LTE | High Speed · Large Capacity · Low Delay | SAE

Technology Reports

Special Articles on "Xi" (Crossy) LTE Service—Toward Smart Innovation—

LTE System and Services as Social Platform for Enriching People's Lives

*Launched by NTT DOCOMO in December 2010 in Tokyo, Nagoya, and Osaka region, "Xi" (Crossy)[*1] is a high-speed, large-capacity and low-delay mobile communications service based on the LTE standard. Telecommunication services based on LTE were first launched in Europe and then in the United States, and many telecommunication operators are planning to support LTE services. Beginning with data communication services, NTT DOCOMO is commercializing LTE toward a smooth 4G rollout while maintaining continuity with existing 3G areas.*

Radio Access Network Development Department — *Masumi Kitagawa*
Core Network Development Department — *Hiroyuki Oto*
Communication Device Development Department — *Toshiyuki Futakata*
Product Department — *Kazuya Anzawa*

1. Introduction

The increasing functionality of mobile terminals and networks and the increasing popularity of flat-rate billing plans are driving the development of sophisticated services and rich content. Indeed, the rapid spread of smartphones has raised expectations for new services and applications, but at the same time, the trend toward higher levels of data traffic including video is expected to continue into the future (**Figure 1**). Finding ways of coping with this jump in data traffic is an issue common to mobile communications operators.

In November 2004, NTT DOCOMO promoted the concept of Super3G to maintain its long-term competitiveness in 3G technology toward faster transmission speeds, shorter delays, and accommodation of growing traffic levels, and to enhance the user experience and drive new services while enabling a

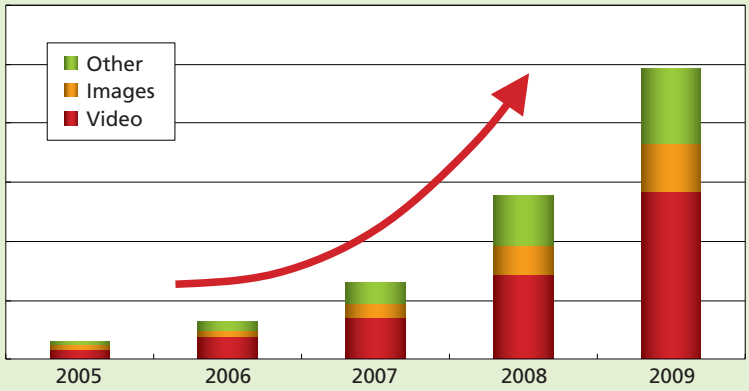

Figure 1 Growth in data traffic

*1 **"Xi" (Crossy)**: "Xi" (read "Crossy") and its logo are trademarks of NTT DOCOMO.

smooth transition to future 4G networks (**Figure 2**). Then, in March 2009, NTT DOCOMO contributed to the formulation of the LTE standard as 3GPP Release 8 based on the Super3G concept, and after its approval, the company moved to commercialize LTE to keep pace with worldwide LTE trends in unison with other leading companies.

This article overviews NTT DOCOMO's LTE-based "Xi" (Crossy) system and services launched in Tokyo, Nagoya and Osaka in December 2010, and compares its technical features with the 3G system. The reader is asked to see the other articles in this collection of Special Articles for detailed information on the makeup the "Xi" (Crossy) system including its radio system and core-network technology, base stations and core-network equipment, and mobile terminals and platform technology.

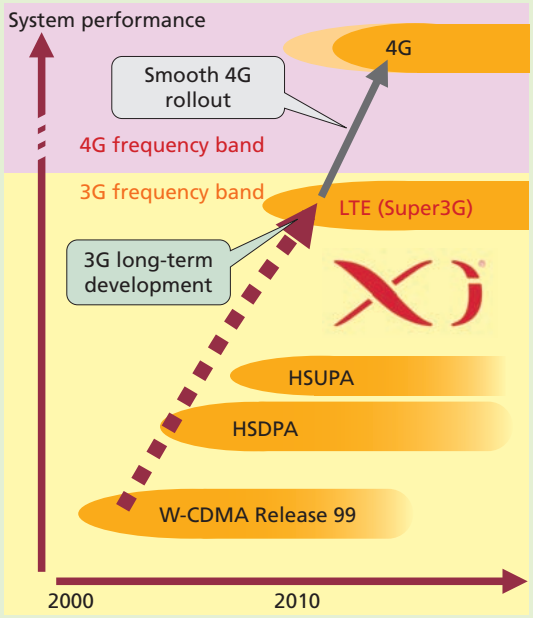

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Figure 2 LTE deployment scenario

