ECE 257A Fall'22 Review Problems for Final Exam
University of California San Diego

Lecture 2. Network architecture and work flow.

1. The modern Internet is a "network of networks". What does this mean? Draw a figure to illustrate the Internet topology as a network of different levels of operators.
2. Understand the function separation between the two major modules in a cellular architecture: RAN and core network.
3. Qualitative understanding of how cellular networks' PHY layer technologies evolved from 2G to 5G.
4. What is mobile SDN and mobile edge computing? How do these technologies address the limitations of current cellular network architecture?
5. Qualitative understanding of how WiFi networks' PHY layer technologies evolved (802.11a/g→802.11n→802.11ac and 802.11ad).

Lecture 3. Wireless Internet workflow; Mobile Internet workflow

1. Qualitative understanding of the differences between WiFi, Bluetooth, cellular networks and 60 GHz WiFi (bit-rate, range, power consumption).
2. Describe the major protocols involved in a mobile Web browsing session, and their work flow.

Lecture 4. Wireless channel model; digital modulation

1. Understand the freespace pathloss model.
2. Understand the causes and effects of small-scale fading (Doppler fading, multipath fading).
3. Understand the quantitative measures of small-scale fading and their relationship
4. Understand the generic model for digital modulation (major stages and their objectives)

Lecture 5. DSSS; OFDM

1. How does DSSS spreading work? How is it implemented in a practical communication system (major signal processing blocks and their roles)?
2. Why can DSSS improve SNR? What's the quantitative improvement as a function of spreading factor?
3. How is DSSS implemented in ZigBee?
4. How is DSSS implemented in 802.11b? Why is sampling time synchronization needed and how is it achieved?
5. What are the advantages of OFDM compared with single-carrier (SC) FDM?
6. Mathematical model of OFDM implementation. How is orthogonality achieved among subcarriers?
7. Why is cyclic prefix needed? How is it implemented in OFDM?

Lecture 6. WiFi packet processing

1. In 802.11 OFDM, how are bits mapped to subcarriers? Why is it done in this way? How is an OFDM symbol constructed?
2. How is the STF preamble constructed to facilitate packet detection? How to detect the STF preamble? How is time synchronization done based on STF?
3. How is the LTF preamble constructed? How to use the LTF to estimate frequency offset?
4. How is channel equalization done for 802.11 OFDM packets?

Lecture 7. MIMO

1. Understand the fundamental differences between diversity gain (from SIMO or MISO) and multiplexing gain (from MIMO).
2. How does SIMO improve wireless link SNR?
3. How does open-loop transmit diversity improve SNR?
4. How does close-loop transmit diversity improve SNR and link capacity?

Lecture 8. MU-MIMO and network MIMO

1. How does MIMO spatial multiplex gain increase with the number of transmit or receive antennas?
2. How does channel rank and channel condition number affect MIMO spatial multiplexing gain? Understand the high-level mathematical reasons behind.
3. How does 802.11 MIMO estimate the channel matrix?
4. How does MU-MIMO enable concurrent transmission from a single AP to multiple users?
5. What's the asymptotic capacity gain of MU-MIMO, as a function of number of antennas/users?
6. Where does the MU-MIMO overhead come from? How does it affect the effective throughput?
7. Understand the differences between the 3 forms of network MIMO implementation in LTE.

Lecture 9. MAC overview; CSMA

1. Slotted ALOHA and unslotted ALOHA: operations, pros and cons, and efficiency
2. How does collision detection and exponential backoff work in CSMA/CD? Why is exponential backoff needed?

Lecture 10. CSMA

1. Pros and cons of major MAC paradigms: channel partitioning, taking turns, random access
2. Why carrier sensing alone doesn't prevent collision in wireless networks? Why CSMA/CD doesn't work for wireless networks?
3. Understand the CSMA/CA operations in 802.11
4. How does random backoff work in 802.11 CSMA/CA?
5. What's hidden terminal? How does it affect WiFi performance? How does RTS/CTS remedy the problem?
6. What's exposed terminal? How does it affect WiFi performance?

7. Understand the differences between bit-rate, capacity, and throughput.
8. What's frame fragmentation and aggregation? How do they affect 802.11 network performance?
9. Qualitative understand of the relation between SNR and link throughput.
10. What are the major challenges for rate adaptation in 802.11?
11. Cause and effect of the rate anomaly in 802.11.

Lecture 11. MAC models

1. Basic concept of stochastic process, Markov process, Markov chain.
2. Markov chain concepts: transition probability, transition matrix, equilibrium state.
3. Basic properties of state vector, transition matrix.
4. Construct a Markov chain transition matrix for a given Markovian problem
5. Model slotted ALOHA as a Markov chain and solve for its steady state; model slotted ALOHA performance based on the steady-state model
6. Model unslotted ALOHA using Markov chain
7. Model CSMA/CD and CSMA/CA (under certain simplifications) using Markov chains
8. Model similar MAC protocols using Markov chains.

Lecture 12. mmWave networking

1. What's mmWave? What are the typical mmWave bands used in practical communication systems?
2. Understand the factors that determine the mmWave link budget
3. How does rate adaptation work in 802.11? Under the same SNR, how will the packet loss rate or bit error rate differ among different MCS levels?
4. How does phased-array beamforming work? What's phased-array gain pattern? How is the gain pattern affected by the phased-array size?
5. How is phased-array beamforming realized in practice? How does it differ from MISO or SIMO diversity?
6. How does CSMA work in directional mmWave networks? What are the limitations?
7. Why is beamforming training needed in 802.11ad? Understand the high level idea of 802.11ad beamforming training

Lecture 13. Mobile IP; routing models

1. Why is mobile IP needed? Work flows, pros and cons of indirect routing and direct routing.

Lecture 14. Wireless routing

1. Formulate an LP for a given network design problem; convert LP formulation to matrix format
2. What are the unique challenges for routing over wireless ad-hoc or mesh networks? How does DSR handle these challenges? What are the limitations of DSR?

Lecture 15. Wireless routing; Wireless TCP

1. Understand the link metric design (ETX and ETT) in Roofnet: How are they derived; why are they designed in this way; What are the limitations?
2. Work flow of TCP

Lecture 16. Wireless TCP

1. Understand the relationship between RTT, loss rate, and TCP bandwidth estimation
2. Work flow, pros and cons of Snoop TCP
3. Understand why/how ELN improves wireless TCP
4. Understand the principles and pros/cons of other TCP optimization mechanisms: timeout freezing, selective retransmission, performance enhancement proxies

Lecture 17. Mobile and wireless applications

1. Understand the challenges and solution principles of mobile Web loading
2. Understand the challenges and solution principles of mobile video streaming