A proposal for a 3G-CS integrated network call control procedure based on IMS

Naomasa Yoshida, Takahiro Kuroiwa, Masateru Nakao and Tomoki Shibahara
NTT DOCOMO, Inc.,Yokosuka-shi,239-8536 Japan
E-mail:{ yoshidana , kuroiwat, nakaom, shibaharat }@nttdocomo.co.jp

Abstract: In this paper, we propose a network architecture and call control procedure (3G-CS integrated network call cotorol procedure based on IMS) that enable control based on an IP Multimedia Subsystem (IMS) capable of providing diverse services and building an economic network upon securing service inheritance based on existing user equipment (UE) for Third Generation Circuit Switch (3G-CS) users.

Keywords: **IMS, MSC, SIP**

I. INTRODUCTION

With the rapid spread of Third Generation (3G) mobile communications in recent years, high-speed, high-capacity communications have become possible and demand for high-grade services is growing. At the same time, in addition to the 3G-CS and 3G-PS (Third Generation Packet Switch) access network system, the provision of services utilizing a variety of new access networks such as Wireless Local Area Network (WLAN) also launch. In this environment, the installation of IMS [1] that utilizes an architecture capable of providing a variety of services based on IP control without depneding on access networks has been advancing. With the installation of an IMS architecture, when a mobile communications carrier provides services, it is possible to build an economical network and is no longer necessary to build a network in each access network units. Integrated control based on IMS is therefore expected with respect to existing 3G-CS services.

Under current conditions, mobile communications carriers generally build networks following architectures under Third Generation Partnership Project (3GPP) [2] documents. Under the current 3GPP documents, however, there is an issue that IMS is defined only for 3G-PS and WLAN, which are packet swithings, but not for 3G-CS. Also, since a large quantity of mobile communications equipment providing 3G-CS services has already shipped to the marketplace, when performing controls based on IMS, there is the issue of the need to secure service inheritance with existing user equipment (UE) that is not supported by IMS control functions.

In this paper, we therefore propose a network architecture and control system concerning 3G-CS integrated IMS controls that can secure service inheritance with existing 3G-CS UE.

This proposal is presented in the following format: Firstly, the necessity of IMS integrated controls for 3G-CS services is explained by providing a detailed description and comparison of architectures defined under the 3GPP standard. Next, we define the required conditions for providing 3G-CS services using IMS integrated controls. On that basis, we propose an architecture that will satisfy those conditions, and we propose, explain, and evaluate control systems based on the proposed architecture.

II. NEED FOR INTEGRATED IMS CONTROL

For example, an architecture that is split into two domains like 3G-CS and 3G-PS is being used in a conventional 3G core network defined under 3GPP 3G-CS provides voice communication services and videophone services, and 3G-PS provides data communication services. By contrast, the IMS defined under 3GPP provides multimedia services that include voice communication services, and is capable of accommodating a variety of IP-Connectivity Access Networks (IP-CANs) such as 3G-PS, Interworking Wireless Local Area Network (I-WLAN), and Long Term Evolution (LTE). At present, however, there is no method for accommodating 3G-CS in an IMS.(Fig. 1)

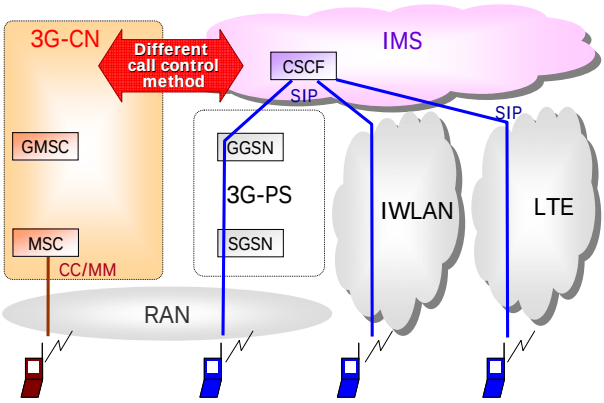

Fig. 1: Networks defined by 3GPP

In existing architectures, 3G-CS and other systems that include 3G-PS, I-WLAN, and LTE must configure independent core networks. This causes redundancy in network equipment concerning the control of voice/videophone communications and the control of services, which is extremely inefficient from the viewpoint of service linking and network economy.

