Questions for Mobile Communications 2nd ed.

Jochen H. Schiller, Freie Universität Berlin, Germany
schiller@computer.org, www.jochenschiller.de

1. Introduction

1.1 Discover the current numbers of subscribers for the different systems. As mobile communications boom, no printed number is valid for too long!

1.2 Check out the strategies of different network operators while migrating towards third generation systems. Which are reasons why a single common system is not in sight?

2. Wireless Transmission

2.1 Frequency regulations may differ between countries. Check out the regulations valid for your country (within Europe the European Radio Office may be able to help you, www.ero.dk, for the US try the FCC, www.fcc.gov, for Japan ARIB, www.arib.or.jp).

2.2 Why can waves with a very low frequency follow the earth's surface? Why are they not used for data transmission in computer networks?

2.3 Why does the ITU-R only regulate 'lower' frequencies (up to some hundred GHz) and not higher frequencies (in the THz range)?

2.4 What are the two different approaches in regulation regarding mobile phone systems in Europe and the US? What are the consequences?

2.5 Why is the international availability of the same ISM bands important?

2.6 Is it possible to transmit a digital signal, e.g., coded as square wave as used inside a computer, using radio transmission without any loss? Why?

2.7 Is a directional antenna useful for mobile phones? Why? How can the gain of an antenna be improved?

2.8 What are the main problems of signal propagation? Why do radio waves not always follow a straight line? Why is reflection both useful and harmful?

2.9 Name several methods for ISI mitigation. How does ISI depend on the carrier frequency, symbol rate, and movement of sender/receiver? What are the influences of ISI on TDM schemes?

2.10 What are the means to mitigate narrowband interference? What is the complexity of the different solutions?

2.11 Why, typically, is digital modulation not enough for radio transmission? What are general goals for digital modulation? What are typical schemes?

2.12 Think of a phase diagram and the points representing bit patterns for a PSK scheme (see Figure 2.29). How can a receiver decide which bit pattern was originally sent when a received 'point' lies somewhere in between other points in the diagram? Why is it, thus, difficult to code more and more bits per phase shift?

2.13 What are the main benefits of a spread spectrum system? How can spreading be achieved? What replaces the guard space in Figure 2.31 when compared to Figure 2.32? How can DSSS systems benefit from multipath propagation?

2.14 What are the main reasons for using cellular systems? How is SDM typically realized and combined with FDM? How does DCA influence the frequencies available in other cells?

2.15 What limits the number of simultaneous users in a TDM/FDM system compared to a CDM system? What happens to the transmission quality of connections if the load gets higher in a cell, i.e., how does an additional user influence the other users in the cell?

3. Medium Access Control

3.1   What is the main physical reason for the failure of many MAC schemes known from wired networks? What is done in wired networks to avoid this effect?

3.2   Recall the problem of hidden and exposed terminals. What happens in the case of such terminals if Aloha, slotted Aloha, reservation Aloha, or MACA is used?

3.3   How does the near/far effect influence TDMA systems? What happens in CDMA systems? What are countermeasures in TDMA systems, what about CDMA systems?

3.4   Who performs the MAC algorithm for SDMA? What could be possible roles of mobile stations, base stations, and planning from the network provider?

3.5   What is the basic prerequisite for applying FDMA? How does this factor increase complexity compared to TDMA systems? How is MAC distributed if we consider the whole frequency space as presented in chapter 1?

3.6   Considering duplex channels, what are alternatives for implementation in wireless networks? What about typical wired networks?

3.7   What are the advantages of a fixed TDM pattern compared to random, demand driven TDM? Compare the efficiency in the case of several connections with fixed data rates or in the case of varying data rates. Now explain why traditional mobile phone systems use fixed patterns, while computer networks generally use random patterns. In the future, the main data being transmitted will be computer-generated data. How will this fact change mobile phone systems?

3.8   Explain the term interference in the space, time, frequency, and code domain. What are countermeasures in SDMA, TDMA, FDMA, and CDMA systems?

3.9   Assume all stations can hear all other stations. One station wants to transmit and senses the carrier idle. Why can a collision still occur after the start of transmission?