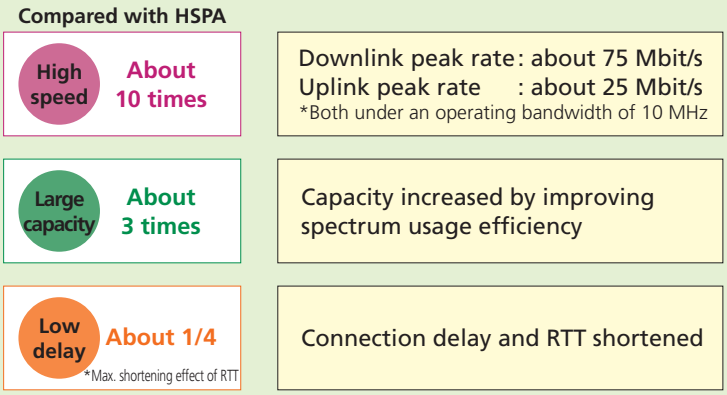

Figure 3 LTE technical features

2. Technical Features

The LTE standard has the following three technical features represented by the phrases "high speed," "large capacity," and "low delay" (**Figure 3**).

The first technical feature is a major increase in uplink and downlink peak rates. At the launch of the "Xi" (Crossy) service, NTT DOCOMO provided mobile terminals of UE category[*2] 3 achieving a downlink peak rate of about 75 Mbit/s at some indoor stations under an operating bandwidth of 10 MHz and about 37.5 Mbit/s under an operating bandwidth of 5 MHz in all other areas (**Figure 4**). These mobile terminals also achieve an uplink peak rate of about 25 Mbit/s at some indoor stations under an operating bandwidth of 10 MHz and about 12.5 Mbit/s under an operating bandwidth of 5 MHz in all other areas.

The second technical feature is greater capacity achieved by using a more advanced radio system that increases spectrum usage efficiency by about three times that of High Speed Packet Access (HSPA)[*3]. The idea here is to achieve a facility-investment reduction effect for accommodating

*2 **UE category**: Performance level of mobile terminal specified by the associated standard. LTE terminals are divided into five categories, each of which specifies peak rates for different bandwidths.

*3 **HSPA**: A specification for increasing packet-data rates in W-CDMA, and a general term encompassing High Speed Downlink Packet Access (HSDPA), which increases the speed from the base station to the mobile terminal, and High Speed Uplink Packet Access (HSUPA), which increases speed from the terminal to the base station.

