Comparative Study of 3G and 4G in Mobile Technology

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Abstract—Mobile communication is one of the hottest areas and it is developing extremely fast in present times, thanks to the advances of technology in all the fields of mobile and wireless communications. Nowadays the use of 3G mobile communication systems seem to be the standard, while 4G stands for the next generation of wireless and mobile communications. This comparative study between 3G & 4G tells about the background and the vision for the 4G. We first present a review on the development history, characteristics, status of mobile communication and related 3G - 4G perspectives. An overall 4G framework features, having the basic keys (diversity and adaptability) of the three targets (terminals, networks, and applications). We present it in both external and internal diversity of each target to illustrate the causes and solutions of the adaptability feature. Then, the 4G domain of each feature in the framework is discussed from technical point, showing techniques and possible research issues for sufficient support of adaptability. At the end, a summary on 4G visions and some of the issues this new technology may face.

Keywords: OFDM, HSPA, LTE, MIMO, MC-CDMA, WCDMA, UMB

I.INTRODUCTION

Mobile broadband is becoming a reality, as the Internet generation grows accustomed to having broadband access wherever they go, and not just at home or in the office. Out of the estimated 1.8 billion people who will have broadband by 2012, some two-thirds will be mobile broadband consumers — and the majority of these will be served by HSPA (High Speed Packet Access) and LTE (Long Term Evolution) networks. People can already browse the Internet or send e-mails using HSPA-enabled notebooks, replace their fixed DSL modems with HSPA modems or USB dongles, and send and receive video or music using 3G phones. With LTE, the user's experience will be even better. It will further enhance more demanding applications like interactive TV, mobile video blogging and advanced games or professional services.

LTE offers several important benefits for consumers and operators: Performance and capacity - One of the requirements on LTE is to provide downlink peak rates of at least 100Mbit/s. The technology allows for speeds over 200Mbit/s and Ericsson has already demonstrated LTE peak rates of about 150Mbit/s. Furthermore, RAN (Radio Access Network) round-trip times shall be less than 10ms. In effect, this means that LTE — more than any other technology — already meets key 4G requirements.

II. DIFFERENTIATION BETWEEN 3G & 4G

3G is currently the world's best connection method when it comes to mobile phones,

and especially for mobile Internet. 3G stands for 3rd generation as it just that in terms of the evolutionary path of the mobile phone industry. 4G means 4th generation. This is a set of standard that is being developed as a future successor of 3G in the very near future.

The biggest difference between the two is in the existence of compliant technologies. There are a bunch of technologies that fall under 3G, including WCDMA, EV-DO, and HSPA among others. Although a lot of mobile phone companies are quick to dub their technologies as 4G, such as LTE, WiMax, and UMB, none of these are actually compliant to the specifications set forth by the 4G standard. These technologies are often referred to as Pre-4G or 3.9G.

4G speeds are meant to exceed that of 3G. Current 3G speeds are topped out at 14Mbps downlink and 5.8Mbps uplink. To be able to qualify as a 4G technology, speeds of up to 100Mbps must be reached for a moving user and 1Gbps for a stationary user. So far, these speeds are only reachable with wired LANs.

Another key change in 4G is the abandonment of circuit switching. 3G technologies use a hybrid of circuit switching and packet switching. Circuit switching is a very old technology that has been used in telephone systems for a very long time. The downside to this technology is that it ties up the resource for as long as the connection is kept up. Packet switching is a technology that is very prevalent in computer networks but has since appeared in mobile phones as well. With packet switching, resources are only used when there is information to be sent across. The efficiency of packet switching allows the mobile phone company to squeeze more conversations into the same bandwidth. 4G technologies would no longer utilize circuit switching even for voice calls and video calls. All information that is passed around would be packet switched to enhance efficiency.

1. 3G stands for 3rd generation while 4G stands for 4th generation.
2. 3G technologies are in widespread use while 4G compliant technologies are still in the horizon.
3. 4G speeds are much faster compared to 3G.
4. 3G is a mix of circuit and packet switching network while 4G is only a packet switching network.

