/2012 Part 2

Question 1

GSM makes use of a combination of TDMA and FDMA, which means that it assigns a time frame and a frequency to devices to transmit. It is therefore not a continuous transmission necessarily, hence the term burst.

There are however multiple types of bursts depending on the information to transmit.

A normal burst is the typical one to transmit data. Its structure is defined and expected by the receiving station. As the stations are already synchronized, there is a smaller need for access coding, and therefore more space for data.

Random access burst is smaller with a bigger guard time to ensure that it fits in the slot regardless of timing issues. Once the systems are aligned again, there is no need to use this burst type again.

In general, guard bands or guards-times are used to reduce the risk of interference between transmissions. The more synchronized the systems are, the smaller the need for guard-intervals.

Question 2

The hidden node problem consists on a scenario where A and B see two common receiver but not each other. Therefore, with no regulations, their packets would collide with each other and none of the transmission would be successful.

One way to solve the problem is to use RTS/CTS packets. When a station wants to transmit, it sends a RTS packet to the receiver. The receiver then sends a CTS if it is ready. This CTS will be listened by both stations, including the one that did not request anything. Therefore, that station knows that another station in range is transmitting and therefore holds its transmission, avoiding collision.

Question 3

OLSR stands for Optimized Link State Routing Protocol and is a pro-active protocol, which means that despite routes being always available, it uses significant network resources to maintain a continuous network control traffic. These messages are HELLO messages, meant to signal neighbours of their presence. It makes use of MPR to minimize traffic in the network.

MPR (MultiPoint Relays) are special nodes used to limit the number of nodes transmitting packets and reduce the number of duplicated transmissions.

Each node selects its MPR which must be at 1 hop distance. They must be minimum and enable communication with every 2-hop-away nodes.

Question 4

GSM to GPRS

The main objective was to simplify the access to the Internet and improve the network efficiency, achieved by adding packet switching to GSM, where data is transferred as packets.

Two new network elements were added:

- SGSN, Serving GPRS Support Node, for authentication, switching, mobility and accounting.
- GGSN, Gateway GRPS Support Node, for IPv4/IPv6 internet routing.

GPRS to UMTS

The main objective was to provide a standard way for personal communications to support large quantities of users. Makes use of WCDMA, where all users share the same time and frequency domain.

Two new components where added:

- UTRAN, Provides and manages the air radio interface for entire network.
- Core Network, Provides all management and central processing of the System (new Network switching subsystem).

UMTS to HSPA

Routing Information Protocol

HSPA to LTE

Routing Information Protocol

Question 5

Mobility management is applied in mobile network topologies. In this scenarios, stations are always moving and my require to change their AP at some point. In general terms, there needs to be a transference from communication with the PAP to the NAP.

One way would be to stop communicating with the PAP when the connection stop being strong enough, and setup a connection on the PAP. This method would case severe disruption, as PAP as to setup the only upper hierarchy of communications and routing before being able to forwards the UE packets.

One method would be for the UE to communicate with the NAP and PAP at the same time. When the connection with the PAP was establish, a tunnel would redirect the traffic to the NAP, where all the connections are established while the PAP does the new configuration. Once the system is stable, the tunnel would be closed, and the PAP would start to forward by itself the UE packets.

Exam 2012/2013 Part 2

Question 1

Wideband wireless transmission have two main problems: high demands in therms of bandwidth and noise that can cause ISI.

OFMD (Orthogonal Frequency Multiple Access) makes use of overlapping sub-streams that significantly reduce the required bandwidth. They also make use of the circular convolution to reduce ISI. There is also the possibility of reduce the usage of higher frequencies that reduce high frequency attenuation.

DSSS is a technique that consists in spreading the information across the frequency spectrum. It multiples the original signal by a code that aims to reduce ISI interference. By spreading the information, it is less prone to be affect by narrowband interference.

Question 2

802.11 is a protocol used for wireless transmissions of mobile devices, which have constrains regarding battery. The main idea is that if the transceiver is not being used, then it goes to sleep to save power.

Stations will wake up periodically and simultaneously. They will listen to the beacon to know if they are expecting to receive something, in which case they stay awake to listen. If it wants to send something, it stays awake until it sends its packets and then goes to sleep.

In an Ad-hoc network, the principle is the same, but stations can also sends beacons to the rest to signal them that they want to transmit something to them.

Although it may reduce the bitrate and increase the delay, it makes mobile transmissions much more efficient and enables long battery life for the devices.

Question 3

The metric Airtime Link Cost for 802.11s is a metric that related the bitrate of the channel as well as the PER associated with it. Therefore, a channel with very high bitrate but also very high PER will produce a big airtime cost, while a smaller channel with very low PER might have a smaller airtime cost.

It is a better representation of the channels quality than hop count, as hop count does not consider the channel characteristics. One hop might force retransmission multiple times due to errors while 3 hops might have a very high success rate and therefore be faster.

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Let us consider a scenario where the UE is connected to source eNB. Based on UE metrics, the eNB decides to request a Handover to the Target eNB. After admission control, the source eNB signals the UE about the handover. While synchronization between the UE and the target eNB is happening, the source eNB forwards all the packets to the target. After the handover is completed and confirmed, the UE starts to communicate directly with the target eNB.

Exam 2014/2015 Part 2

Question 1

A mobile call is initiated as follows:

- A connection and correspondent authentication is requested by the MS to BSS;
- Security checks are made to the HLR;
- Resources are requested to GMSC;
- A call is afterwards established by the MSC.