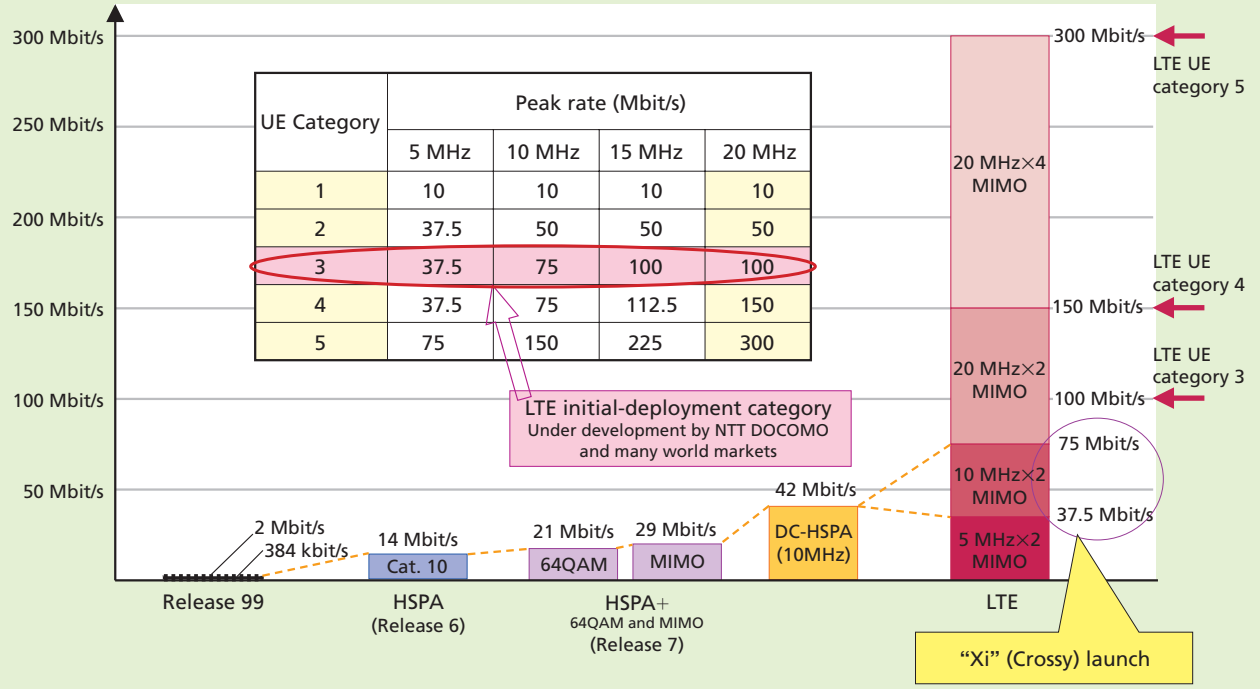

Figure 4 Change in downlink peak rate

ever increasing amounts of data traffic through a synergetic effect between greater capacity and the reduced cost of equipment

Finally, the third technical feature is a significantly shorter time delay achieved by redesigning the radio system, control sequence, and network configuration. This shorter delay effects a shorter connection delay from the mobile terminal's standby Idle state to its Active state establishing a radio link with the network, and a shorter Round Trip Time (RTT) for user data transmitted from a mobile terminal to the target server and back again. This shorter time delay is expected to improve application response and throughput[*4] dependent on communication conditions and to simplify mobile terminal and network interfacing. In short, a shorter time delay is expected to be used as a foundation for new solutions.

3. Deployment Scenario

An example of an LTE deployment scenario is shown in **Figure 5**. The mobile terminals slated to be used at the launch of "Xi" (Crossy) will be dual terminals having both LTE and W-CDMA capabilities. In this scenario, the LTE technical features described above will be provided within LTE areas and seamless switching to 3G (HSPA) will be performed in all other areas. This scheme provides thorough coverage of the 3G network simultaneously with LTE.

The LTE system is specifically for Packet Switching (PS) and does not support Circuit Switching (CS). Thus, the stage at first is to switch to 3G to provide voice and other CS services provided only by 3G.

Based on the above conditions, the scenario envisioned by NTT DOCOMO is to first provide 3G and LTE services by overlaying the LTE system on the 3G (HSPA) system and to then have the 3G system migrate to LTE and even 4G over time.

4. System Overview

System configuration is shown in **Figure 6**. Based on the current 3G network, this system features a new switching station (Evolved Packet Core

*4 **Throughput**: Effective amount of data transmitted without error per unit time.

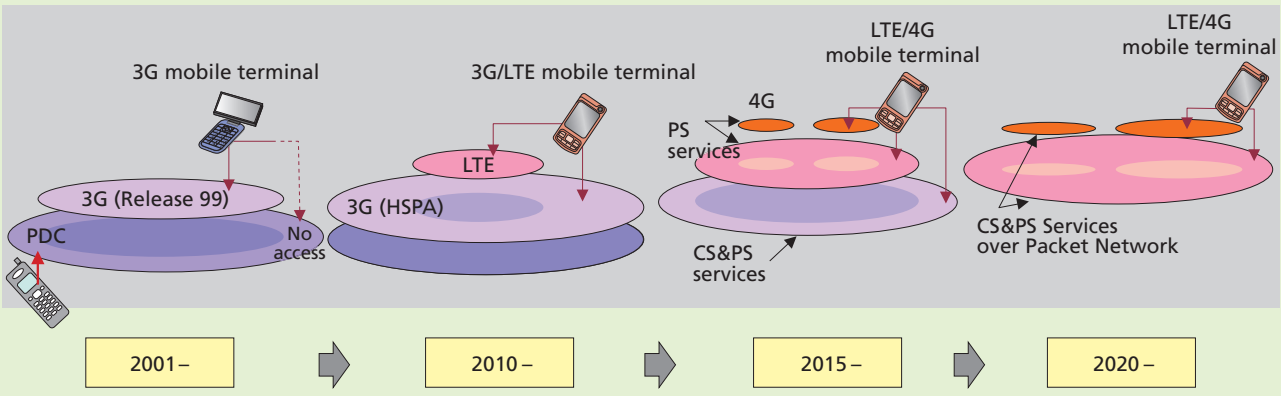

Figure 5 Example of an LTE deployment scenario

(EPC)) for the core network and a new radio base station (evolved Node B (eNodeB)) for the radio access network. The functions of the 3G radio control station (Radio Network Controller (RNC)) have been allocated to EPC and eNodeB and RNC as a node has been eliminated making for a flatter and simpler configuration. At the same time, the system adopts Internet Protocol (IP) as a packet relay protocol to enable the network to be configured with general-purpose equipment at lower cost while increasing affinity with packet traffic. Plus, to make effective use of existing facilities, eNodeB has been designed so that it can be installed with existing 3G Base Transceiver Stations (BTSs) enabling BTS sites, antennas, and radio facilities to be shared.