III. Features of 3G

3G telecommunications, is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specified by the International Telecommunication Union.[1] Application services include wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV, all in a mobile environment. To meet the IMT-2000 standards, a system is required to provide peak data rates of at least 200 kbit/s. Recent 3G releases, often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to smart phones and mobile modems in laptop computers.

The following standards are typically branded 3G:

- the UMTS system, first offered in 2001, standardized by 3GPP, used primarily in Europe, Japan, China (however with a different radio interface) and other regions predominated by GSM 2G system infrastructure. The cell phones are typically UMTS and GSM hybrids.

Several radio interfaces are offered, sharing the same infrastructure:

- The original and most widespread radio interface is called W-CDMA.
- The TD-SCDMAradio interface, was commercialised in 2009 and is only offered in China.
- The latest UMTS release, HSPA+, can provide peak data rates up to 56 Mbit/s in the downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s in the uplink.

IV. Features of 4G

4G, a range of new services and models will be available. These services and models need to be further examined for their interface with the design of 4G systems. Figures 2 and 3 demonstrate the key elements and the seamless connectivity of the networks.

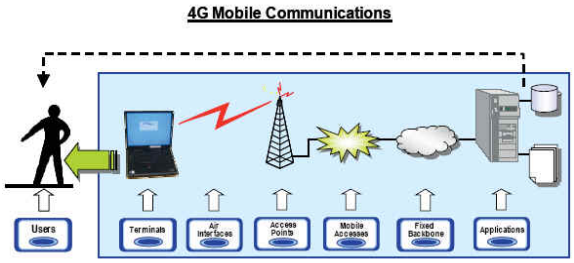

Figure 1. 4G Visions (Ref. 1)

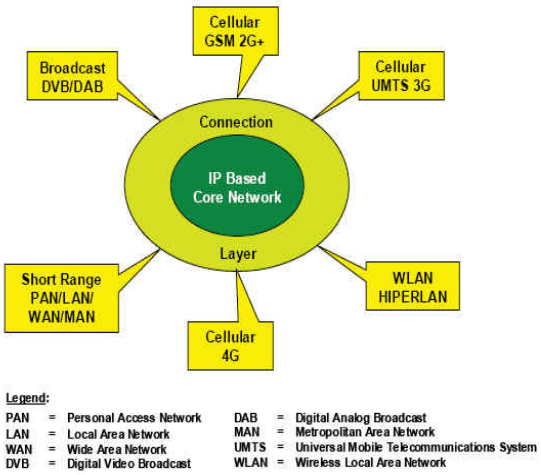

Figure 2

4.1. Terminals

Till date the “terminal” for accessing mobile services has been the mobile phone. With the advanced 3G and also the 4G in future, we can also expect to see a broadening of this concept. User interfaces of terminals will vary from traditional keyboard, display, and tablet, to new interfaces based on speech, vision, touch, soft buttons, etc. These will be general-purpose computing and communication devices, and devices with more specific purposes to serve particular marker segments. There will still be recognizable mobile phones. But many of these will have larger screens to display Internet pages or the face of the person being spoken to. There will be smaller "smart-phones" with limited web browsing and e-mail capabilities. The addition of mobile communication capabilities to laptop and palmtop computers will speed up the Convergence of communication and computing, and bring to portable computing all the functions and features available on the most powerful desktop computers. There will be videophones, wrist communicators, palmtop computers, and radio modem cards for portable computers. Innovative new voice based interfaces will allow people to

control their mobile communication services with voice commands.

4.2. Networks

Worldwide roll-out of 3G networks are delayed in some countries by the enormous Costs of additional spectrum licensing fees. In many parts of the world 3G networks do not use the same radio frequencies as 2G, requiring mobile operators to build entirely new networks and license entirely new frequencies. So that a number of spectrum allocation decisions, spectrum standardization decisions, spectrum availability decisions, technology innovations, component development, signal Processing and switching enhancements and inter-vendor cooperation have to take place before the vision of 4G will materialize.

