International Journal of Multidisciplinary Approach and Studies

ISSN NO:: 2348 – 537X

4G Mobile Communications - Emerging Technologies

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ABSTRACT

Consumers demand more from their technology. Whether it is a television, cellular phone, or car, the latest technology purchase must have new features. With the advent of the Internet, the most-wanted feature is better and faster access to information. Mobile communications and wireless networks are developing at an amazing speed with evidences of significant growth in the areas of mobile subscribers and terminals, mobile and wireless access networks, and mobile services and applications.

The term 4G is used broadly to include several types of broadband wireless access communication systems, not only cellular telephone systems. One of the terms used to describe 4G is MAGIC—Mobile multimedia, anytime anywhere, Global mobility support, integrated wireless solution, and customized personal service. The 4G systems not only will support the next generation of mobile service, but also will support the fixed wireless networks.

The goal of 4G mobile communications technologies is to realize wireless communications at the same high data rate as is made possible through use of the fibre-optic transmission systems that are available today.

This paper studies the history of Mobile Services and goals and characteristics of 4G mobile network services. Some of the key technologies required for 4G are also presented in detail in this article. Some tools that genuinely improve the user's multimedia quality of experience are also discussed in this article.

KEYWORDS: *4G, Mobile, Technology & wireless network*

1.0 INTRODUCTION

The newest large waves in telecommunication and mobile telephony have spread over the whole world. Still, more and more people are connecting to the mobile network. At the same time, network providers are offering a variety of advanced multimedia services such as video communications and high speed internet access. It is expected that this will lead to the mobile communication more important to our daily lives and will expand the role on a lifestyle basis in the next few years. It is also expected that such an era requires a more advanced wireless communication system, such as the Fourth-Generation (4G) mobile communication system.

2.0 FOURTH GENERATION MOBILE TECHNOLOGY

This new generation of wireless is intended to complement and replace the 3G systems, perhaps in few years. Accessing information anywhere, anytime, with a seamless connection to a wide range of information and services, and receiving a large volume of information, data, pictures, video, and so on, are the keys of the 4G infrastructures. With this feature, users will have access to different services, increased coverage, the convenience of a single device, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks.
The future 4G infrastructures will consist of a set of various networks using IP (Internet protocol) as a common protocol so that users are in control because they will be able to choose every application and environment. The key concept is integrating the 4G capabilities with all of the existing mobile technologies through advanced technologies. i.e. The 4G will encompass all systems from various networks, public to private; operator-driven broadband networks to personal areas; and ad hoc networks. The 4G systems will interoperate with 2G and 3G systems, as well as with digital (broadband) broadcasting systems. In addition, 4G systems will be fully IP-based wireless Internet.

At the moment, 4G is simply an initiative by R&D labs to move beyond the limitations, and deal with the problems of 3G. In January 2007, China launched the first trials of a home-grown 4G mobile communications network in a district of Shanghai. The groups of 10 Chinese institutions involved in the 4G project have obtained more than 200 patents for the system since starting research in 2001, and some of its fundamental technologies have been adopted by international standards organizations. The goal has been to put the 4G system into trial commercial use between 2006 and 2010.

2.1 Goal of 4G

The goal of 4th Generation (4G) mobile communications technologies is to realize wireless communications at the same high data rate as is made possible through use of the fibre-optic transmission systems that are available today. Realization of 4G mobile communications is foreseen in the early 2010s, but various precursor technologies and services have been appearing as of late.

Some of the important characteristics of 4th generation mobile networks follow:

- **High Speed** – 4G systems should offer a peak speed of more than 100 Mbits per second in stationary mode with an average of 20 Mbits per second when travelling.
- **High Network capacity** – It Should be at least 10 times that of 3G systems. This will quicken the download time of a 10-Mbyte file to one second on 4G, from 200 seconds on 3G, enabling high-definition video to stream to phones and create a virtual reality experience on high-resolution handset screens.
- **Fast/Seamless handover across multiple networks** - 4G wireless networks should support global roaming across multiple wireless and mobile networks. This provides much greater flexibility in vendor selection.