3.10   What are benefits of reservation schemes? How are collisions avoided during data transmission, why is the probability of collisions lower compared to classical Aloha? What are disadvantages of reservation schemes?

3.11   How can MACA still fail in case of hidden/exposed terminals? Think of mobile stations and changing transmission characteristics.

3.12   Which of the MAC schemes can give hard guarantees related to bandwidth and access delay?

3.13   How are guard spaces realised between users in CDMA?

3.14   Redo the simple CDMA example of section 3.5, but now add random 'noise' to the transmitted signal (–2,0,0,–2,+2,0). Add, for example, (1,–1,0,1,0,–1). In this case, what can the receiver detect for sender A and B respectively? Now include the near/far problem. How does this complicate the situation? What would be possible countermeasures?

4. Telecommunication systems

4.1   Name some key features of the GSM, DECT, TETRA, and UMTS systems. Which features do the systems have in common? Why have the older three different systems been specified? In what scenarios could one system replace another? What are the specific advantages of each system?

4.2   What are the main problems when transmitting data using wireless systems that were made for voice transmission? What are the possible steps to mitigate the problems and to raise efficiency? How can this be supported by billing?

4.3   Which types of different services does GSM offer? Name some examples and give reasons why these services have been separated.

4.4   Compared to the TCHs offered, standard GSM could provide a much higher data rate (33.8 kbit/s) when looking at the air interface. What lowers the data rates available to a user?

4.5   Name the main elements of the GSM system architecture and describe their functions. What are the advantages of specifying not only the radio interface but also all internal interfaces of the GSM system?

4.6   Describe the functions of the MS and SIM. Why does GSM separate the MS and SIM? How and where is user-related data represented/stored in the GSM system? How is user data protected from unauthorised access, especially over the air interface? How could the position of an MS (not only the current BTS) be localised? Think of the MS reports regarding signal quality.

4.7   Looking at the HLR/VLR database approach used in GSM—how does this architecture limit the scalability in terms of users, especially moving users?

4.8   Why is a new infrastructure needed for GPRS, but not for HSCSD? Which components are new and what is their purpose?

4.9   What are the limitations of a GSM cell in terms of diameter and capacity (voice, data) for the traditional GSM, HSCSD, GPRS? How can the capacity be increased?

4.10   What multiplexing schemes are used in GSM for what purposes? Think also of other layers apart from the physical layer.

4.11   How is synchronisation achieved in GSM? Who is responsible for synchronisation and why is synchronisation very important?

4.12   What are the reasons for the delays in a GSM system for packet data traffic? Distinguish between circuit-switched and packet-oriented transmission.

4.13   Where and when can collisions occur while accessing the GSM system? Compare possible collisions caused by data transmission in standard GSM, HSCSD, and GPRS.

4.14   Why and when are different signalling channels needed? What are the differences?

4.15   How is localisation, location update, roaming, etc. done in GSM and reflected in the data bases? What are typical roaming scenarios?

4.16   Why are so many different identifiers/addresses (e.g., MSISDN, TMSI, IMSI) needed in GSM? Give reasons and distinguish between user related and system related identifiers.

4.17   Give reasons for a handover in GSM and the problems associated with it. Which are the typical steps for handover, what types of handover can occur? Which resources need to be allocated during handover for data transmission using HSCSD or GPRS respectively? What about QoS guarantees?

4.18   What are the functions of authentication and encryption in GSM? How is system security maintained?

4.19   How can higher data rates be achieved in standard GSM, how is this possible with the additional schemes HSCSD, GPRS, EDGE? What are the main differences of the approaches, also in terms of complexity? What problems remain even if the data rate is increased?

4.20   What limits the data rates that can be achieved with GPRS and HSCSD using real devices (compared to the theoretical limit in a GSM system)?

4.21   Using the best delay class in GPRS and a data rate of 115.2 kbit/s – how many bytes are in transit before a first acknowledgement from the receiver could reach the sender (neglect further delays in the fixed network and receiver system)? Now think of typical web transfer with 10 kbyte average transmission size—how would a standard TCP behave on top of GPRS (see chapter 9 and chapter 10)? Think of congestion avoidance and its relation to the round-trip time. What changes are needed?