4.3. Applications

The emerging applications for 3G and 4G wireless systems typically require highly Heterogeneous and time varying quality of service from the underlying protocol layers. So adaptability will be one of the basic requirements to the development and delivery of new mobile services. Promising techniques and possible topics may include: Mobile application should refer to a user's profile so that it can be delivered in a way most preferred by the subscriber, such as context-based personalized services. This also brings the applications with adaptability to terminals that are moving in varying locations and speeds. Techniques such as adaptive multimedia and unified messaging take the terminal characteristics into account and ensure that the service can be received and run on a terminal with the most suitable form to the host type.
The 4G technology will be able to support Interactive services like Video Conferencing (with more than 2 sites simultaneously), Wireless Internet, etc. The bandwidth would be much wider (100 MHz) and data would be transferred at much higher rates. The cost of the data transfer would be comparatively very less and global mobility would be possible. The networks will be all IP networks based on IPv6. The antennas will be much smarter and improved access technologies like OFDM and MC-CDMA (Multi Carrier CDMA) will be used. Also the security features will be much better.

Long-Term (Radio) Evolution or LTE is also part of 3G technology. It's a 3GPP its research item for Release 8. It's also known as 3.9G or "Super 3G" by some researchers. It's planned to commercialize in 2009. It was aims at peak data rates of 200 Mbps (DL) and 100 Mbps (UL).

The WiMax lobby and the people who are working with the WiMax technology are trying to push WiMax as the 4G wireless technology. At present there is no consensus among people to refer to this as the 4G wireless technology. I do not think this is popular with the researching community. WiMax can deliver up to 70 Mbps over a 50Km radius. As mentioned above, with 4G wireless technology people would like to achieve up to 1Gbps (indoors). WiMax does not satisfy the criteria completely. Also WiMax technology (802.16d) does not support mobility very well. To overcome the mobility problem, 802.16e or Mobile WiMax is being standardized. The important thing to remember here is that all the researches for 4G technology is based around OFDM. WiMax is also based on OFDM. This gives more credibility to the WiMax lobby who would like to term WiMax as a 4G technology. Since there is no consensus for the time being, we have to wait and see who would be the winner.

V. MULTIPLE ACCESS TECHNIQUES

3G wireless multiple access techniques are widely based on CDMA and WCDMA. But 4G demands a better multiple access technique for reducing the MAI (Multiple Access Interference) and ISI (Inter Symbol Interference) and thus improve the bit error rate performance. MC-CDMA is the best candidate that would satisfy the demands of 4G wireless systems. Moreover adaptive modulation techniques have been proposed for 4G, where the modulation scheme is changed dynamically based on the current channel estimates. MCCDMA is the hybrid combination of OFDM (Orthogonal Frequency Division Multiplexing) and CDMA. MC-CDMA with adaptive modulation promises to meet the demands of 4G regarding high data rate with a lower BER (Bit Error Rate).

OFDM has the capability to cancel multi-path distortion in a spectrally efficient manner. Rapid variation in channel characteristics are caused by multi-path and Doppler spread (due to the different speeds of mobile). Sometimes these time varying channels are characterized by very good SNR (Signal to Noise Ratio), but worse SNR at other times. So a fixed modulation technique cannot achieve the best Spectral efficiency as the system has to be built with a modulation scheme considering the worst case scenario. Hence during good channel conditions the system would not be able to obtain the best possible spectral efficiency. This is where adaptive modulation shows its role. Adaptive Modulation techniques takes advantage of the time varying channel characteristics and adjust the transmission power, data rate, coding and modulation scheme for the best spectral efficiency.

MC-CDMA

The basic idea of CDMA is to maintain a sense of orthogonality among the users in order to eliminate the MAI. This is done by employing orthogonal spreading codes to spread the data sequence. In MC-CDMA these spreading codes are defined in the frequency domain. Pseudo orthogonal codes can be used instead of orthogonal codes, thus increasing the number of users that can be accommodated. But pseudo orthogonal codes can increase MAI since the spreading codes are not fully orthogonal.

