Core Network Control Method | Capacity Enhancement | Smartphone

Technology Reports

New Packet Processing Nodes for 3G Core Network Supporting Large-capacity Communications in Smartphone Era

The dramatic penetration of smartphones is rapidly increasing the number of simultaneous network connections and volume of packet traffic, and increasing the capacity and cost efficiency of network facilities is becoming an urgent requirement in the core network. In response to this need, we have upgraded the hardware used in the existing serving/gateway General packet radio service Support Node (xGSN) to high-performance equipment, and we have developed a new packet processing node called the New serving/gateway General packet radio service Support Node (NxGSN) that achieves a significant increase in capacity and cost efficiency by improving the software processing system.

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1. Introduction

The dramatic growth in the smartphone market in recent years has rapidly increased the number of simultaneous network connections and volume of packet traffic. There is consequently an urgent need to raise the capacity and cost efficiency of network facilities.

The New serving/gateway General packet radio service Support Node (NxGSN) that we recently developed began operations in October 2011 as a successor to the serving/gateway General packet radio service Support Node (xGSN)*1[1] originally deployed in October 2004. This new equipment is intended to support the increasing demand for smartphones in the years to come.

The NxGSN network configuration is shown in **Figure 1**. As in the case of the preceding xGSN node, the NxGSN node integrates the Serving General packet radio service Support Node (SGSN)*2 and the Gateway General packet radio service Support Node (GGSN)*3. It connects to the Radio Network Controller (RNC))*4, Charging and Protocol Conversion Gateway (CPCG)*5 and Multi Access Platform System (MAPS)*6[2] that serves as NTT DOCOMO's ISP service platform, and it provides FOMA data communication services such as i-mode and sp-mode. The NxGSN node also connects to Evolved Packet Core (EPC)*7[3] to provide "Xi" (Crossy) data communication services in FOMA areas [4][5].

This article describes the deployment objectives, hardware configuration and software architecture of NxGSN.

*1 **xGSN**: A packet communication processing device in the FOMA network. It has both the SGSN (see *2) function and the GGSN (see *3) function specified by 3GPP.

*2 **SGSN**: A logical node in the 3GPP standard managing the mobility of mobile terminals that perform packet switching and packet communications.

2. NxGSN Development Background and Objectives

A variety of measures have been taken to deal with the increase in packet traffic in the core network*8 since the launching of FOMA services in 2001. These include the introduction of xGSN by separating circuit switching and packet switching and the improvement of processing performance by upgrading xGSN hardware and improving xGSN software processing.

However, the rapid penetration of smartphones in recent years has caused the number of simultaneous connections and packet traffic in the core network to increase at an unprecedented rate. In particular, the number of simultaneously connected mobile terminals in the network has been increasing in proportion to the spread of smartphones. Connections come in two types as shown in **Figure 2**. In an on-demand connection typical of i-mode, a connection is made with the network only during a communication session, while in an always-on connection for smartphones as in sp-mode, the connection with the network is maintained even after a communication session has completed. Given the trend toward an increasing number of smartphone users and the migration to "Xi" (Crossy) ser-