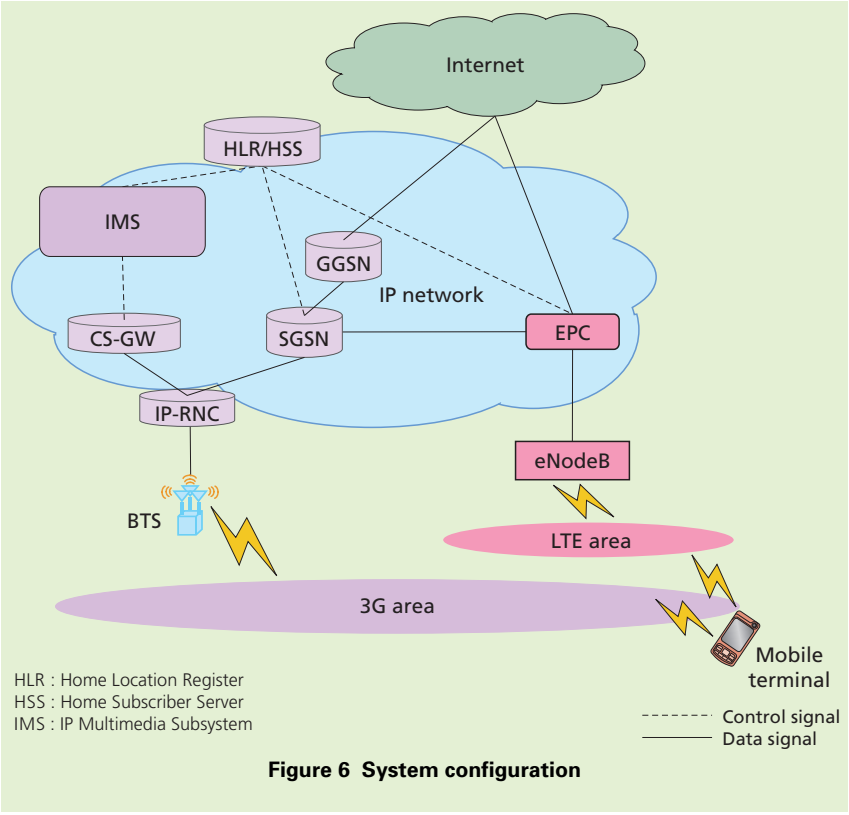

Figure 6 System configuration

For 3G mobile terminals, the connection route within the core network runs from the Serving General Packet Radio Service (GPRS) Support Node (SGSN), which is the existing switching station for subscriber-grade packet communications in 3G, to the Gateway GPRS Support Node (GGSN), which provides a gateway to connection points leading to server groups. Meanwhile, for 3G/LTE dual terminals, the connection route to server groups runs from the Serving Gateway (S-GW), which consists of subscriber-grade gateway equipment including the LTE EPC switching station, to the Packet Data Network (PDN) Gateway (P-GW). When communicating in the 3G area, a

3G/LTE dual terminal connects via the P-GW from the SGSN.

5. Overview of Provided Services and Terminals

"Xi" (Crossy) services will be initially provided by specialized data terminals. Data communication services will consist of Internet connections through mopera the same as FOMA and data communications provided by telecommunication operators via Mobile Virtual Network Operators (MVNOs).

The data-terminal lineup will initially consist of a USB type of terminal (L-02C) and an express-card-type (F-06C). Either terminal will support both LTE and W-CDMA and will automatically switch to the 3G system when outside LTE areas. Even 2G (GPRS) will be supported when roaming enabling a broad range of use.

6. Main Functions

6.1 Handover

The LTE handover is broadly divided into a backward handover (PS handover) and forward handover. In the former, the network performs cell switching and notifies the mobile terminal of the destination cell, and in the latter, the mobile terminal performs autonomous switching to pick up the destination cell.

