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R&D for Wireless Multimedia Communications in Next Decade

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Abstract

The rapid convergence of the voice, data and video networks is driving the wireless communications industry to undergo and unprecedented paradigm shift. Similar to voice services, multimedia services are now an indispensable mobile service component. This is exemplified by Apple's recent success in selling more than one million units of its next-generation iPhone 3GS on the first debut weekend in June even when the recession is in full swing. In this article, we will review and envisage the R&D development on multimedia technologies and the underlying wireless communication networks, respectively.

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R&D for Wireless Multimedia Communications in Next Decade

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The rapid convergence of the voice, data and video networks is driving the wireless communications industry to undergo an unprecedented paradigm shift. Similar to voice services, multimedia services are now an indispensable mobile service component. This is exemplified by Apple's recent success in selling more than one million units of its next-generation iPhone 3GS on the first debut weekend in June even when the recession is in full swing. In this article, we will review and envisage the R&D development on multimedia technologies and the underlying wireless communication networks, respectively.

We begin with the advancements in multimedia technologies. Clearly, applications and contents will be the key driving factors in the next generation broadband wireless multimedia communications. The H.264/AVC video coding standard [1] has been well received by the multimedia industry. Its scalable extension, namely, H.264/SVC [2], has a great potential since it can meet different quality of services (QoS) requirements easily and offer robust performance in the presence of unreliable wireless channels. On the other hand, the great flexibility of H.264/SVC does impose challenges in system integration for the operators. A substantial amount of industrial R&D is needed to have a good cross-layer design to exploit the advantages of H.264/SVC fully.

High definition (HD) video with a data rate of 10Mbps or higher becomes more popular nowadays. However, H.264/AVC and H.264/SVC are still not effective in the coding of high definition content. New standardization efforts have been initiated along this line, including ITU-T H.265 [3] and MPEG High-performance Video Coding (HVC) [4] activities. A key objective is to reach the same video quality while reducing the bit rate of the state-of-the-art coding standard by one half. Several recent R&D efforts have shown good promises in achieving this ambitious goal. It seems feasible that we will see another quantum jump of the video coding performance after H.264, which will enable wireless HD video within the next decade.

Location-based and network-based services and applications will emerge and become popular. Mobile devices serve as capturing instruments, recording numerous video and audio for local and/or remote storage. Besides, queries are sent to the data center through networks to search information of interest in form of multimedia. Thus, content-based media search, indexing and retrieval will be in great demand. Despite its technical challenges, some major breakthrough is expected along this line in the next decade. Another interesting area to observe is the development of social networks such as Facebook and Twitter, where multimedia data will become more dominant. Clearly, real-time high quality multimedia information sharing among user groups will create a lot of traffic. Network coding [5] offers an excellent framework to efficient video multicast in theory. Its practical implementation [6] is expected in the near future.

To support these advanced multimedia services over mobile broadband networks, the wireless communications industry has to develop innovative technologies capable of providing fast multimedia services over all-IP wireless networks. The existing technologies such as High Speed Packet Access (HSPA) and IEEE 802.11g can typically deliver maximum real-world throughput on the order of 10Mbps in the downlink transmissions, which is increasingly seen as inadequate. To the rescue, HSPA+ is currently being implemented to double the throughput as an affordable and incremental upgrade. In contrast, the emerging IEEE 802.11n improves upon IEEE 802.11g by adopting some latest technologies such as the multiple-input multiple-output (MIMO) technology. By exploiting multiple antennas and bonding wider bandwidth channels, IEEE 802.11n is expected to increase the throughput to the 100Mbps range. However, the mobile data usage is foreseen to strain the current network capacity in a few years time.

This growing demand for even higher throughput, lower latency and longer transmission range has motivated substantial fourth-generation (4G) standardization activities on IEEE 802.16 (also known as WiMAX) and Long-Term Evolution (LTE). Notwithstanding their different historical origins and subsequently backward compatibility constraints, both WiMAX and LTE are designed to achieve significantly higher data rates compared to any existing standards. More specifically, IEEE 802.16m and LTE-Advanced (LTE-A) are targeting at a peak data rate of 1Gbps [7],[8]. This stringent data-rate requirement demands a wide array of novel technologies to revolutionize the current network design. For instance, both WiMAX and LTE utilize the scalable orthogonal frequency division multiple access (OFDMA) as the air interface technology for its robustness against multipath fading and flexibility in dynamic resources allocation. Furthermore, both capitalize on sophisticated MIMO technologies coupled with advanced scheduling schemes. In addition, to enhance the QoS of cell-edge users, technologies such as relaying and collaborative transmission among multiple base stations are being actively investigated. Finally, one emerging technology developed for LTE-A is carrier aggregation. In carrier aggregation, multiple 20 MHz carrier components in different frequency bands can be flexibly aggregated together into wider bandwidth for very fast data transmission. It is expected that the WiMAX and LTE standardization activities will continue expediting the R&D efforts on these cutting-edge technologies.

However, speed is not the sole feature to characterize future wireless multimedia communications. A few distinguishing features are highlighted in the following. First, due to the broadcasting nature of wireless communications, information security has become an imminent concern. In addition to the conventional cryptography techniques, information-theoretic techniques are being developed to strengthen information security by exploiting wireless channels [9]. Second, "green" design to dramatically improve the system energy efficiency has become increasingly important for high data-rate communications. This has to be achieved by developing novel energy-efficient hardware design and network architecture [10]. Third, to achieve higher spectral efficiency via multiplexing or frequency reuse, the importance of interference management appears even more prominent. More sophisticated signal processing technologies for interference suppression or cross-layer approaches are useful to circumvent the problem [11]. Last but not the least, despite the success in analyzing different theoretical aspects of point-to-point links, little work has been achieved in developing theoretical frameworks for wireless networks comprised of multiple links. Therefore, more fundamental understandings on wireless networks such as their capacity and practical performance will play an essential role in improving holistic network design [12].

Ubiquitous wireless multimedia communications have been envisioned by many pioneers for years. With the arrival of 4G networks, high-quality and robust wireless multimedia communications are no longer science fiction in the near future.

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