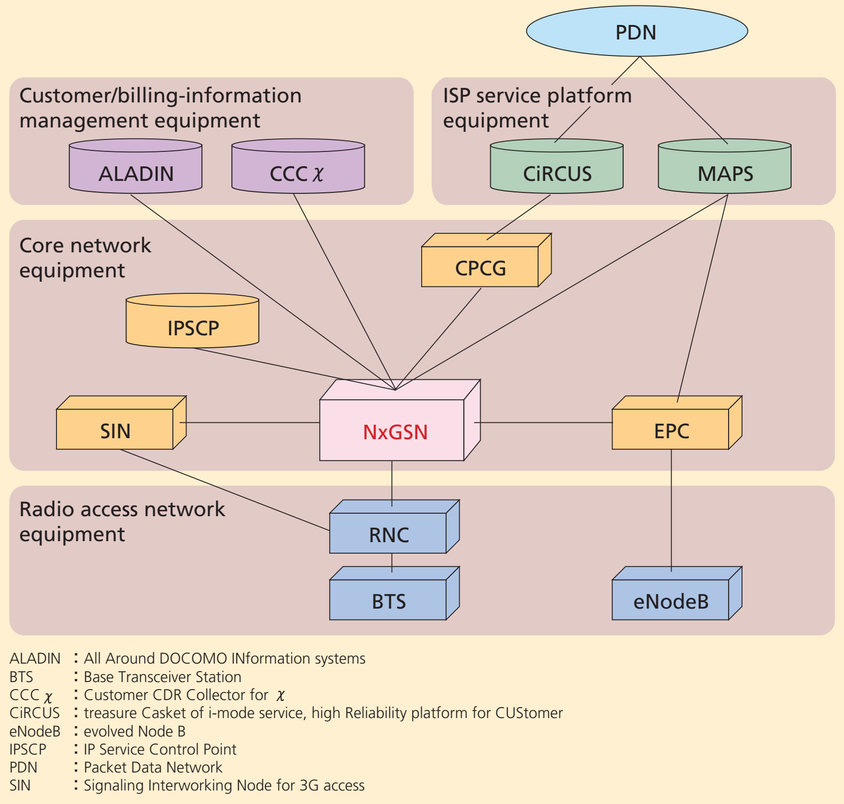

Figure 1 NxGSN network configuration

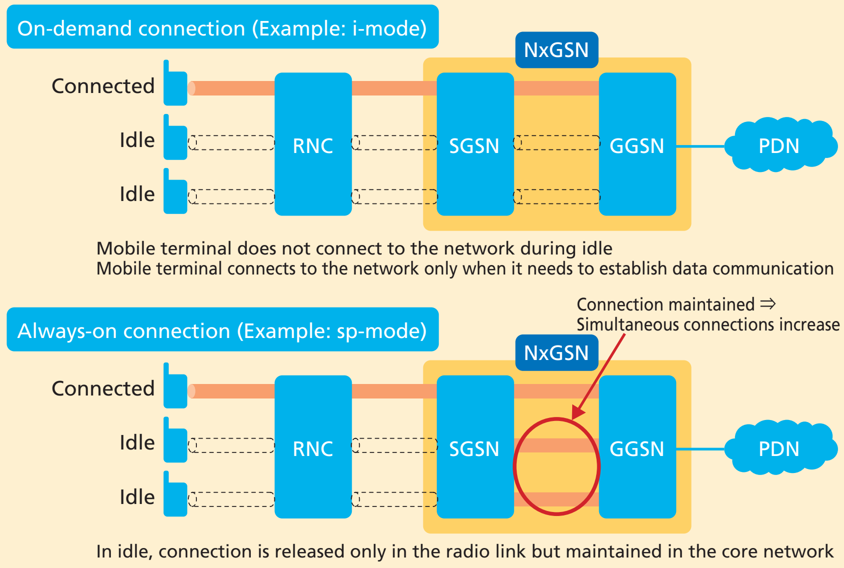

Figure 2 On-demand connection versus always-on connection

*3 **GGSN**: A logical node in the 3GPP standard acting as a connection point with PDN and performing IP-address allocation and packet transfer with SGSN.

*4 **RNC**: A device that performs radio circuit control and migration control in the 3G network defined on 3GPP.

*5 **CPCG**: i-mode gateway equipment in the NTT DOCOMO network.

*6 **MAPS**: A platform providing Internet and business-system connections from FOMA, "Xi" (Crossy), and other access circuits.

*7 **EPC**: A core network (see *8) that can accommodate diverse radio access systems including LTE.

*8 **Core network**: A network consisting of switches and subscriber-information management equipment. Mobile terminals communicate with the core network via the radio access network.

vices, it is desirable that the capacity and cost efficiency of network facilities be further increased so that the number of simultaneous connections and packet traffic forecast for the future can be adequately supported.

It is expected, moreover, that the number of xGSN simultaneous connections will not decrease with the rollout of "Xi" (Crossy) services. This is because the Idle mode Signaling Reduction (ISR) function [6] for omitting location registration during the radio-access-system switchover between 3G and LTE will, in effect, maintain connections with the 3G network even as the migration to "Xi" (Crossy) services expands.