Accordingly, we need a method of accommodating into the IMS the conventional 3G-CS that does not have IMS functions and of providing services.

In the process of integrating multiple networks for access network into one network, it is extremely important to add

3G-CS to the IMS, because IMS is a next-generation architecture for networks, and many multimedia services provided by IMS and 3G-CS give higher value to users.

III. Requirements for Integrated IMS Control

At present, since 3G is the primary service adopted by a large number of users, technology for smooth migration to IMS and for using IMS to provide 3G users with expansive services is important not only from the viewpoint of user experience but also from the viewpoint of operators[3], as it is expected to contribute considerably to efficient network planning in the future.

The conditions required[4] for migrating 3G-CS to integrated IMS control are as follows:

(1) Efficiency of facilities

Since 3G-CS can only be accommodated using facilities on the IMS side, the facility can be configured based on total traffic without depending on the number of users of each access system.

(2) System migration

Smooth migration can be accomplished using the same access system and UE as those used for 3G-CS. Interface conditions to the exterior network are not changed in the migration.

(3) Connection time

It is essential to minimize connection delays and ensure connection times equivalent to those of conventional 3G-CS.

In this paper, we propose an architecture that satisfies the above conditions. Details are provided in section IV.

IV. Proposal of Architecture that Satisfies the Required Conditions

Circuit Switch GateWay (CS-GW) is newly defined as a logic function for accommodating 3G-CS in IMS. The CS-GW is located at the midpoint between the existing 3G-CS and the IMS. It has functions for terminating the IuCS interface, functions that operate as a virtual Session Initiation Protocol user equipmen (SIP-UE) for the IMS side, and protocol converting functions for User Plane (U-plane) data between the Iu-CS[5] side and the IMS side. (Fig. 2)

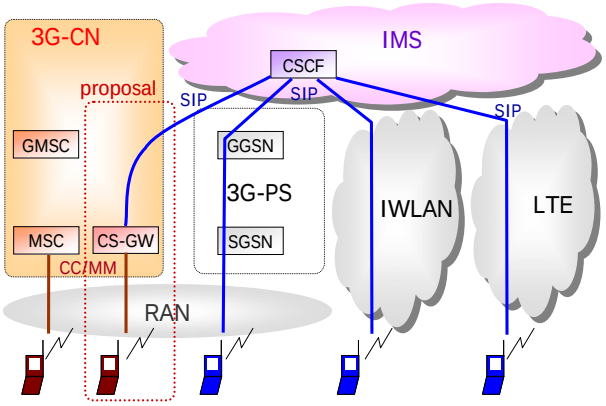

Fig. 2: Proposed network

The CS-GW needs to fully support 3G interfaces and protocols for UE and access that existing Mobile Switching Center (MSC)[6] has (e.g. Radio Access Network Application Part, Call Control/ Mobility Management[7], Supplementary Service(SS)[8], etc.). In addition, to provide users in IMS control area with services equivalent to those received by users in MSC control area, an Application Server (AS) for 3G-CS services must be installed on the IMS in order to realize existing 3G-CS services on the IMS. Interfaces with other networks can be supported at the Media Gateway Control Function (MGCF)/ Media Gateway Function (MGF), IMS standard entities. The above makes it possible for the IMS to recognize 3G-CS in the same way it recognizes other IP-CANs.

This architecture enables efficiency of facilities that utilized existing UE, one of the required conditions.

V. 3G-GW Control System

Characteristic technical elements of the above-mentioned method for accommodating 3G-CS accesses by CS-GW (IMS integrated network control) are described below.

