3G Long Term Evolution

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ABSTRACT

In cellular mobile communication, standardization activities currently focus on a long term evolution of the existing 3G systems (3G LTE). In parallel, major cellular network operators have started an organization (NGMN Ltd.) to formulate and promote their needs and requirements. The current system deployment roadmaps of these groups reach far into the next decade. This paper summarizes key points of a white paper of the NGMN organization and key features of the physical layer of 3G LTE, which will be presented and reviewed in more detail in the lecture.

1.0 INTRODUCTION

A key area of emerging wireless communication technologies is mobile, cellular communication. Significant research has been done on candidate technologies for future 4G systems. The experience with the introduction of 3G systems has changed the position of industry and operators substantially. Before the introduction of 4G systems, a significant evolution of the current 3G systems is envisaged. Standardization of 3GPP currently focuses on this enhancement under the title "3G Long Term Evolution" (3G LTE).

Since mobile communication is a highly competitive volume market, operators have a vital interest that the evolution supports their needs. Besides an already established active role in the standardization process, key mobile network operators have taken a further step and founded an organization to promote their needs, the NGMN Ltd. (www.ngmn.org) . Because of its expected impact, it is very relevant to understand the position of these operators before looking into 3G LTE standardization. In chapter 2, some key views and requirements which were laid down in a white paper [1] are summarized and discussed.

Some of the features of 3G LTE have already been discussed in an earlier lecture, in particular, related to the protocol layers [2]. Chapter 3 will discuss key new services and important features of the physical layer of 3G LTE.

2.0 NGMN REQUIREMENTS

2.1 The NGMN Organisation

In 2006 major operators (T-Mobile, Orange, KPN, Vodafone, Sprint-Nextel) initiated a white paper on next generation mobile networks and held a conference together with participants from industry and research to discuss major issues and requirements of future mobile networks and technology. In the meantime additional operators joined the group and an organization was established in the UK.

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2.2 Key Issues

Besides a new Intellectual Property Rights (IPR) regime, which is a commercial and legal issue, key technology requirements of next generation mobile networks were defined and ranked in a white paper [1] by NGMN. Mandatory requirements for the system are

- Seamless mobility, i.e. the ability to seamlessly handover from a cell to an adjacent cell
- Spectral efficiency
- Simplicity, i.e. minimization of the complexity of the architecture and protocols
- Total cost of ownership, i.e. taking into account cost of migration and future upgrades, existing asset reuse and operational efficiency
- Reliability, i.e. deliver sustained correct system operation

Strong requirements for the system are

- Low latency, defined as user visible latency
- High End-to-End Throughput, defined as user visible data rate
- Quality of Service, i.e. delivery of predictable throughput to users
- Security, i.e. end-to-end security

It is interesting to note that the strongest emphasis is on cost related issues. Second strongest emphasis is on a higher service quality, like reduced latency, higher throughput and predictable performance as seen by the user (i.e. end-to-end performance). Integrated networking supporting both NGMN and other access technologies is seen as compromise-able requirement.

2.3 New Services

Besides the above discussed more generic issues it is of high interest, which services are seen as key drivers of next generation mobile networks. The specification of 3G and beyond mobile communications must address these services specifically and provide the enabling basis. Of particular importance are services which demand broadband and/or low latency access since their reliable delivery represents one of the strongest challenge in mobile communications. According to NGMN among these driver services are

- Multimedia conferencing and video telephony
- Fast interactive sessions
- Broadcast and multicast services

Another challenging service class are trust based services requiring an outstanding level of security and safety as well as a high, guaranteed quality of service.

It is expected that in 2007-2009 optimised multimedia mobile handsets will become available. Major enhancements will be peak data rate reference values of up to 7 Mb/s in good radio conditions on the downlink, High-Speed Uplink Packet Access (HSUPA) and overall HSPA improvements. For the next decade the down link peak data rates are required to reach 100 Mb/s. The “Next Generation Mobile Network” provides broadband mobile communication based on broadband radio and an IP based wideband network, supporting peer-to-peer communication. It is seen as a key stepping stone towards one integrated network.