3. Hardware Configuration

The NxGSN hardware configuration is shown in **Figure 3**. Similar to xGSN, the basic NxGSN hardware structure consists of a group of servers and Layer2 SWitches (L2SWs) that interconnect those servers. This structure separates the signal control unit (Control-Plane: C-Plane)[*9] and user-date processing unit (User-Plane: U-Plane)[*10]. The server group adopts the Advanced Telecom Computing Architecture (ATCA)[*11]-specified generic blade server[*12].

3.1 Hardware Changes and Cost-efficiency Measures

In NxGSN, the User Plane Blade (UP-Blade)[*13] adopts hardware common to xGSN, but other equipment adopts new high-performance hardware. This approach makes it possible to appropriate the UP-Blade from xGSN while achieving higher capacities. In short, NxGSN helps to reduce facility installation costs by making effective use of existing hardware resources.

Furthermore, with the exception of Redundant Arrays of Inexpensive Disks (RAID)[*14], all of the hardware making up NxGSN consists of blade servers

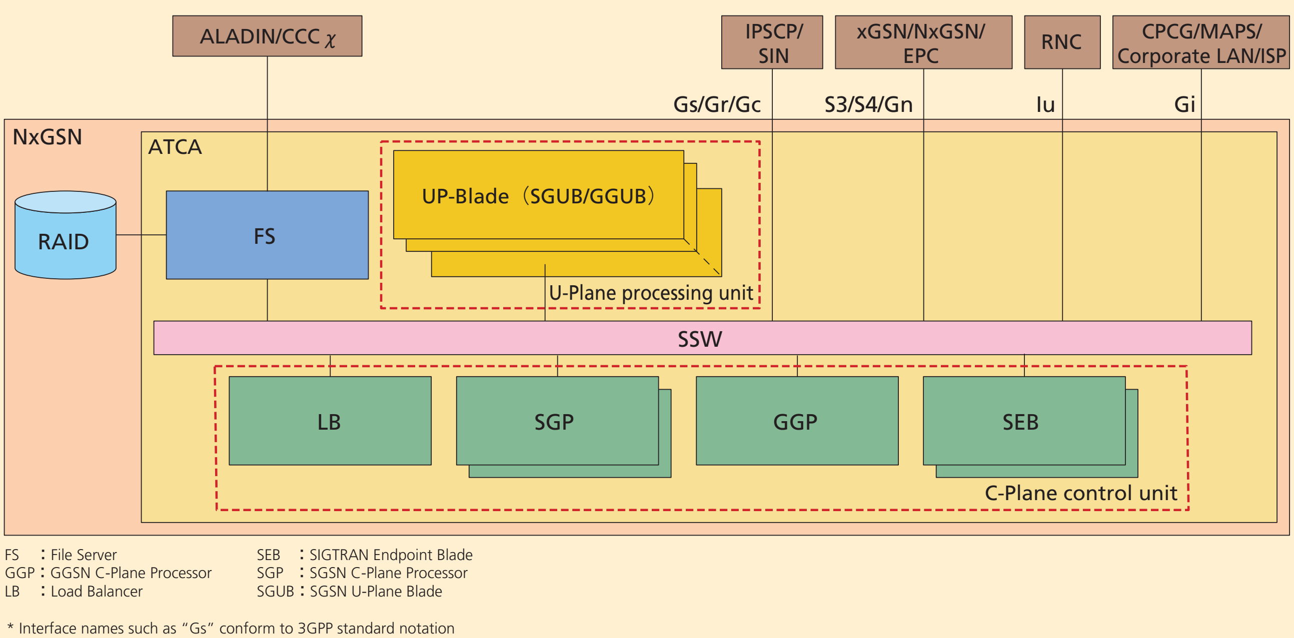

Figure 3 NxGSN hardware configuration

*9 **C-Plane**: This refers to the control plane, a series of control processes that is executed when a call is established and other such times.

*10 **U-Plane**: The protocol for the sending and receiving of user data.

*11 **ATCA**: Industrial standard specifications for carrier-oriented next-generation communication equipment specified by the PCI Industrial Computer Manufacturers Group (PICMG).

*12 **Blade server**: A server that is configured of multiple boards and all of the components of a computer are installed on each board. They are mounted in a chassis that provides power, LAN and other such functions.

*13 **UP-Blade**: A blade server for transferring user data.