First, the form of implementing IMS functions on 3G-PS or I-WLAN, which is considered to be a common form of providing IMS service, is shown in Fig. 3. In this case, 3G-PS/I-WLAN is positioned in IMS as an IP-CAN and plays the role of assuring connections to the IMS network at the IP level. 3G-PS/I-WLAN merely provides the bearer access to the IMS but does not provide other functions such as services, so UE can perform a dialog with the IMS network at the SIP level and enjoy services only when it holds the IMS-UE function as an upper-order application in addition to functions as a 3G-PS/I-WLAN UE.

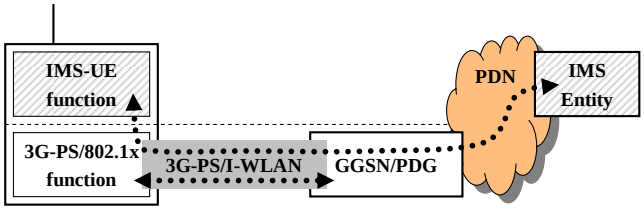

Fig. 3: IMS access over 3G-PS/I-WLAN

Fig. 4 shows the form of actualization wherein the same control system is applied to 3G-CS. Because 3G-CS simply functions as an IP-CAN in the form of actualization shown in Fig. 5, MSC plays the role of merely setting the circuit with the UE but does not provide services.

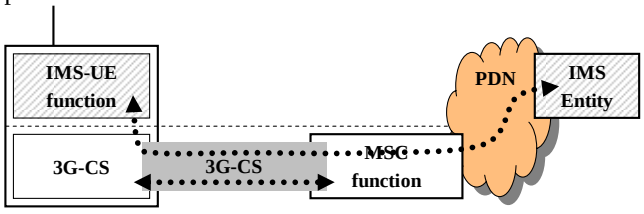

Fig. 4: IMS access over 3G-CS

This method does not meet the requirement, because it requires UE to have IMS-UE functions to receive services. This method also requires the following two steps for completing the call connection, so connection time will increase compared with conventional 3G-CS:

1. 3G-CS bearer connection between UE and MSC

2. IMS level session establishment between IMS-UE and IMS via a 3G-CS bearer

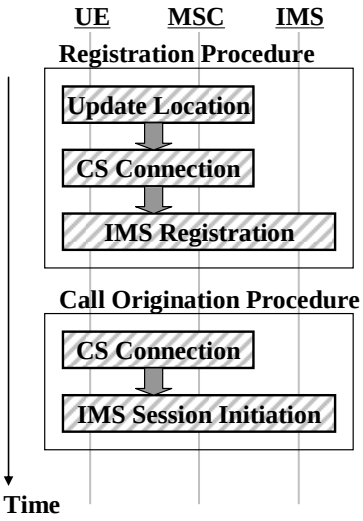

Fig. 5: IMS Service Procedure on 3G-CS

On the other hand, Fig. 6 depicts the form of actualization using 3G-CS integrated IMS control. CS-GW, which is positioned at the midpoint between the existing 3G-CS access network and the IMS, has functions to terminate the Iu-CS interface, operate as a virtual SIP-UE to the IMS side, and convert the U-plane data protocol between the Iu-CS side and the IMS side. With these functions, IMS recognizes a CS access network as an IP-CAN equivalent to 3G-PS.

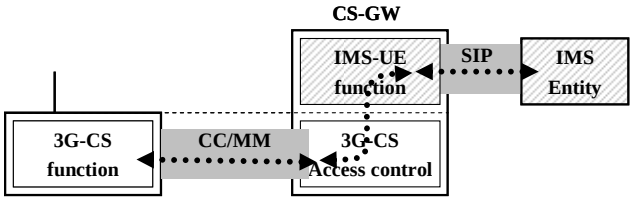

Fig. 6: IMS Service Procedure on 3G-CS

Another feature of this system is the number of processing steps required to connect to the IMS entity, i.e. the connection time.

In the 3G-CS integrated IMS control system, as shown in Fig. 7, because setting of the 3G-CS bearer and processing on the SIP level are performed in parallel through mutual cooperation between the UE and the CS-GW and between the CS-GW and the IMS, it can be expected that services can be implemented by utilizing the IMS with the same connection time as that of conventional services using MSC.