4.22   How much of the original GSM network does GPRS need? Which elements of the network perform the data transfer?

4.23   What are typical data rates in DECT? How are they achieved considering the TDMA frames? What multiplexing schemes are applied in DECT for what purposes? Compare the complexity of DECT with that of GSM.

4.24 Who would be the typical users of a trunked radio system? What makes trunked radio systems particularly attractive for these user groups? What are the main differences to existing systems for that purpose? Why are trunked radio systems cheaper compared to, e.g., GSM systems for their main purposes?

4.25 Summarise the main features of 3rd generation mobile phone systems. How do they achieve higher capacities and higher data rates? How does UMTS implement asymmetrical communication and different data rates?

4.26 Compare the current situation of mobile phone networks in Europe, Japan, China, and North America. What are the main differences, what are efforts to find a common system or at least interoperable systems?

4.27 What disadvantage does OVSF have with respect to flexible data rates? How does UMTS offer different data rates (distinguish between FDD and TDD mode)?

4.28 How are different DPDCHs from different UEs within one cell distinguished in UTRA FDD?

4.29 Which components can perform combining/splitting at what handover situation? What is the role of the interface I_{ur}? Why can CDMA systems offer soft handover?

4.30 How does UTRA-FDD counteract the near-far effect? Why is this no problem in GSM?

5. Satellite systems

5.1 Name basic applications for satellite communication and describe the trends.

5.2 Why are GEO systems for telecommunications currently being replaced by fibre optics?

5.3 How do inclination and elevation determine the use of a satellite?

5.4 What characteristics do the different orbits have? What are their pros and cons?

5.5 What are the general problems of satellite signals travelling from a satellite to a receiver?

5.6 Considered as an interworking unit in a communication network, what function can a satellite have?

5.7 What special problems do customers of a satellite system with mobile phones face if they are using it in big cities? Think of in-building use and skyscrapers.

5.8 Why is there hardly any space in space for GEOs?

6. Broadcast systems

6.1 2G and 3G systems can both transfer data. Compare these approaches with DAB/DVB and list reasons for and against the use of DAB/DVB.

6.2 Which web pages would be appropriate for distribution via DAB or DVB?

6.3 How could location based services and broadcast systems work together?

7. Wireless LAN

7.1 How is mobility restricted using WLANs? What additional elements are needed for roaming between networks, how and where can WLANs support roaming? In your answer, think of the capabilities of layer 2 where WLANs reside.

7.2 What are the basic differences between wireless WANs and WLANs, and what are the common features? Consider mode of operation, administration, frequencies, capabilities of nodes, services, national/international regulations.

7.3 With a focus on security, what are the problems of WLANs? What level of security can WLANs provide, what is needed additionally and how far do the standards go?

7.4 Compare IEEE 802.11, HiperLAN2, and Bluetooth with regard to their ad-hoc capabilities. Where is the focus of these technologies?

7.5   If Bluetooth is a commercial success, what are remaining reasons for the use of infrared transmission for WLANs?

7.6   Why is the PHY layer in IEEE 802.11 subdivided? What about HiperLAN2 and Bluetooth?

7.7   Compare the power saving mechanisms in all three LANs introduced in this chapter. What are the negative effects of the power saving mechanisms, what are the trade-offs between power consumption and transmission QoS?

7.8   Compare the offered QoS in all three LANs in ad hoc mode. What advantages does an additional infrastructure offer? How is QoS provided in Bluetooth? Can one of the LAN technologies offer hard QoS (i.e., not only statistical guarantees regarding a QoS parameter)?

7.9   How do IEEE 802.11, HiperLAN2 and Bluetooth, respectively, solve the hidden terminal problem?

7.10   How are fairness problems regarding channel access solved in IEEE 802.11, HiperLAN2, and Bluetooth respectively? How is the waiting time of a packet ready to transmit reflected?

7.11   What different solutions do all three networks offer regarding an increased reliability of data transfer?

7.12   In what situations can collisions occur in all three networks? Distinguish between collisions on PHY and MAC layer. How do the three wireless networks try to solve the collisions or minimize the probability of collisions?