Question 2

The standard 802.11ac is an evolution of the 802.11n. It has a number of different characteristics, such as supporting 5GHz and supporting 256-QAM, therefore bigger bit rates. However, the biggest difference is the support for multi-user MIMO, which enables the AP to send data to multiple clients at the same time. Beam-forming is also supported for users in different locations.

Question 3

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In Fast Handover in MIP6 is a handover method where the MN finds about the new router (NAR) while still connected to the old router (PAR). The auto-configuration of the new CoA can be made while MN is associated with the PAR.

While the binding update for the nCoA (MIP6, HomeAgent, CNs) is being performed, the MN can still be connected by using a tunnel between the NAR and PAR.

Exam 2015/2016 Part 2

Question 1

The **PLR** (Packet Loss Ratio) represents the probability that a packet is lost. It is closely related to a number of factors:

- BER (bit error probability), where an increasing probability of errors also increases the probability of losing the packet to also errors.
- SNR, where channel noise increases the BER
- SINR, where channel interference increases the BER
- Pr (Signal power at the receiver), where lower power means bigger BER
- Pt (Signal power at the transmitter), where lower power means lower Pr, and therefore lower BER

Question 2

FDMA (frequency Division Multiple Access) consists on dividing the bandwidth into multiple channels (different frequencies) and assign each one as a transmission slot for each user. The transmission is therefore continuous but with lower rate. Requires guard-bands to reduce ISI.

TDMA (Time Division Multiple Access) consists on dividing the transmission time into multiple timeslots and assign each one as a transmission slot for each user. Each user is assigned a cyclically-repeating timeslot to transmit. It is no continuous but with higher rate as it uses the whole bandwidth of the channel.

OFDMA is an extension of FDMA and TDMA, where channels are assigned both based on time and frequency. The scheduling is opportunistic, basing its decision on a deciding factor (BEST SNR, Best Global throughput, fairness).

CDMA is assigned a code to spread his information signal (codes need to be orthogonal). It is based on multi-user spread spectrum. The resulting spread signal consists on signals that occupy the same band and are transmitted at the same time.

Question 3

Ad-hoc networks are based on a dynamic topology, where information needs to be refreshed more frequently as the network topology is always changing. Excessive polling is major concern as mobile networks have limited resources (bandwidth, energy, etc).

The protocols for this topology can be:

- Reactive, like AODV.
- Pro-active, like OLSR.

AODV stands for Ad hoc On-demand Distance Vector, when a route is only searched when a packet needs to be sent. It broadcasts Route-Request to find the route. It uses less resources but is also slower to update

and therefore has a bigger average delay.

OLSR stands for Optimized Link State Routing Protocol and is a pro-active protocol, which means that despite routes being always available, it uses significant network resources to maintain a continuous network control traffic. These messages are HELLO messages, meant to signal neighbours of their presence. It makes use of MPR to minimize traffic in the network.

Question 4

The **LTE Admission Control** admits that a new arrival is characterised by R_j bit/s, requiring N_j blocks/frames. If there are blocks available, considering the ones that are already assigned, then the call is accepted. These blocks are characterised by the frequency and the frame period.

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Exam 2017/2018 Part 2

Question 1

Duplex transmission consists in the transference of data in both directions: uplink and downlink. This means the creating of a channel for each direction.

There are two methods of implementing a duplex system.

The first is **FDD**, where the wireless link is separated into frequency bands. Given this, bands are assigned to uplink and downlink channels. Peers therefore communicate in both directions using different bands.

The second is **TDD**, where the wireless link is separated into timeslots. Then, timeslots are assigned to the transmitter for each direction. Peers use the same frequency band but at different times.

In terms of **interference**, FDD requires guard-bands while TDD requires guard-intervals. As for **channel estimation**, FDD requires estimation for both directions, while TDD it is the same for both (same frequency). FDD demands **frequency planning**, using pairs of bands for each transmitter, while TDD does not. **Asymmetric allocation** of capacity is easier in TDD, where you can just give more channels to one direction, while you cannot do that for FDD (different frequencies may not be supported).

Question 2

The **LTE Admission Control** admits that a new arrival is characterised by R_j bit/s, requiring N_j blocks/frames. If there are blocks available, considering the ones that are already assigned, then the call is accepted. These blocks are characterised by the frequency and the frame period.

The **UMTS Admission Control** admits that a new arrival is characterised by R_j bit/s. Depending on the transmission, a new arrival is characterised by a load factor, that is related to the interference cause by the transmissions. If the total load of the system is smaller than a threshold set previously, then the call is accepted.

Question 3

5G is a response to a set of requirements like the ever-growing bandwidth requirements, low delay, and massive connected devices. For this matter, 3 broad categories were created:

- eMBB (Enhanced Mobile Broadband), with high user data rates, with wide-area coverage (high mobility), or hotspot coverage (high bitrate).
- URLLC (Ultra-Reliable and Low Latency Communications), with very high requirements for RMA and latency.
- mMTC (Massive Machine Type Communications), supporting a very large number of devices, characterised by low-volume, non-delay-sensitive data. They need to be low cost and have a very long battery life.

Question 4

Mobility management consists in enabling the network to be aware of the terminals location. Maintains the route/connection to the terminal when it moves.

It consists in 2 main functions, location management and hand-off management.

In **location management**, the terminal informs the network about its current Access Point regularly.

In **hand-off management**, the terminal maintains network connection when it moves. Consists in 3 main steps:

- Initiation, need to hand-off initiation.
- New route / connection generation, where radio resources are found for the hand-off connection and routing operations are performed.
- Data-flow control, consisting on the delivery of data from the old to the new path, maintaining QoS.