*14 **RAID**: A device that manages multiple hard disks at the same time.

conforming to ATCA specifications. As a result, the L2SWs that interconnect NxGSN servers can be consolidated within a L2SW Shelf Switch (SSW)[*15] thereby reducing the number of L2SW units and simplifying the hardware configuration compared with that of xGSN.

With NxGSN, it has also become possible to configure a system with a smaller server group compared to xGSN, which means that the space needed for system installation can be kept at the same level as that of xGSN while increasing system capacity.

By integrating hardware and improving processing performance in this way, NxGSN cuts facility installation costs by more than 50% compared with xGSN. Looking forward, NxGSN will be able to significantly reduce the cost of facilities for supporting the predicted increase in simultaneous connections and packet traffic caused by the growing use of smartphones.

3.2 Improvement of User-data Transfer Performance

As described in Section 3.1, NxGSN can configure a system with a smaller server group compared with that of xGSN. As a result, user-data transfer performance can be improved over that of xGSN by (1) mounting more UP-Blades than that possible in xGSN, (2) using high-speed circuits on the user-data transfer paths between the UP-blade, SSW and other nodes, and (3) separating the interfaces to RNC and xGSN/EPC, which had been superposed on the same physical circuit in xGSN, into different physical circuits.

4. Software Architecture

The NxGSN software configuration is shown in **Figure 4**.

For the OS, NxGSN adopts a subsequent version of Carrier Grade Linux (CGL)[*16] adopted by xGSN and a subsequent version of the middleware[*17] used in common with other ATCA equipment. This ongoing use of generic products from xGSN reduces development costs, shortens the development period, and achieves high reliability and high maintainability equivalent to that of xGSN. In a similar manner, the use of common source files for xGSN and NxGSN makes the development of applications more efficient, and specifying a compile option[*18] makes it possible to compile a Load Module (LM)[*19] for each of the xGSN and NxGSN environments (**Figure 5**).

4.1 Support of New Hardware

Since differences exist between

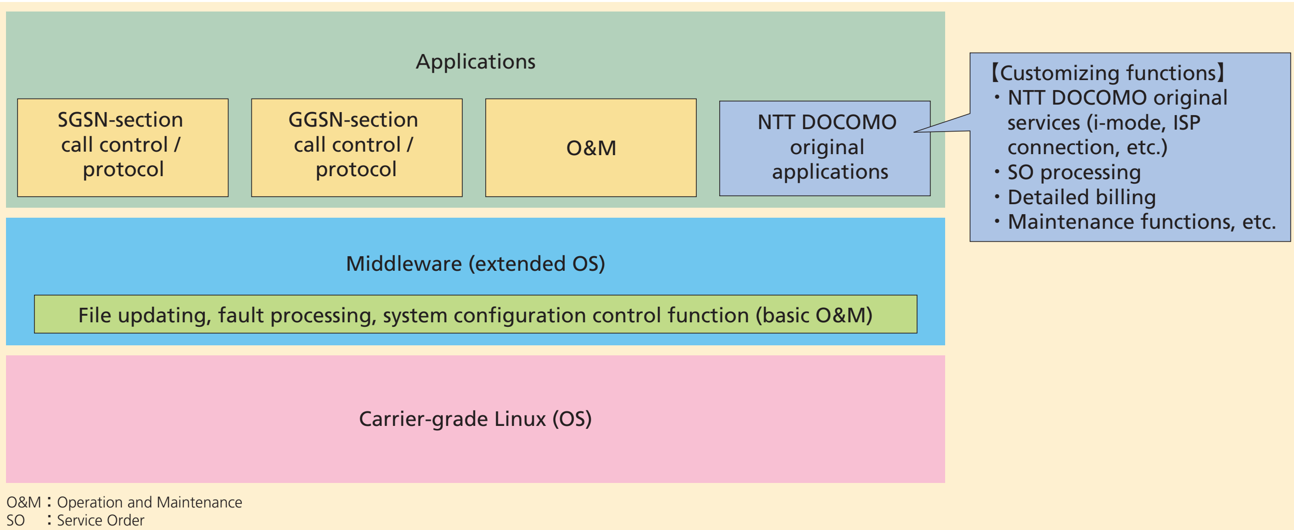

Figure 4 NxGSN software configuration

*15 **SSW**: A switch situated inside a shelf for connecting blade servers, where a "shelf" refers to housing for accepting a blade server within a rack.