3.0 3GPP LTE

3.1 Introduction

As mentioned earlier, 3GPP is currently working on major enhancement of 3G standards under the label “3G Long Term Evolution (3G LTE)”. In line with the requirements of the white paper [1], it targets higher data rates, further expansion and enhancement of packet oriented access, higher quality of service and a simplification of the network architecture. It is not the intention to provide a full overview of the standardization activity. Rather, some key enhancements of the physical layer [3] will be discussed (for other layers see also [2]).

A key new service type introduced with LTE is the Multimedia Broadcast/Multicast Service (MBMS) which enables broadcasting and multicasting using the cellular network resources rather than a separate broadcasting network like with DVB-H. Since in broadcasting mode the same data is send to all users, the signal from an adjacent cell may be considered as diversity rather than interference when sent on the same frequency. Thus, a reuse of the frequency in adjacent cells, i.e. a single frequency network (SFN) for broadcasting, is advantageous and, therefore, considered in 3G LTE.

3.2 LTE Physical Layer Features

Downlink

A major change is the use of OFDM and OFDMA in the downlink. Using a fixed subcarrier spacing (15 kHz) different transmission bandwidths are supported by different number of subcarriers. The subcarriers are grouped into resource blocks (RB) of 12 subcarriers, between 6 RB’s (1 MHz) and 110 RB’s (20 MHz) are supported as total system bandwidth.

Data rate and efficiency are controlled by adaptive modulation and coding (up to 64 QAM), multiple access is implemented by assigning blocks of subcarriers to different users. Both features can be used to implement efficient allocation strategies. Mobile communication suffers from frequency selective fading. By estimation of the received signal quality in the different subbands and subsequent feedback, the basestation can be enabled to schedule the transmission to different users in subbands where their link quality is high.

For SFN (single frequency network) operation, a mobile receives the same signal from different basestations. Thus, larger delay spreads may occur. Therefore, a short and a long cyclic prefix are foreseen.

Uplink

Besides the above mentioned flexibility, OFDM has further significant advantages in frequency selective fading environment. Each subcarrier exhibits flat fading, equalization in the frequency domain is straightforward. OFDM suffers, however, from a high peak-to-average-power ratio (PAPR) which is a particular disadvantage in the uplink (where the mobile transmits). Therefore, the uplink uses Single Carrier FDMA (SC FDMA). The available spectrum is divided into a small number of frequency blocks which can be assigned to different users. The introduction of guard intervals enables FFT-based frequency domain equalization (FDE) similarly as with OFDM.

General

The efficient use of multiple antennas in both basestation and mobile is an integral part of LTE. When the same signal is transmitted with different weights through the different antennas, beamforming results. Beamforming will be used to improve the throughput, in particular, at the cell edges. On the other hand, with multiple antennas both at the basestation and the mobile multiple data streams may be transmitted (MIMO). In LTE, both single user MIMO (multiple data streams to one user) and multiple user MIMO (different data streams to different users) are foreseen. MIMO requires particular channel conditions, e.g. higher SNR and paths between the transmit and receive antennas which are not strongly correlated. When these conditions are not met, multiple antennas can still be used to get a more reliable transmission (multiple antenna diversity).

4.0 SUMMARY

Key drivers for enhancement in the physical layer are optimum use of resources like power and spectrum, flexibility and higher quality of service but also new services like the MBMS with its single frequency network (SFN). Due to the flexibility and straightforward equalization in the frequency domain, OFDM(A) is a key future technology for the downlink of mobile cellular systems. While in the past the physical layer standardization was mainly targeting an optimization of the individual link performance with other links regarded as interference, the focus is now shifted towards the optimization of the cell traffic (e.g. multi-user MIMO, beamforming).

5.0 REFERENCES

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