- **Next-generation multimedia support** - The underlying network for 4G must be able to support fast speed and large volume data transmission at a lower cost than today.
- **Security** – The security will be an essential part of 4G network architecture. The Internet Everywhere Experience will allow the mobile subscriber to access a whole host of Internet related services, but the flexibility comes with the risk associated with Internet connectivity. Next generation solutions must have a carefully thought out security approach that protects both the network and the subscriber.

3.0 REQUIREMENTS FOR 4G SYSTEMS

3.1 Broadband wireless access

The traffic carried by mobile communication systems until today was mainly for voice communications. The 2G mobile system, the Personal Digital Cellular system, introduced the i-mode services, which enabled the Internet access, electronic commerce and e-mail from mobile terminals, and mainly used for the text-based data communications. The International Mobile Telecommunications-2000 (IMT-2000) system offers high bit rate transmission service from 64 kbit/s to 384 kbit/s, and it is expected that the proportion of the amount of data traffic to the voice traffic would continue to increase. Moreover, the rising popularity of broadband services such as Asymmetric Digital Subscriber Line (ADSL) and optical fibre access systems and office or home LANs is likely to lead to a demand for comparable services in the mobile communication environment.

3.2 Low cost

To make broadband services available to the user to exchange various kinds of information, it is necessary to lower charges dramatically in order to keep the cost at or below the cost of existing service. The IMT-2000 system aimed at lower bit cost and economical charge rates, however for the 4G system, a broadband channel and an even lower bit cost are both required.

3.3 Wide area coverage

One feature of mobile communications is that it is available for use at anytime and anywhere. That advantage is important for future mobile communication as well. In particular, it is important to maintain the service area in which the terminals of the new system can be used during the transition from the existing system to a new system. It can be assumed that terminals that have relatively large display screens, such as PDAs or personal computers are used indoors rather than outdoors. Accordingly, better coverage of indoor service areas is needed.

3.4 Capable for Wide Variety of Services

Mobile communication is for various types of users. In the future, we expect to make the advanced system performance and functionality to introduce a variety of services not only the ordinary telephone service but to transfer information about the five sensual modes. Those services must be made easier for anyone to use.

4. KEY 4G TECHNOLOGIES

Some of the key technologies required for 4G are briefly described below:

4.1 OFDMA

Orthogonal Frequency Division Multiplexing (OFDM) not only provides clear advantages for physical layer performance, but also a framework for improving layer 2 performance by proposing an additional degree of freedom. Using ODFM, it is possible to exploit the time domain, the space domain, the frequency domain and even the code domain to optimize radio channel usage. It ensures very robust transmission in multi-path environments with reduced receiver complexity.

In ODFM the signal is split into orthogonal sub-carriers, on each of which the signal is "narrowband" (a few kHz) and therefore immune to multi-path effects, provided a guard interval is inserted between each OFDM symbol. OFDM also provides a frequency diversity gain, improving the physical layer performance. It is also compatible with other enhancement technologies, such as smart antennas and MIMO. OFDM modulation can also be employed as a multiple access technology (Orthogonal Frequency Division Multiple Access; OFDMA). In this case, each OFDM symbol can transmit information to/from several users using a different set of sub-carriers (sub-channels). This not only provides additional flexibility for resource allocation (increasing the capacity), but also enables cross-layer optimization of radio link usage.

4.2 Multiple-input Multiple-output

MIMO uses signal multiplexing between multiple transmitting antennas (space multiplex) and time or frequency. It is well suited to OFDM, as it is possible to process independent time symbols as soon as the OFDM waveform is correctly designed for the channel. This aspect of OFDM greatly simplifies processing. The signal transmitted by m antennas is received by n antennas. Processing of the received signals may deliver several performance improvements: range, quality of received signal and spectrum efficiency. In principle, MIMO is more efficient when many multiple path signals are received. The performance in cellular deployments is still subject to research and simulations. However, it is generally admitted that the gain in spectrum efficiency is directly related to the minimum number of antennas in the link.