*16 **CGL**: A Linux® OS specified by Open Source Development Labs (OSDL) for achieving the high level of performance and reliability demanded of telecommunications operations. Linux® is a registered trademark or trademark of Linus Torvalds in the United States and other countries.

*17 **Middleware**: Software providing functions for common use by multiple applications.

*18 **Compile option**: An option that can be specified when generating an executable file from source files.

*19 **LM**: A module in executable-file format generated by compiling.

NxGSN and xGSN in terms of hardware used and hardware configuration, we made changes to the software-based equipment monitoring function to support new hardware. Furthermore, as differences also exist between NxGSN and xGSN in terms of LMs and the firmware on each server, we added a function for differentiating between these two types of nodes in the file update function and managing each accordingly.

4.2 Improvement of Processing Performance

The performance of various types of processing has been improved in NxGSN compared to xGSN. This performance improvement was difficult to achieve solely on the basis of hardware performance improvements, so we also made improvements to the software processing system in conjunction with those hardware enhancements.

NxGSN adopts hardware that increases the number of cores[*20], but the issue here was how to efficiently distribute processes among those cores to extract improvements in computational performance. In short, our goal was to improve parallelism in NxGSN software processing, and to that end, we divided the software into small functions. We looked in particular at loop processing or processes that took a relatively long time and subdivided the task in question to increase the degree of parallel processing. In this way, we were able to make more efficient use of the higher number of cores.

This improvement in processing performance in NxGSN, however, also increased the amount of data that had to be saved. As a result, much time would be needed to retrieve data by existing data-processing and data-searching methods, which would drop overall software processing speed. Thus, for NxGSN, we changed the data-processing method and improved data search speeds. In the existing scheme, data was organized into different tables and each table was searched sequentially starting from the head of the table. In NxGSN, we increased the number of tables compared with that of xGSN and prevented the number of data items within a single table from increasing to achieve search times equivalent to that of xGSN.

4.3 Functions for Improving Reliability

The performance of various types of processing has been improved in NxGSN as described above. However, this improvement in node performance means that many mobile terminals will be disconnected from the network in the event of a node fault. In principle, the disconnection process is performed one mobile terminal at a time, which

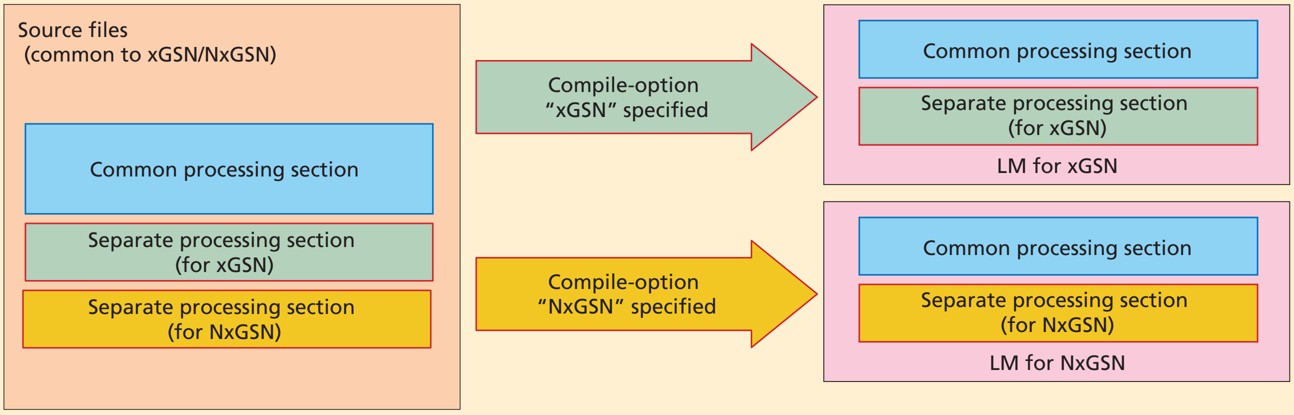

Figure 5 LM compiling method for xGSN/NxGSN

*20 **Number of cores**: The number of units performing processing within a CPU.

would increase the time required to terminate the connections of all connected terminals in NxGSN compared with xGSN. The solution to this issue is to increase the speed of terminating a mobile terminal connection in NxGSN. However, if disconnection speed were to be carelessly raised when sending a termination-request control signal to another node, the performance of that node can be adversely affected. For this reason, we have set disconnection speed in NxGSN within a range that does not affect the performance of another node but that also enables the connections of all terminals to be terminated within a length of time equivalent to that of xGSN.

