DOCOMO Today

Growth and Mission of Mobile Communication



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The LTE "Xi" (Crossy) service, launched in December 2012, has amassed over 11 million subscribers by the end of March 2013. When NTT DOCOMO's commercial service using Personal Digital Cellular (PDC), the first digital mobile phone system, was introduced in 1993, the maximum data transmission rate was 9.6 kbps. A transmission rate of 112.5 Mbps (using a 15 MHz bandwidth) is now being offered. This means the transmission rate has increased a dramatic 10,000 fold over the past twenty years. The total amount of traffic being carried on mobile networks is still growing ever vaster.

I remember that in past, when we studied methods to increase the speed of radio transmission, we frequently had debates on "What kinds of applications will use such high-speed transmission, and are they necessary?" I remember that each time, we proceeded under the mindset that if we achieved lowering costs by increasing speed (and thus also increasing capacity), allowing high-speed services to be provided, then applications will come about as a result. Needless to say, high-speed transmission is being used today, and its demand is rising as video contents and terminals equipped with high-resolution digital cameras and with bigger displays proliferate. Furthermore, the quality of user experience, such as "user throughput" and "a sense of smoothness," has now become a critical factor in raising the competitiveness of mobile networks. High-speed systems are being demanded to support this trend. Of course, in the past two to three years, the explosion in the use of smartphones has magnified the demand for greater speed.

Looking at how the speed of radio transmission has increased, we find a variety of basic technologies that have made this possible, such spread spectrum $_{1}^{*1}$, W-CDMA and Orthogonal Frequency Division Multiplexing (OFDM)². These are methods in terms of principles and systems that have been traditionally proposed. In recent years, advanced signal processing to the extent unattainable in the past, using

technologies such as LSI, Field Programmable Gate Arrays (FPGA)^{*3} and Digital Signal Processors (DSP)^{*4}, and owing to dramatic improvements in chips' computational power and increased memory capacity, has also made improvements in radio transmission speed possible. W-CDMA and OFDM have long represented systems that made high-speed radio transmission possible. In addition, Multi Input Multi Output (MIMO)^{*5} and interference cancellers^{*6}, which are in practical use these days, are also similar to these traditional technologies.

To further expand capacity, increase speed, and improve user experience, we have been working on developments for LTE-Advanced¹. LTE-Advanced has a framework in which higher speed is achieved by using a combination of functions selected from multiple standardized functions. At NTT DOCOMO, we are working to realize Carrier Aggregation (CA), which bundles multiple frequency bands to increase speed, and to achieve greater efficiency and capacity by effectively adding small cells and superimposing them on macro cells. We have proposed and are applying our advanced Centralized-RAN (C-RAN) architecture to increase speed and capacity without increasing control signals between core networks due to the terminal mobility. Under this C-RAN architecture, numerous small remote radio heads extend from high-density Baseband Digital Equipment (BDE)^{**} with optical fibers. We are building a high-performance system by combining the features of each of these technologies and exploiting them to the fullest extent possible. For this, it is important to use engineering ingenuity to create a system that can achieve high efficiency. Using this system as the source of NTT DOCOMO systems' competitiveness will become critical going forward.

In NTT DOCOMO's statement of its corporate philosophy, the company's "dream" and "mission" are keywords. NTT DOCOMO's "dream" means realizing more convenient and richer lifestyles (smart life). NTT DOCOMO's "mission" means guaranteeing communication that connects persons to persons as part of the public infrastructure. For an infrastructure that utilizes mobile radio technologies, our mission is precisely to satisfy the demands of our customers for safety and security and maintain high reliability, while increasing speed and capacity. We are striving to satisfy our customers and create competitive systems with speed and a spirit of challenge in R&D so that we can achieve major progress in mobile communication services in the future, both in terms of realizing NTT DOCOMO's "dream" and accomplishing the company's "mission."

- *1 **Spread spectrum**: Techniques to increase resistance to noise and interference by broadly spreading the bandwidth of the signals after modulation.
- *2 **OFDM**: Enables signal transmission with high spectrum efficiency by converting a signal with a high data rate to multiple low-speed narrow-band signals and transmitting those signals in parallel along the frequency axis.
- *3 **FPGA**: LSI whose logic can be freely designed.
- *4 **DSP**: A general term for a microprocessor that is specialized for processing digital signals.
- *5 MIMO: A signal transmission technology that uses multiple antennas at both the transmitter and receiver to perform spatial multiplexing and improve communication quality and spectral efficiency.
- *6 Interference canceller: Technology that seeks to decrease cross-correlated signals and increase the capacity of the system.
- *7 LTE-Advanced: The enhanced LTE radio interface that has been standardized as 3GPP Release 10.
- *8 BDE: Digital signal processing equipment of base stations in the LTE system, which comprises baseband signal processors as well as operations, administration and maintenance functions.