To control packet loss due to a momentary cutoff at the time of radio switching, PS handover supports a data forwarding process that transfers undelivered data from the switching-source eNodeB to the switching-destination eNodeB and a reordering process that corrects sequencing mistakes between forwarded data and new data.

The forward handover can be classified into Release with Redirection triggered by a cutoff signal from the network and Non Access Stratum (NAS)[*5] Recovery in which the mobile terminal autonomously performs a NAS recovery, either of which is accompanied by data loss due to a momentary cutoff.

From a different perspective, handover can be classified in the following two ways according to whether it is accompanied by Radio Access Technology (RAT) or frequency switching or by eNodeB or EPC switching (**Figure 7**).

1) Intra-RAT handover

This is a handover that occurs within the LTE system in which node transition occurs between sectors within an eNodeB, between eNodeBs within an EPC switch, or between EPC switches.

A handover between eNodeBs within an EPC switch may be an X2 or S1 handover. In an X2 handover, signal processing is performed by the X2 logical interface between eNodeBs, while in an S1 handover, signal processing is performed by the S1 logical interface between an eNodeB and the EPC switch. There is a tradeoff between the cost of maintaining an X2 link and the cost incurred by an S1 handover, and operations are configured accordingly.

Handover can also be classified by whether the center frequency is the same before and after handover, that is, whether the handover occurs within the same frequency or between frequencies.

2) Inter-RAT handover

This is a handover that occurs between RATs either as a transition

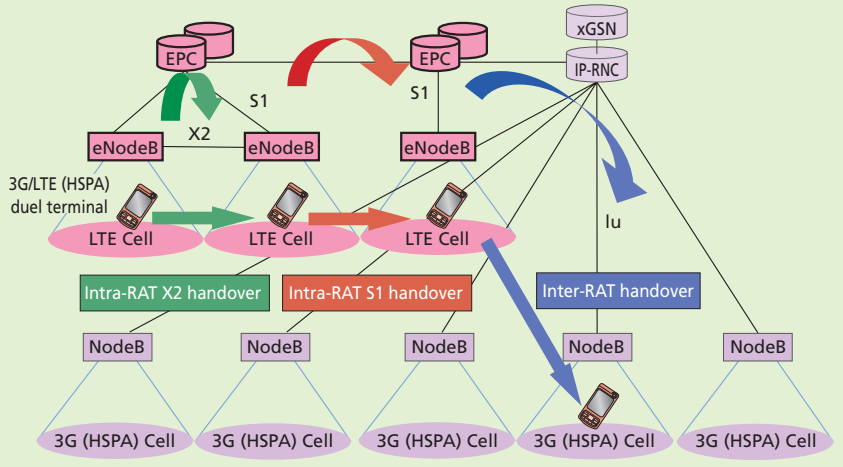

Figure 7 Overview of handover function

*5 **NAS**: The functional layer between the mobile terminal and core network located above the Access Stratum (AS).

from LTE to 3G or from 3G to LTE.

6.2 Voice service provision

As described above, LTE is a system specifically for PS, and voice services provided by CS in 3G will be initially provided by switching to 3G in a process called "CS fallback." In the future, however, voice services initially provided by CS fallback in this way are envisioned to be provided in the PS domain on LTE.

6.3 Always-ON

The LTE standard adopts the "Always-ON" concept that maintains a continuous connection based only on an IP connection instead of Point-to-Point Protocol (PPP)[*6]. At attach[*7] time (such as when turning power ON) in an LTE area, the mobile terminal will be automatically connected to the PDN set by the user and an IP address will be assigned. A manual connection to a PDN can also be performed by user settings.

7. Conclusion

This article described an overview of the LTE-based "Xi" (Crossy) system. At NTT DOCOMO, we first promoted the Super3G concept about five years ago, and our research and development efforts since then have resulted in the development of a mobile communications service conforming to the LTE standard. This service was launched in Tokyo, Nagoya and Osaka region in December 2010 under the brand name of "Xi" (Crossy). Looking forward, we plan to expand the LTE service area according to our schedule, increase transmission speeds and functionality by expanding user bandwidth, provide an extensive lineup of mobile terminals, and enlarge our subscriber number. We will also hope to spread the use of LTE-based "Xi" (Crossy) in society as a platform for enriching people's lives.

*6 **PPP**: A layer 2 protocol widely used for data communication in 3GNW. It enables two points on the network to be connected and data communication to be performed between those points.

*7 **Attach**: The process of registering a mobile terminal to a network when the terminal's power is turned on , etc.