**Wireless Multimedia Systems**

Fall, 2020 (HOMEWORK 1, Due Day: 9:00 AM Oct 7 , 2020)

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1. **(5G Wireless Access)** ITU-R Working Party (WP) 5D is responsible for the overall radio system aspects of International Mobile Telecommunications (IMT) systems. These consists at present of IMT-2000 (3G) and IMT-Advanced (4G) and IMT-2020 (5G). We are just at the beginning of a transition into a fully connected Networked Society that will provide access to information and sharing of data anywhere and anytime for anyone and anything. (A) Conventional mobile broadband (MBB) applications will continue to drive demand for higher traffic capacity and higher end user data rates. For next generation wireless access networks explain the data rates we envision in 5G? (B) In addition, new machine type communication (MTC) use cases will impose other sets of requirements. Explain them (such as mission critical MTC applications and massive MTC connectivity).
2. **(6G Frontier) (A)** Within 10 years, current methods of remote interaction among human beings will become obsolete, as new forms of interaction arise that lead to true immersion into distant environments. Communications and services in 5D, integrating all human sense information, are expected to arise together with holographic communications thus providing a truly immersive experience. Explain what are communications and services in 5D and holographic communications? (B) To fulfill the challenging requirements of these new services, 6G will build on a set of technological enablers. Explain the development of semantic inference algorithms and semantic communication strategies to incorporate knowledge representation in communication. (C) Explain the new physical layer to support holographic communications?

1. **(Transport Layer Performance over 5G mmWave)** To enable the expected massive traffic increased, additional spectrum will have to be assigned to mobile wireless communications. Fortunately, vast amounts of relatively idle spectrum do exist in the mmWave range of 30-300 GHz, where wavelengths are 1-10. (A) Explain the main reason that mmWave spectrum lies idle? (B) Explain why the use of mmWave bands could create networks with two features that have never been seen together before, namely links with massive peak capacity, but capacity that is highly variable. (B) Scenario 1: We let a UE move over a path characterized by sudden link transitions due to human obstacles, represented as 0:5 m \_ 0:5 m cubes. TCP/UDP data packets are sent from a remote host to the UE with source rate 1 Gbps. We report both the topology and the time evolution of the received power in Fig. 2a. (C) Offer possible solutions to address the challenge.



1. **(What is 5G?)** (A) The need to support the mobile data traffic explosion is unquestionably the main driver behind 5G. Explain 5G target goals for aggregate data rate, edge rate (or 5% rate) and peak rate. (B) Describe the “big three” 5G technologies get to 1000 X Data Rate (for the most part, be achieved by combined gains by three categories). (C) Current 4G round trip latencies are on the order of about 15 ms, and are based on 1ms sub-frame time with necessary overheads for resource allocation and access. Describe 5G latency requirement. Explain the possible ways to realize the delay requirement. (D) Describe two major trends (advances) in the 5G mobile communication networking.
2. At the start of 21st century, the wireless mobile markets are witnessing unprecedented growth fueled by an information explosion and a technology revolution. (A) Explain (1) the trend in the radio frequency (2) the trend in the mobile network area. (B) The first-generation cellular wireless mobile systems were analog and were based on frequency-division multiplex (FDM) technology. Explain why it was once projected by some that the cellular industry could only see limited growth. (C) Describe why OFDMA replaces CDMA for 4G standard. (D) In order to fully utilize spectrum resources, describe how “***cognitive radio technologies***” and “***ultra-wideband radio technologies***” share the spectrum with existing wireless systems.
3. **(Performance Anomaly)** IEEE 802.11b uses the CSMA/CA protocol to share the radio channel in a fair way. However, we have observed that in some common situations in a wireless environment, the method results in a considerable performance degradation. In a typical wireless local area network, some hosts may be far away from their access point so that the quality of their radio transmissions is low. In this case current 802.11b products degrade the bit rate from the nominal 11 Mb/s rate to 5.5, 2, or 1 Mb/s – when a host detects repeated unsuccessful frame transmissions, it decreases its bit rate. If there is at least one host with a lower rate, a 802.11 cell presents a *performance anomaly*: the throughput of all host transmitting at the higher rate is degraded below the level of the lower rate. Such a behavior penalizes fast hosts and privileges the slow one.

(A) Can you offer the reason for the 802.11b performance anomaly?

(B) Can you offer a solution for the 802.11 performance anomaly?

1. **(Fairness in 802.11)**In this question, we study the problem of maintaining fairness for upstream and downstream connections in wireless local area networks (WLANs) based upon the IEEE 802.11 standard. Current implementations of 802.11 use the so-called Distributed Coordination Function (DCF), which provides similar medium access priority to all stations. Although this mode of operation ensures fair access to the medium at the MAC level, it does not provide any provisions for ensuring fairness among the upstream and downstream connections. Connection unfairness may result in significant degradation of performance leading to users perceiving unsatisfactory quality of service. (A) Can you explain why current 802.11 might produce this so-called “critical unfairness” between upstream and downstream connection as the attached Figure 2. (B) Can you revise IEEE 802.11 to solve this problem? Can you ensure fairness among the upstream and downstream connections?

