Evolvement of Speed in future Mobile Broadband

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***Abstract*—This extended summary focuses on speed and date rates performances of future mobile broadband systems in Europe, in today and more technical terms called LTE Release 8 for 3G: LTE and later LTE Release 10 for 4G. With new end nodes, the network is able to send data at much higher rates thanks to of MIMO, OFDMA and an optimized system architecture. This network is going to be highly suitable for the increasing demand of many users transmitting smaller packets. Applications such as Facebook notifications, e-mail push, weather updates and other services that demand a network that can hande many transmissions from many users at the same time. Using MIMO transmission modes, it will be possible to allow forward compatibility by allowing beam forming modes to support two orthogonal spatial layers that can be transmitted to a user or a set of multiple users.**

To enable a MIMO transmission OFDM has been adopted which is a crucial components in LTE enabling technologies. Thorough design of physical layer techniques to exploit the unique characteristics of a high densiy tiny cell network is required to fulfill the aggressive area capacity in future networks. In addition to MIMO and carrier aggregation, physical layer enhancement techniques can be effective to boost the spectral efficiency in dense small cell networks. However, the current efficiency of bandwidth aggregation is limited by the available spectrum and maximum site power constraint.

We are heading to a completely different type of mobile network. With the heritage from GSM and GPRS left behind and transitioning to packet switched instead of standard circuit switched phone calls newer techniques will provide higher latency for each individual handset and enable better reception with more communication between transmitting nodes. More complex antenna techinques will provide high performance speeds that it will be in competition with todays home LAN networks that only provide 100Mbit/s. We can also expect the user equipment to get alot more complex and a growth of number of category 8 UE in the future.

I. Introduction

This report will focus on the speed and data rates performances of future mobile broadband systems, or in general what is called 4G. However, the term 4G has become overused by operators all over the world, in the U.S. the term has been used when the technology IEEE 802.16x standards (or WiMAX) was released. When the LTE later was released in U.S. this created confusion and later the LTE network in U.S. was called 4G: LTE.

Today, in Europe atleast, we call LTE Release 8 for 3G: LTE and the LTE Release 10 will be called 4G. This is because of the ITU's standard IMT-Advanced that defines the 4G. But to be realistic, 4G is just a label for the marketing guys to sell more phones with the only promise, higher speeds. This is also what the customers want, even though ”true” 4G will be based other technology in the backbone, for example relaying, carrier aggregation, new modulation schemes and so forth. The only thing that the customer will see is the increased speeds. That's why this report focuses on the speed increase of the new 4G techniques LTE-Advanced/LTE Release 10/IMT-Advanced.

II. Speed

The users of the future mobile broadband will only focus on the speeds of the network. The general public do not care about the how the network architecture works, even if LTE-Advanced architecture is quite spectacular, with design implemenations in the coding schemes that we today can not prove mathematically, however, there have been practial tests on the network that proves that it work, just not how. This coding scheme is called turbo-coding and is one of the reasons that the LTE-Advanced can come up to speeds in the downloink at around 3000 Mbit/s, and 1500Mbit/s in the downlink if you have a user equipment of type 8. The speeds will get alot lower if you have user equipment of lower type. If you have user equipment of type 6 in Release 10 you will get speeds to abuout 300Mbit/s in downlink and 150Mbit/s in uplink.

This is what customers are looking for, a reliable, high speed network with low latency that can handle many small packets, and at the same time deliver good peak speeds for high quality voice and video and even other file sharing protocols like torrent and other peer-to-peer like networks.

III. Why is it faster?

When 3GPP started to realize that the 3G technique was able to evolve further, they started the standardization of 3G: Long Term Evolution. With new end nodes, the network was able to send data at much higher rates because of MIMO, OFDMA and an optimized system architecture[2]. This release was called Release 8 and was, wrongly figured as 4G of many operators. The release showed speeds on the 3G net that were alot higher then todays HSDPA speeds, however it did not make the network more reliable, or make the network handle more traffic, which makes latencies still a problem.

Later an improvement of LTE was released called LTE Release 9. This was mainly used for LTE's suitabilty for different markets with special requirements like North America. What was new in Release 9 was that it had better positioning, public warning systems and a new type broadcast mode. In conjunction with this MIMO also improved, giving support for two orthogonal spatial layers that can be transmitted to one single user[2].