In addition, the equipment switching function for switching to standby equipment in the event of a fault in an active GGSN U-Plane Blade (GGUB)[*21] would, in the existing scheme, execute the switch only after terminating the connections to all mobile terminals connected to that GGUB. Considering, however, that mobile terminals having always-on connections to the network as in the case of smartphones are expected to proliferate in the years to come, the number of terminals that need to be disconnected owing to GGUB switching can be expected to increase compared to conventional levels. Additionally, it is common for a mobile terminal having an always-on connection to immediately reconnect to the network after being disconnected so that the user will not sense that the connection was ever terminated. Thus, if many mobile terminals simultaneously disconnect from the network at the time of GGUB equipment switching, the network will also simultaneously receive many reconnection requests from those terminals. This concentration of connection requests will extend the time needed to complete all connections or create a state of network congestion[*22], which, in either case, can lead to a drop in communication quality. In light of the above, we have added in NxGSN a process for storing in standby equipment information on active equipment.

As shown in **Figure 6**, this process makes it possible to execute a GGUB equipment switch without having to terminate the connection with the mobile terminal. This improvement to NxGSN can be immediately applied to future conditions dominated by mobile terminals with always-on connections, and as such, it can also be applied to xGSN.

5. Conclusion

This article explained the need for deploying NxGSN as successor equipment to xGSN and described the NxGSN hardware configuration and software architecture. With NxGSN, the core network can quickly and flexibly respond to rapid increases in the

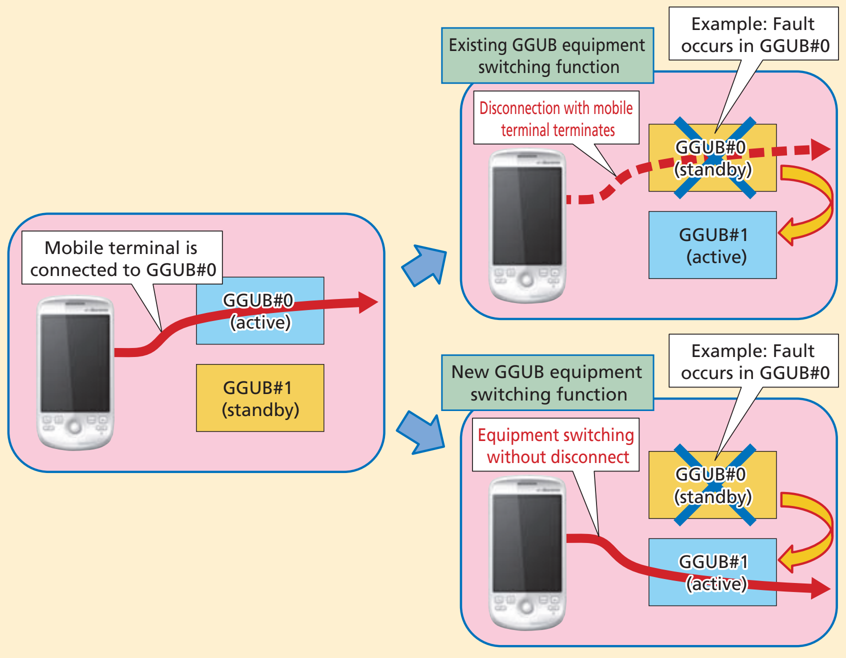

Figure 6 Overview of GGUB equipment switching

*21 **GGUB**: UP-Blade for GGSN use.

*22 **Congestion**: A state where communication requests are concentrated inside a short time period and exceed the processing capabilities of the network, thereby obstructing communications.

number of simultaneous connections and volume of packet traffic brought on by the widespread penetration of smartphones while also supporting further increases in packet traffic generated by increasingly faster services.

Looking to the future, NTT DOCOMO plans to replace all currently installed xGSN with NxGSN and to pursue functional extensions with the aim of taking network reliability and functionality to an even higher level.

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