Though accommodation of 3G-CS access in the IMS is enabled by the CS-GW, this environment is required to provide services corresponding to conventional 3G-CS services. Because various services in the IMS are provided in the form of ASs, it is appropriate to introduce ASs to provide 3G-CS services in the same manner. However, because the division of functions concerning startup of services differs between MSC-controlled 3G-CS and IMS, consideration must be given in the transition phase, particularly during the period where MSC and CS-GW coexist. This subject will be described later.

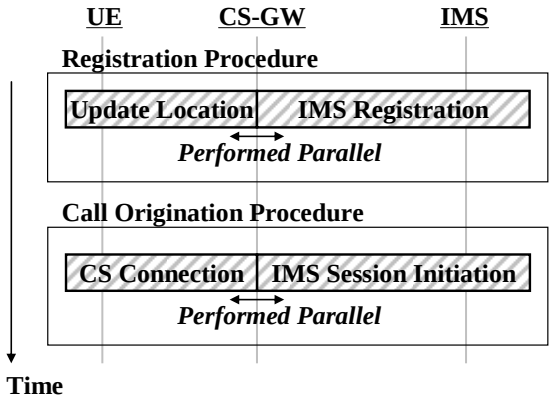

Fig. 7: IMS Service Procedure on 3G-CS via CS-GW

VI. LOCATION UPDATE PROCEDURE CONTROL

This section outlines location update procedure control by using CS-GW, described above. The CS-GW registers subscribers to the IMS network by terminating MM signals as the conventional control protocol to and from 3G-CS UE and performing SIP Registration with corresponding signals to the IMS network. In this case, although the Diameter defined in 3GPP is used between Call Session Control Function (CSCF)/AS and Home Subscriber Server (HSS)/Home Location Register (HLR), conventional Mobile Application Part (MAP) may be applied to the section between CS-GW and HSS/HLR. Fig. 8 is expressed on the assumption that MAP is used between CS-GW and HSS/HLR and Diameter is used between CSCF/AS and HSS/HLR.

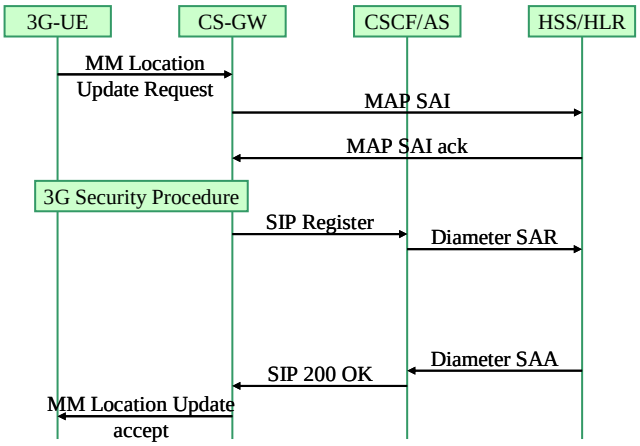

Fig. 8: Location Update Procedure

Incidentally, although profile information necessary for subscribers is downloaded by Registration processing, the information corresponding to the subscriber profile held by Visitor Location Register (VLR) in 3G-CS will be held by work sharing between the CS-GW and the AS. Subscriber information that is interlocked with radio control such as authentication of access by subscribers will be held by the CS-GW, and subscriber information that is necessary for service control such as added service information is held by the AS.

Next, a summary of the call origination procedure is shown in Fig. 9. As before, the UE perform the call origination control with CC signals as the protocol used in 3G-CS. When the CS-GW, which has a converting

function, receives CC protocol signals, it transmits them to the IMS network after converting them into signals corresponding to the SIP protocol. Besides protocol conversion, the CS-GW also performs authentication, ciphering, and radio access bearer setting processing, etc. for 3G-UE and radio access networks.