Release 10 of LTE was the LTE release with the greatest changes, from using much of the 3G networks main structure and LTE began with evolved packet core which gave higher speeds. This was further developed in Release 10 when the transisition from being dependent of the circuit switched network to be able to make phone calls, LTE Relase 10 is totally packet switched with phone calls made over IP. One other main feature of LTE 10 is carrier aggregation. This makes it possible for one single user to use as much as 100 MHz (5x20MHz) if the whole frequency band is free.

This network will be very suitable for the demand of many users sending smaller packets. Like Facebook notifications, e-mail push, weather updates and other services that demand a network that can handle many transmissions from many users at the same time.

IV. The techniques

As different release LTE progressed and reached levels of completion and acceptance by the IMT, development of standardizaition work continued, handled and improved current techniques. MIMO transmission modes were the goal to be able to allow forward compatibility by allowing beam forming modes to support two orthogonal spatial layers that can be transmitted to a user or multiple users. To enable a MIMO transmission OFDM was adopted which is to crucial component in LTE enabling technologies. Coordinated multipoint transmission is also an LTE relevant discussed technique.

A. Orthogonal Frequency Divison Muliplexing

OFDM, orthogonal frequency division muliplexing is referred to a type of multicarrier transmission with a set of large number of subcarriers. Using multiple carrier transmission technique for a longer symbol time in combination with a cyclic prefix implies higher robustness channel frequency selectivity. Because of OFDM being applied in both the downlink and uplink transmission directions, it gives the scheduler access to both the time and frequency domains. Thus, the scheduler has, for each time instant and frequency region(OFDMA), greater freedom to select the user with the best channel conditions. The current release 10 handles OFDMA which gives a range of different possibilites and exploitations of frequency and multiuser diversiy . Another apparent advantage with OFDMA is the transmission bandwith can be easily teared down or turned on making it possible to have transmission bandwiths up to 100 Mhz[4][2].

B. Multiple Input Multiple Output

The case of multiple antennas at both the transmitter and the receiver i.e MIMO, muliple-input multiple-output, allows the possibility for so-called spatial multiplexing, which contributes for more efficient utilization of high signal-to-noise/interference ratios and significantly higher data rates over the radio interface. By achieving larger bandwiths in the newer releases and using high-order demodulation, we can by using spatial multiplacing improve cell capacity and higher throughput at UE. An LTE Advanced offers supporting antenna configurations of 8 x 8 in Downlink and 4 x 4 in the Uplink.

C. Coordinated multi-point transmission

Coordinated multi-point transmission (CoMP) refers to a number of different coordination schemes of very different characteristics. It includes all from from dynamic inter-cell scheduling coordination to joint transmission on/reception at multiple sites. CoMP can, to a certain extent, be considered as an extension of the inter-cell interference coordination that is already part of LTE.

D. Carrier Aggregation

First release of LTE already provided extensive support for deployment in spectrum allocation of various characteristics. This release had bandwiths ranging from rougly 1MHz to 20MHz[4]. In Release 10 this was evolved further and multiple component carriers are aggregated and joinly used to transmit and receive. As told earlier the bandwiths range from 20MHz to 100MHz, depending on how many 20MHz slots are used. They do not have to be consecutivly aggregated, which means if you have the baseband 1800MHz, you can have 20Mhz in the begining of the band and another 20Mhz in another slot, 60 MHz away. This is called fragmented spectrum.

The whole carrier aggregation is backward compatible, all the component carriers (LTE 10 have many) will show up as LTE 8 handsets, thus, even if you have LTE 8 handsets, LTE 10 handsets can be present in the network without having to deploy new techniques for LTE 10 handsets. In a baseband perspective, there is no difference in the complexity of the network, however in the Radio Frequency implementation, the complexity is much higher.

Technical Challenges Thorugh design of physical layer techniques to exploit the unique characteristics of a high density tiny cell network is required to fulfill the aggressive area capacity in future networks. In addition to MIMO and carrier aggregation, physical layer enhancement techniques can be effective to boost the spectral efficiency in dense small cell networks. However, the current efficiency of bandwidth aggregation is limited by the available spectrum and maximum site power constraint[1].

Today, we are looking beyond the 3Gbit/s goal. In the future, we will be heading to $25Gb/s/km^2$. The new demand on the mobile networks puts huge pressure on the data rates and the quality of service (QoS) of the mobile network. During busy hours in urban areas with the typical user density of 25000 people per square kilometer and with a data rate of at least 1Mbit/s, we need to obtain speeds of at least $25Gb/s/km^2$. There have been some techniques proposed to fulfill these future specifications[1].

- Two radio access network architectures, the Cloud RAN and the self-orginization RAN.