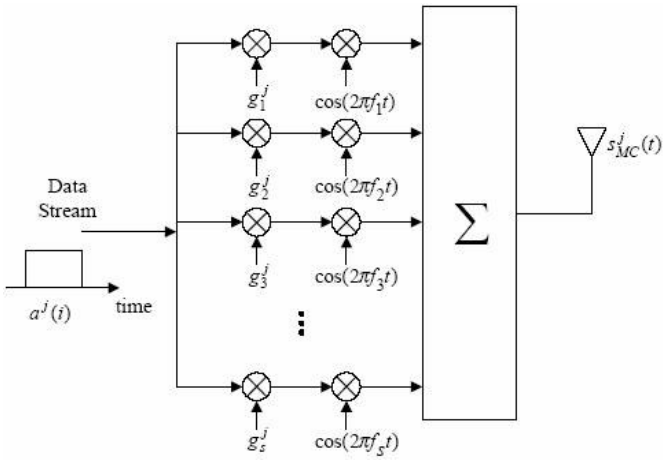

Figure 3: MC-CDMA Transmitter

Fig 3 shows the configuration of an MC-CDMA transmitter for user. It takes 3 the input data stream and converts into parallel data sequences each parallel data Sequence is multiplied with the spreading code. A guard interval in inserted between the symbols to eliminate ISI caused by multi-path fading.

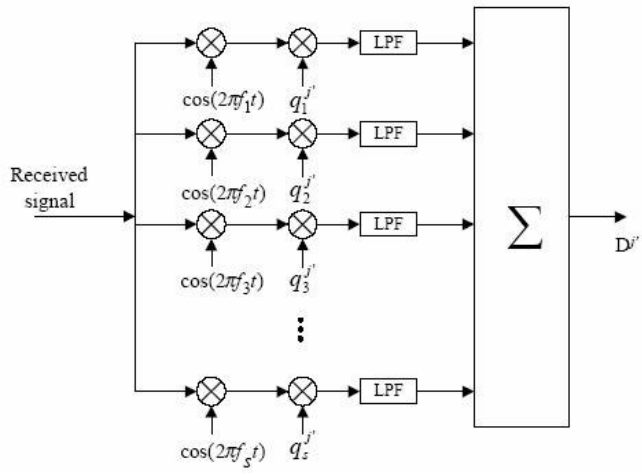

Figure 4: MC-CDMA receiver

In MC-CDMA receiver the received data are first coherently detected and then multiplied with the gain to combine the energy of the received signal scattered in the frequency domain. The system model for adaptive MC-CDMA is shown in the below fig 8.

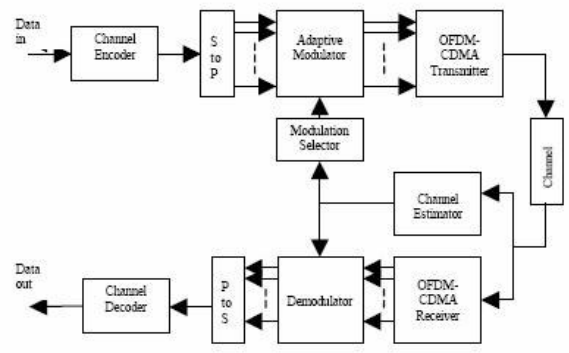

Figure 8: System model for adaptive MC-CDMA

VI. MULTIMEDIA – VIDEO SERVICES

4G wireless systems are expected to deliver efficient multimedia services at very high data rates. Basically there are two types of video services: bursting and streaming video Services. Streaming is performed when a user requires real time video services, in which the server delivers data continuously at a playback rate. Streaming has little memory requirement as compared to bursting. The drawback of streaming video is that it does not take advantage of available Bandwidth. Even if the entire system bandwidth is available for the user, streaming video service will transmit data only at a particular playback rate. Bursting is basically file downloading using a buffer and this is done at the highest data rate taking advantage of the whole available bandwidth. The flaw with this type of transmission is that it demands a large memory requirement. So work is being done to come up with a new scheme that limits the memory requirements and can exploit the available bandwidth of the system. The simulation details and comparison of streaming and bursting video comparison.