7.13   Compare the overhead introduced by the three medium access schemes and the resulting performance at zero load, light load, high load of the medium. How does the number of collisions increase with the number of stations trying to access the medium, and how do the three networks try to solve the problems? What is the overall scalability of the schemes in number of nodes?

7.14   How is roaming on layer 2 achieved, and how are changes in topology reflected? What are the differences between infrastructure based and ad hoc networks regarding roaming?

7.15   What are advantages and problems of forwarding mechanisms in Bluetooth networks regarding security, power saving, and network stability?

7.16   Name reasons for the development of wireless ATM. What is one of the main differences to Internet technologies from this point of view? Why did WATM not succeed as stand-alone technology, what parts of WATM succeeded?

8. Mobile network layer

8.1   Recall routing in fixed IP networks (Kurose, 2003). Name the consequences and problems of using IP together with the standard routing protocols for mobile communications.

8.2   What could be quick 'solutions' and why do they not work?

8.3   Name the requirements for a mobile IP and justify them. Does mobile IP fulfil them all?

8.4   List the entities of mobile IP and describe data transfer from a mobile node to a fixed node and vice versa. Why and where is encapsulation needed?

8.5   How does registration on layer 3 of a mobile node work?

8.6   Show the steps required for a handover from one foreign agent to another foreign agent including layer 2 and layer 3.

8.7   Explain packet flow if two mobile nodes communicate and both are in foreign networks. What additional routes do packets take if reverse tunnelling is required?

8.8 Explain how tunnelling works in general and especially for mobile IP using IP-in-IP, minimal, and generic routing encapsulation, respectively. Discuss the advantages and disadvantages of these three methods.

8.9 Name the inefficiencies of mobile IP regarding data forwarding from a correspondent node to a mobile node. What are optimizations and what additional problems do they cause?

8.10 What advantages does the use of IPv6 offer for mobility? Where are the entities of mobile IP now?

8.11 What are general problems of mobile IP regarding security and support of quality of service?

8.12 What is the basic purpose of DHCP? Name the entities of DHCP.

8.13 How can DHCP be used for mobility and support of mobile IP?

8.14 Name the main differences between multi-hop ad hoc networks and other networks. What advantages do these ad hoc networks offer?

8.15 Why is routing in multi-hop ad hoc networks complicated, what are the special challenges?

8.16 Recall the distance vector and link state routing algorithms for fixed networks. Why are both difficult to use in multi-hop ad hoc networks?

8.17 What are the differences between AODV and the standard distance vector algorithm? Why are extensions needed?

8.18 How does dynamic source routing handle routing? What is the motivation behind dynamic source routing compared to other routing algorithms from fixed networks?

8.19 How does the symmetry of wireless links influence the routing algorithms proposed?

8.20 Why are special protocols for the support of micro mobility on the network layer needed?

8.21 What are the benefits of location information for routing in ad hoc networks, which problems do arise?

8.22 Think of ad hoc networks with fast moving nodes, e.g., cars in a city. What problems arise even for the routing algorithms adapted to ad hoc networks? What is the situation on highways?

9. Mobile transport layer

9.1 Compare the different types of transmission errors that can occur in wireless and wired networks. What additional role does mobility play?

9.2 What is the reaction of standard TCP in case of packet loss? In what situation does this reaction make sense and why is it quite often problematic in the case of wireless networks and mobility?

9.3 Can the problems using TCP be solved by replacing TCP with UDP? Where could this be useful and why is it quite often dangerous for network stability?

9.4 How and why does I-TCP isolate problems on the wireless link? What are the main drawbacks of this solution?

9.5 Show the interaction of mobile IP with standard TCP. Draw the packet flow from a fixed host to a mobile host via a foreign agent. Then a handover takes place. What are the following actions of mobile IP and how does TCP react?

9.6 Now show the required steps during handover for a solution with a PEP. What are the state and function of foreign agents, home agents, correspondent host, mobile host, PEP and care-of address before, during, and after handover? What information has to be transferred to which entity in order to maintain consistency for the TCP connection?