4.3 Handover and Mobility

Handover technologies based on mobile IP technology have been considered for data and voice. Mobile IP techniques are slow but can be accelerated with classical methods (hierarchical, fast mobile IP). These methods are applicable to data and probably also voice. In single-frequency networks, it is necessary to reconsider the handover methods. Several techniques can be used when the carrier to interference ratio is negative, but the drawback of these techniques is capacity. In OFDM, the same alternative exists as in CDMA, which is to use macro-diversity. In the case of OFDM, MIMO allows macro-diversity processing with performance gains. However, the implementation of macro-diversity implies that MIMO processing is centralized and transmissions are synchronous. This is not as complex as in CDMA, but such a technique should only be used in situations where spectrum is very scarce.

4.4 Software defined radio

Software Defined Radio (SDR) benefits from today's high processing power to develop multi-band, multi-standard base stations and terminals. Although in future the terminals will adapt the air interface to the available radio access technology, at present this is done by the infrastructure. Several infrastructure gains are expected from SDR. For example, to increase network capacity at a specific time (e.g. during an election result announcement), an operator will reconfigure its network adding several modems at a given Base Transceiver Station (BTS). SDR makes this reconfiguration easy.

In the context of 4G systems, SDR will become an enabler for the aggregation of multi-standard pico/micro cells. For a manufacturer, this can be a powerful aid to provide multi-standard, multi-band equipment with reduced development effort and costs through simultaneous multi-channel processing.

4.5 Caching and Pico Cells

Memory in the network and terminals facilitates service delivery. In cellular systems, this extends the capabilities of the MAC scheduler, as it facilitates the delivery of real-time services. Resources can be assigned to data only when the radio conditions are favourable. This method can double the capacity of a classical cellular system.

In pico cellular coverage, high data rate (non-real-time) services can be delivered even when reception/transmission is interrupted for a few seconds. Consequently, the coverage zone within which data can be received / transmitted can be designed with no constraints other than limiting interference. Data delivery is preferred in places where the bit rate is a maximum. Between these areas, the coverage is not used most of the time, creating an apparent discontinuity. In these areas, content is sent to the terminal cache at the high data rate and read at the service rate. Coverage's are "discontinuous". The advantage of coverage, especially when designed with caching technology, is high spectrum efficiency, high scalability. A simple, robust and reliable protocol is used between the terminal and the cache for every service delivered in this type of coverage.

4.6 coverage

Coverage is achieved by adding new technologies (possibly in overlay mode) and progressively enhancing density. Take a WiMAX deployment, for example: first the parent coverage is deployed; it is then made denser by adding discontinuous pico cells, after which the pico cell is made denser but still discontinuously. Finally the pico cell coverage is made continuous either by using MIMO or by deploying another pico cell coverage in a different frequency band. Parent coverage performance may vary from 1 to 20 bit/s/Hz/km, while pico cell technology can achieve from 100 to 500 bit/s/Hz/km, depending on the complexity of the terminal hardware and software. These performances only refer to outdoor coverage; not all the issues associated with indoor coverage have yet been resolved. However, indoor coverage can be obtained by:

- ***Direct penetration*****;** this is only possible in low frequency bands (significantly below 1 GHz) and requires an excess of power, which may raise significant interference issues.
- ***Indoor short range radio*** connected to the fixed network.
- ***Connection via a relay*** to a pico cellular access point.

5.0 CONCLUSION

Estimation on increasing users' expectations and growing demand for mobile services around the year 2010 requires another new mobile network system, 4G, with improved capability than 3G or IMT-2000 which is believed not sufficient to cope up with users demand around 2010. This surge of interest in the 4G networks systems that are expected to be launched within the next five years is due to the fundamental change that such network will present in the re-shaping the current mobile communication systems and also with the third generation the goal will be changed from voice-centric to data-centric. Moreover total mobility became an objective to pursuit. In this generation it is possible to combine voice, multimedia applications and mobility in a never experienced manner.

The 4G infrastructure operator will mix several technologies, each of which has its optimal usage. In this environment, roaming is seamless and users are always connected to the best network. It tries to overcome the problem global mobility and more bandwidth with lower cost. It can be done by integrating all different wireless technologies. With the plethora of promising features 4G is truly moving towards getting universally accepted as the ideal next generation communication system. 4G is visualized as a conglomeration of different heterogeneous access technologies.

In spite of all the evolving technologies the final success of new mobile generations will be dictated by the new services and contents made available to users. These new applications must meet user expectations, and give added value over existing offers.

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