VII. Applications of 4G

Virtual Presence: This means that 4G provides user services at all times, even if the user is off-site. Virtual navigation: 4G provides users with virtual navigation through which a user can access a database of the streets, buildings etc of large cities. This requires high speed data transmission.

7.1.Tele-Medicine: 4G will support remote health monitoring of patients. A user need not go to the hospital instead a user can get videoconference assistance for a doctor at anytime and anywhere.

7.2. Tele-geoprocessing applications: This is a combination of GIS (Geographical Information System) and GPS (Global

Positioning System) in which a user can get the location by querying.

7.3.Crisis management: Natural disasters can cause break down in communication

systems. In today's world it might take days or weeks to restore the system. But in 4G it is expected to restore such crisis issues in a few hours.

7.4. Education: For people who are interested in lifelong education, 4G provides a good opportunity. People anywhere in the world can continue their education through online in a cost effective manner.

VIII. Wi-Fi vs. WiMax

Comparing WiMax to Wi-Fi is akin to comparing apples to oranges. Initially it's easy to see why the comparison would exist, as most people think WiMax is merely a more robust version of Wi-Fi. Indeed they are both wireless broadband technologies, but they differ in the technical execution and ultimately their business case is very different. In addition to the technical differences that exist, the marketplace difference is that equipment is more or less non-existent for WiMax and certainly not geared towards a residential environment with very high pricing to be expected. It will take at least 2 years to see equipment of mass market uptake pricing.

WiMax could not be commercially available until the second half of 2005, and even then at a very controlled level. This is primarily due to standardization issues. In fact, it could not be until 2006 that a robust production and implementation would happen due to the ramp-up period for manufacturers. This is certainly one challenge to the widespread adoption of WiMax. Additionally, WiMax will have issues of pricing, and will remain far more expensive than Wi-Fi. WiMax will be primarily adopted by businesses to replace or displace DSL, and offices that want to cover a lot of territory without entering the world of endless repeaters that are necessary with the 802.11 technologies. It will take some time (2 years) for WiMax to significantly reduce its price-point for residential uptake. WiMax will not displace Wi-Fi in the home because Wi-Fi is advancing in terms of speed and technology. Each year brings a new variant to the 802.11 area with various improvements.

Additionally, for commercial deployment, frequency allocation will be an issue. With the three dominant communications players controlling the best frequencies, it will be hard to get the type of traction needed with the remaining companies operating in the frequencies available. WiMax will become extremely robust and displace Wi-Fi as the deployment of choice for commercial deployments, but that could not even begin until the end of 2006. Based upon the number of public hotspots already deployed, WiMax will not be chosen to replace those as they are up and running adequately and personnel involved understand how to work with the technology. The business case does not exist at the hotspot level. Where it may exist is for wider free use deployments such as city deployments (free ones) and other government sponsored or carrier sponsored (with ultra inexpensive pricing for consumers) deployments. If this happens then it's only Wi-Fi that will be displaced, but also cable and DSL will also lose a percentage of their subscriber base. What will cause the displacement is the consumer's proven desire for a bundled package.

IX. CONCLUSION

4G seems to be a very promising generation of wireless communication that will change the people's life to wireless world. There are many striking attractive features proposed for 4G which ensures a very high data rate, global roaming etc. New ideas are being introduced by researchers

throughout the world, but new ideas introduce new challenges. There are several issues yet to be solved like incorporating the mobile world to the IP based core network, efficient billing system, smooth hand off mechanisms etc. 4G is expected to be launched by 2010 and the world is looking forward for the most intelligent technology that would connect the entire globe.

Someday 4G networks may replace all existing 2.5G and 3G networks, perhaps even before a full deployment of 3G. multiple 3G standards and springing up that would make it difficult for 3G devices to be truly global.

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