9.7 What are the influences of encryption on the proposed schemes? Consider for example IP security that can encrypt the payload, i.e., the TCP packet.

9.8 Name further optimisations of TCP regarding the protocol overhead which are important especially for narrow band connections. Which problems may occur?

9.9 Assume a fixed Internet connection with a round trip time of 20 ms and an error rate of 10^{-10}. Calculate the upper bound on TCP's bandwidth for a maximum segment size of 1000 byte. Now two different wireless access networks are added. A WLAN with 2 ms additional one-way delay and an error rate of 10^{-3}, and a GPRS network with an additional RTT of 2 s and an error rate of 10^{-7}. Redo the calculation ignoring the fixed network's error rate. Compare these results with the ones derived from the second formula (use RTO = 5 RTT). Why are some results not realistic?

9.10 Why does the link speed not appear in the formulas presented to estimate TCP's throughput? What is wrong if the estimated bandwidth is higher than the link speed?

10. Support for mobility

10.1 Why is strong consistency of file systems problematic in a wireless and mobile environment? What are the alternatives?

10.2 How do conventional file systems react to disconnected systems? Try unplugging a computer that has mounted a file system via a network.

10.3 What advantages has the statelessness of HTTP? In what situations is state useful and how is it provided today? Where is long-term state stored, where short-term?

10.4 Which properties of HTTP waste bandwidth? What is the additional problem using HTTP/1.0 together with TCP? How does HTTP/1.1 improve the situation?

10.5 How does caching improve access time and reduce bandwidth requirements? What are locations for a cache and their specific advantages?

10.6 What are problems of caches in real life? What type of content can be cached, which content causes problems? What are the additional problems with client mobility?

10.7 What discrepancies exist between the possibilities of HTML and the realities of wireless handheld devices? What are proposed solutions? What is the role of plug-ins today and how do they influence the usability of web pages?

10.8 Name mechanisms to improve web access for handheld devices. What is their common problem and what led finally to the development of WAP?

10.9 What are typical enhancements to the basic client/server architecture of the web? Reconsider these enhancements for a mobile wireless user with web access over a mobile phone network. What are efficient locations for the enhancements?

10.10 What are the primary goals of the WAP Forum efforts and how are they reflected in the initial WAP protocol architecture?

10.11 What migration paths does WAP 1.x offer for Internet and telephony applications and their protocols? Compare with WAP 2.0.

10.12 Is WDP a fixed protocol and why does WAP not define a SAP which WDP can use?

10.13 Why does WAP define its own security layer and does not rely on the security provided by the mobile phone network? What problems does the WAP security layer cause? Think of end-to-end security.

10.14 Name the advantages and disadvantages of user acknowledgements in WTP. What are typical applications for both cases?

10.15 Which WTP class reflects the typical web access best? How is unnecessary overhead avoided when using WSP on top of this class for web browsing?

10.16 What problems of HTTP can WSP solve? Why are these solutions especially needed in wireless mobile environments?

10.17 Why does WSP/B not put responses into the same order as the requests? Think, for example, of requests for different items on a web page.

10.18 What advantages does a connectionless session service offer compared to a simple datagram service?

10.19 What are the enhancements of WAE to the classic client/server model of the web? What are functions of this enhancement?

10.20 What is the fundamental difference of WML compared to HTML? Why can this difference be important with respect to handheld devices? What is specified in addition to save bandwidth?

10.21 Why has a scripting language been added to WML? How can this language help saving bandwidth and reducing delay?

10.22 What are typical telephony events and how are they integrated into WAP? How can a user access features of mobile phones via the web browser?

10.23 What is the role of a WTA server? What are the different ways of integrating WTA servers into the WAP architecture?

10.24 What is the difference between WAP service indication and service loading? What applications could use these services? What is a push good for anyway?

10.25 Name key differences between WAP 1.x and i-mode. What were problems in the early WAP days and why was i-mode that successful in Japan?

10.26 Why is a common synchronisation framework useful? What problems remain?

10.27 What are major differences between WAP 2.0 and WAP 1.x? What influenced the WAP 2.0 development?

10.28 Compare the presented protocol stacks for WAP 2.0 and give application examples.