Key Technologies for the Next Generation Wireless Communications

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ABSTRACT
The principal objectives of next generation wireless communication are the delivery of higher data rate services including video, audio, data and voice signals with worldwide compatibility. The promise of new radio spectrum encouraged the world's mobile tele-communication operators to pay very high prices for 3G licenses. Most 3G systems is arranged to operate in 2GHz frequency band. The 4G represents the next development stages of cellular evolution beyond 3G, and offers an ideal basis and bandwidth to provide more efficient cellular multicast services. At present, 4G exists only in the conceptual framework to discuss and address future high-speed network and handset requirements. In this context, we address the following important topics such as key technologies of wireless communication system, main standardization trends of next generation and major implementation issues for wireless SOC.

Categories and Subject Descriptors
A.1 [Introductory and survey]

General Terms
Design, Standardization

Keywords
DMB, WiMAX, 4G, OFDM, LTE, SDR, Smart Antenna, MEMS
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1. INTRODUCTION
The mobile handset is considered as an information hub including not limited to audio, game, LBS, commerce, TV, imaging, storage, computing. The most important trends of the telecommunication network area seem to be wireless data prevalence, broadcasting-communication merger and device convergence.

With plentiful research efforts, the area of mobile communication has being developed very rapidly. Recently, telecommunications industry has watched significant growth in sales of products. The average increment of sales growth in telecommunications industry during the period of 2000-2004 turns out to be 51%. The fact encourages us to develop technologies and make products in order to prepare the future. There are many standard bodies in next communication's area and they are not only co-working but also competing each other. There are also lots of technical issues that have to be taken into account. We categorize this paper into three sections for addressing for the next generation wireless communication systems. The first is key technologies, the second is standardization trends and the last one is implementation issues. Since these topics are closely connected, this categorization helps us to understand for the future wireless mobile communications.

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2. KEY TECHNOLOGIES OF WIRELESS COMMUNICATION SYSTEM
The new technologies of wireless communications are developed and revised very fast in present. The wireless communication standardization committees (3GPP, 3GPP2, IEEE-SA) are the central bodies that are pursuing the evolution. To be successful in this competing environment, one must not simply follow the evolution but create it. There are severe competitions among telecommunication manufacturers and service providers. Now, here is next generation communication system, which is leading advanced technologies and services. We are familiar to see from mass media such as 4G, Mobile WiMAX, LTE, etc. As we commented earlier, they are striving to be the winner while cooperating for the synergy.

Let us consider what the trends are for the next generations;

- Support for advanced and wideband multimedia services
- Extended coverage area, enhanced system capacity
- High data rate, over 100 Mbps in some cases
- High speed, low delay
- Software defined radio (SDR)
- Seamless mobility and internetworking in hybrid networks.
- Digital Convergence of the Telecommunication and Multimedia Broadcasting
- All-IP system such as Mobile IPTV

We can also think the key technologies of advanced communication methods are as following;

- Orthogonal Frequency Division Multiplexing (OFDM)
- Advanced channel coding techniques (Turbo codes, LDPC codes)
- Multi-antenna signal processing (MAS)
- Multiple-Input, Multiple-output (MIMO)

- Smart antennas
- Space-time coding
- Ad-hoc operation

3. MAIN STANDARDIZATION TRENDS OF NEXT GENERATION

The main concepts with summaries for the major standardization trends and Samsung's activities of next generation wireless communication are presented in this section. The major activities are WiMAX, LTE and Mobile DTV.

WiMAX

WiMAX is an acronym for Worldwide Interoperability for Microwave Access and is specified in the IEEE 802.16 standard. While WiMAX originates in the Wi-Fi standard for wireless local area networks (WLAN), it allows for higher data rates, more scalability, broader coverage and lower latency than Wi-Fi. Another important difference from the Wi-Fi is that WiMAX defines a special MAC layer with support for multiple physical layer (PHY) specifications. This allows the standard to adaptively evolve to various end-user requirements, which has made WiMAX known as "a framework for the evolution of wireless broadband". The IEEE 802.16 standard utilizes a technique known as OFDM-256. However, in IEEE 802.16e, another technique known as Scalable OFDMA (SOFDMA) is likely to be used instead. This standard provides some significant improvements over the previous one - improving non-line-of-sight (NLOS) coverage by utilizing advanced antenna diversity schemes, and Hybrid-Automatic Retransmission Request (H-ARQ), introducing high-performance coding techniques such as Turbo Coding and Low-Density Parity Check (LDPC), enhancing security and NLOS performance, increasing system gain by use of denser sub-channelization, thereby improving indoor penetration, introducing downlink sub-channelization, allowing administrators to trade coverage for capacity or vice versa, enhanced Fast Fourier Transform (FFT) algorithm can tolerate larger delay spreads, increasing resistance to multi-path interference

Samsung unleashed the power of Wireless Broadband (WiBro), which offers true mobility, high performance, wide-area services and global standardization for wireless broadband applications. Mobile WiMAX enables broadband internet access on a vehicle traveling at 120km/h.