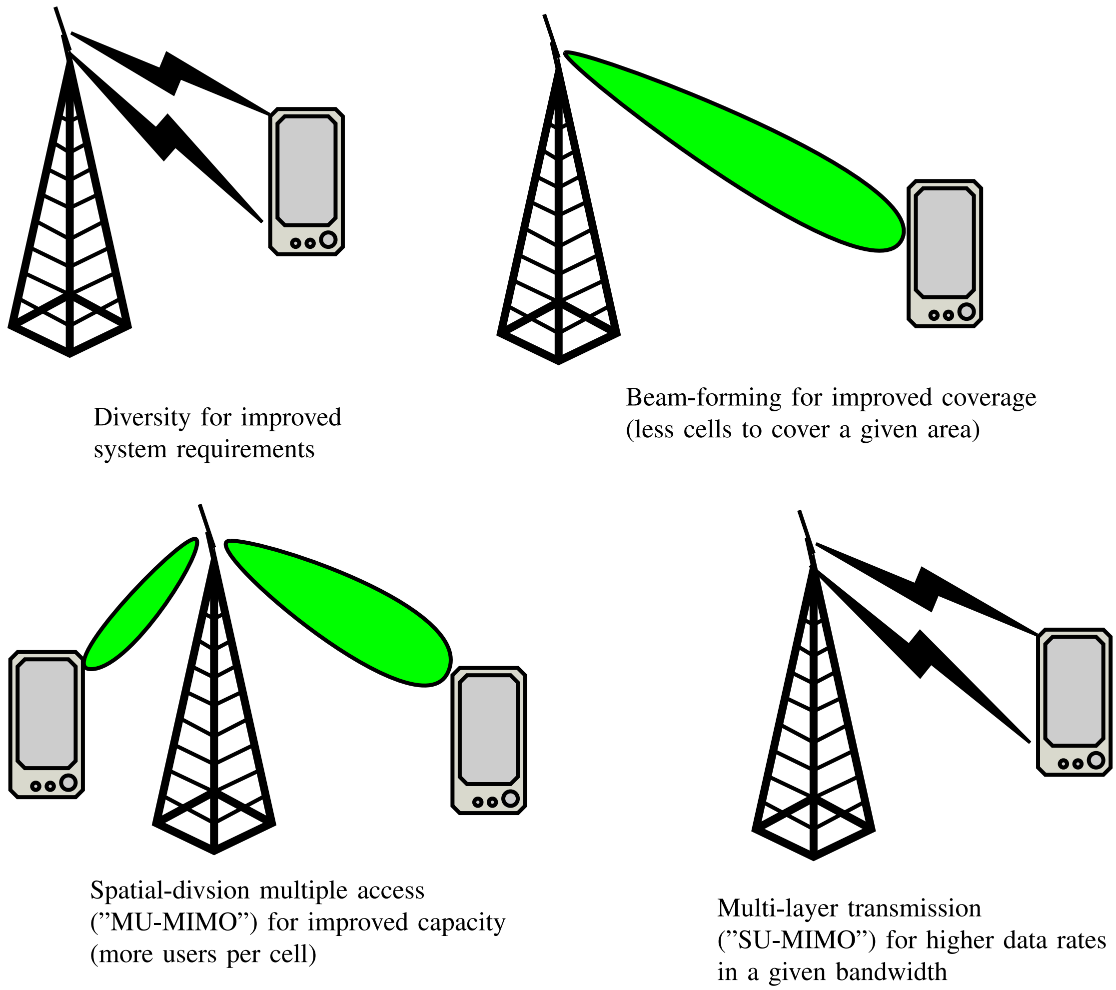

Fig. 1. Multiple-antenna techniques in LTE.

- Advanced physical layers techniques to interference mitigation techniques.
- Cooperative MIMO communications
- Urban small cell deployment.

Urban small cell deployment allows increased network capacity and at the same time benefits the energy effiency of the network. Energy effienct design for green radio has been a trend both for the network architecture as with mobile handsets. This will lower the CO_2 emissions and the cost for operators to have the network running. The problems with having many cells close to each other will result in some technical challenges, these challenges

V. Conclusion

We are heading to a completely different mobile network. With the old type of network inherrited from GSM and GPRS left behind we are transitioning to packet switched with VoIP instead of standard circuit switched phone calls. Other techniques will provide lower latency for each individual handset, better reception with more communication between transmitting nodes. More complex antenna techinques can provide so high speeds that it will be in competition with todays home LAN networks that only provid 100Mbit/s. The user equipment will also get alot more complex and we will see more handsets of category 8 in the future.

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