WiBro base stations will offer an aggregate data throughput of 30 to 50 Mbps and cover a radius of up to 5km allowing for the use of portable internet usage within the range of a base station. From testing during the APEC Summit in Pusan in late 2005, the actual range and bandwidth were quite a bit lower than these numbers. The technology will also offer QoS(Quality of Service). The inclusion of QoS allows for WiBro to stream video content and other loss-sensitive data in a reliable manner. It is the second internet revolution that the fixed high speed network with ADSL is moving toward wireless high speed internet. The leading global commercialization after World First introduction in Korea is as follows

- '03.01 WiBro project began
- '04.12 First Trial Product
- '05.08 4G Forum Demonstration
- '05.11 APEG Demonstration
- '05.12 Standard Approval of IEEE802.16e
- '06.02 Torino Olympic Demonstration
- '06.04 Trial Service
- '06.06 Commercialization

Samsung also demonstrated the benefits of mobile WiMAX technology with terminals and systems. It leads the industry by evolving mobile phones into multifunctional devices that deliver multi services and entertainment.

LTE

The Long Term Evolution is marked by visions of what the future wireless networks should evolve. The 3GPP Long Term vision will gradually come into focus through a careful study of market trends, understanding of future user requirements and the availability of new network and wireless access technologies. In long term, the performance improvements (spectral efficiency, higher bit rates, shorter delays) of 3GPP radio access should be continued. Long term target peak data rates are up to 100 Mbps in full mobility, wide area deployments, or, up to 1 Gbps in low mobility, local area deployments. Reaching the peak data rate targets may take place by gradual evolution of existing 3GPP (UTRAN) and alternate access means (e.g. WLAN), but also new access techniques should be considered according to the availability of additional or re-allocated spectrum, as defined by WRC.

Mobile DTV

Several standards are competing for the mobile DTV, that are, DVB, ISDB, DMB and MediaFLO.

DVB (Digital Video Broadcasting) uses multiple-carrier modulation system. Consequently, it can more easily resolve any transmission problems, return-path functions or mobile reception. DVB is a set of internationally accepted, open standards for digital television protocols maintained and devised by the Digital Video Broadcasting Project. There are four core standards of DVB: DVB-S (Satellite television and satellite Internet), DVB-C (Cable), DVB-T (Terrestrial) and DVB-H (Handheld).

ISDB (Integrated Services Digital Broadcasting) is the Japanese standard for digital television. The concept was named for its similarity to ISDN, both allow multiple channels of data to be transmitted together. ISDB-T operates on unused TV channels. The core standards of ISDB are ISDB-S (satellite television), ISDB-T (terrestrial) and ISDB-C (cable).

DMB (Digital Multi media Broadcasting) system requires some modifications to the DAB. Thus it allows to leverage on its widely installed and established network infrastructure. Currently, the main DMB market is in South Korea.

MediaFLO is an OFDM-based air interface designed specifically for multicasting. It allows mobile operators to provide live streaming video channels, in addition to supporting 50-100 national local contents channels. It requires only two or three broadcast towers per metropolitan area, which is 30-50 times fewer than that required by cellular network systems. The FLO technology might be cost effective for mobile multimedia content distribution than competing broadcast technologies such as DVB-H.

Market forecasts show that market demand of mobile TV handset

sales will increase from 5.8 million units in 2006 to 185 million units in 2010. In 2010, the market shares of DVB-H, T-DMB, ISDB-T, MediaFLO are predicted as 41%, 27%, 16% and 9%, respectively.

The domestic service status in Korea is that mobile TV is becoming a commodity application for phones. DMB phone will account for 30% of total handheld phone sales in 2006. Currently, one million people are enjoying DMB on March 2006. The commercial service of S-DMB begins on May 2005 with nation-wide coverage over 84 cities. It includes 13 video and 26 audio channels. T-DMB is commercially started on Dec. 2005 in the metropolitan area. It provides 7 video, 13 audio and 4 data channels.

Samsung mobile TV is the world first on S-DMB (May '05) and T-DMB (Dec. '05). 11 unique mobile TV phones (9 for S-DMB, 2 for T-DMB) are already launched. It occupies more than 70% of market share in current. Samsung recently unveiled SPH-B4100, dual-DMB phone which supports both T-DMB and S-DMB service and become the world first to develop such phone. It would create a significant impact on rapidly emerging DMB phone market. Dual DMB phone features swiveling design and PIP that enables users to watch T/S-DMB channels simultaneously.

Samsung is initiating and developing mobile TV market with innovative design, unique functions, accumulated know-how and retaining technologies. It offers stylish and innovative designs that best suit user experiences in both mobile TV and communication and differentiating from competitor model by offering unique mobile TV functions. There are landscape view, scissor type, swivel type and normal type designs for mobile TV. It is easy to access any channel on any contexts by electronic SVC guide such as normal guide, idle screen and TV screen in the form of a ticker. It is adopting relevant multimedia features such as PIP (Picture In Picture), recording, video output and PMP functions. Samsung is retaining all core technologies to develop the optimal mobile TV through the vertical integration and save the development time and accumulated experience and know-how from domestic market and leveraged it for the first to overseas mobile TV markets.

For overseas market, Samsung provides SGH-P900 as Europe's first T-DMB phone to support T-DMB, which allows anyone to view live TV which will be a boon during the FIFA2006.

4. MAJOR IMPLEMENTATION ISSUES FOR WIRELESS COMMUNICATION SYSTEM

In sections 2 & 3, we reviewed key technologies and standardizations that are now considered as "state of art" of next generation. We also ought to be well informed about main trends of mobile implementation since we need to make products from the technologies and standardization for the customers.

It is objective of all handset manufacturers to minimize the production cost of a device. Not only does this make their device more profitable, but it also makes it more attractive to both operators and end users. However, it is important to note that with increased complexity in devices, and the desire for added functionality and features, comes an increased Bill of Materials (BOM). The challenge is to find the balance between device cost, performance, form-factor and style depending on the target market.

Low Power

The outstanding problem with current mobile handset is the battery drain on the device. Resolving this problem is becoming more important for operators as users will not be able to make calls or send mail once the battery reaches a certain low level. Battery life is also a problem with 3G-based systems that provide full video, sound and the 3G connection. Improvement in components such as displays, CPUs and memory, combined with better power management and smarter software that can manage power consumption according to user needs, will be fundamental for prolonging battery life. On the other hand, new power sources such as fuel cell, Lithium polymer, solar chargers or disposable batteries also have the potential to challenge existing technologies by improving battery capacity and reducing its size and weight.

The recent researchers announce that the technology will enable mobile phone batteries to last 10 times longer with a single recharge, thereby extending their standby time to a maximum of about 30days from the current two to three days. The technological breakthrough concerns that a CMOS transistor used in mobile phones and other small terminals for current control. The companies have managed to cut its power consumption to one-tenth, by reducing the linewidth of transistor circuits and cutting the thickness of the insulating film to 10 nanometers from 100nm.

Further, Effective dynamic power reduction technologies are as follows:

- Clock gating (20%-40% dynamic power reduction)
- Dynamic/Adaptive Voltage Scaling (20% - 50% dynamic power reduction)
- Variable Threshold CMOS(VTCMOS)
- Combinations of Adaptive Voltage Scaling and VTCMOS

SDR

The Software-Defined Radio (SDR) Forum defines SDR as "radios that provide software control of a variety of modulation techniques, wide-band or narrow-band operation, communications security functions (such as hopping), and waveform requirements of current and evolving standards over a broad frequency range."

Rather than relying on hardware-based analog radio solutions, SDR systems uses software executed on a general purpose computer to perform the modulation and demodulation of radio signals. These systems are highly reconfigurable and programmable and it is for instance possible to reconfigure the antenna, the radio transceiver and the base band. What further distinguishes this technique from traditional radio is that most important operation can perform reconfiguration of network connections and services "on-the-fly."

MEMS (Micro Electro Mechanical System)

MEMS stands for Micro Electro-Mechanical System and is made to perform specific functions by electromechanical, electrochemical means. MEMS is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through micro fabrication technology. A MEMS consists of components with a size range between a micrometer and a millimeter. Recently, the researchers are playing a key role in the drive to make electronic gadgets smaller, smarter and even more powerful. They are designing a new generation of nano-electronic circuits or chips that will power the computers and mobile phones of the future. The

circuits may also make possible entirely new forms of electronic device that could benefit a range of sectors, including entertainment, communications and medicine.

5. CONCLUSIONS

Underpinning its mobile convergence strategy, Samsung releases a suite of feature-rich mobile handsets packed with multimedia functions such as gaming, music and video recording and playback, mobile printing, and HDD storage.

In 4G network environment, the network is all-IP based and the special features are going to be ubiquity, high capacity from 100Mbps for mobile to 1Gbps for nomadic, wide coverage, and core technologies such as OFDM, LDPC, MIMO, Smart Antenna and SDR.

Technologies for beyond 3G can be approached either by evolution-based or revolution-based visions. As 3G technology is becoming more and more stable, the time has come to explore and seek out ways to establish common visions for the next generation to come. Samsung aims to stimulate interest and promote the development of 4G standards, business opportunities and research. Samsung will provide industry, academia, standardization bodies and service providers a unique opportunity for both promoting their own visions, as well as acquiring a balanced view on 4G technology strategy and prospects on a global level.

The remarkable features of next generation wireless communication may be represented as ubiquitous, broadband and digital convergence. Especially, we have better pay our attention to the digital convergence, which is now energetically making its progress in the form of converging communication and broadcasting. In the near future, two paths may exist for 4G technologies. One path is 4G may come from evolution of 3GPP/3GPP2, and the other path is 4G may come from revolution of IEEE802.16e (Mobile WiMAX). Or the combination of these two paths is also possible.

In the implementation of next generation wireless communication systems we must pay more attention for low power technology, form factor, low cost, and MEMS technology.

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