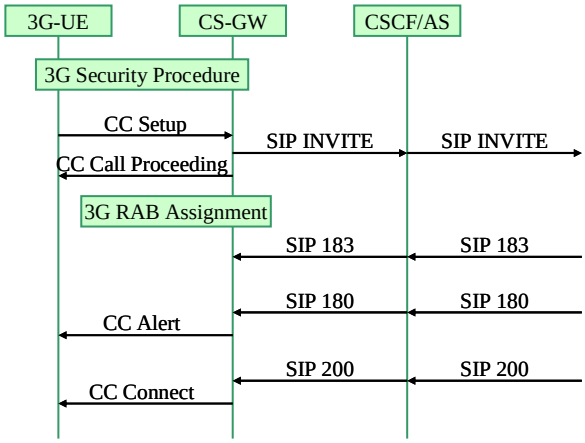

Fig. 9: Session Origination Procedure

Lastly, the call termination control is outlined below. The role of the CS-GW is to convert CC signals into SIP signals and vice-versa, as in the case of the call origination control.(Fig.10)

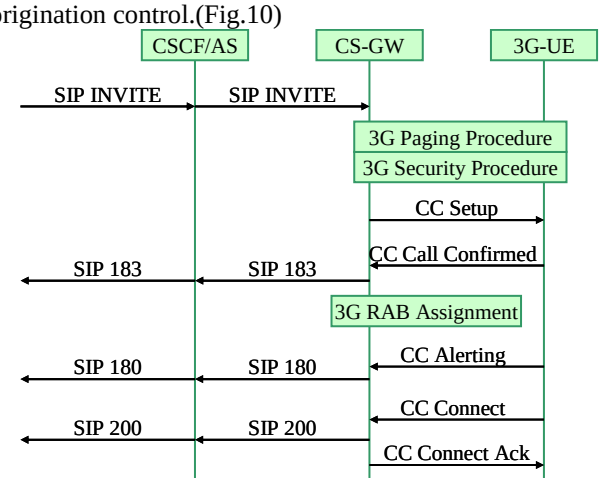

Fig. 10: Session Termination Procedure

To evaluate connection times, we compared the number of steps required for sending and receiving signals between the UE and the network, from attach to completion of voice phone connection, in 3G-CS, IMS Access over 3G-PS, and the proposed system.(Table 1)

Table 1: Number of steps for sending/receiving signals

Compared system	PTN1 3G-CS	PTN2 IMS Access over 3G-PS	PTN3 Proposed system
Update Location	3	3	3
IP Connectivity	–	2	–
SIP Registration	–	4	–
CS Connection	6	12 (including ACK processing, etc.)	6
Total steps	9	21	9

Note: Wireless control processing is not included, as it is the same for all systems.

The proposed system achieved a simplification of approximately 57% compared with IMS Access over 3G-PS. It also has the same number of steps as 3G-CS, and the required condition concerning connection time can be satisfied.

VII. SERVICE CONTROL SYSTEM THAT CONSIDERS MIGRATION

In this section, we clarify issues and propose solutions concerning service control systems when two systems are mixed. These issues occur when existing 3G-CS networks are migrated to IMS integrated control networks.

A. Outline of service control systems in existing 3G-CS networks and IMS integrated networks

In conventional MSC-controlled 3G-CS network (3G-CS (MSC) network), the MSC on the network on the originator side performs both call origination service control (e.g. Calling Line Identification Restriction/Calling Line Identification Presentation) and call termination service control (e.g. Call Forwarding) in cooperation with HLR.

In the IMS network, however, because S-CSCF/AS, which accommodates users, performs both call origination and call termination service control, the call termination service control is performed by the network entity on the terminator side, unlike in the case of MSC. Also in the 3G-CS integrated IMS network, termination service is performed by the network entity on the terminator side in accordance with the concept of IMS.(Fig 11)

Thus, with regard to call termination service control, there is architectural differentiation concerning the service control point. When developing IMS integrated control, discussions are necessary concerning the service control system for the coexistence phase of the existing 3G-CS (MSC) network and the integrated IMS network.

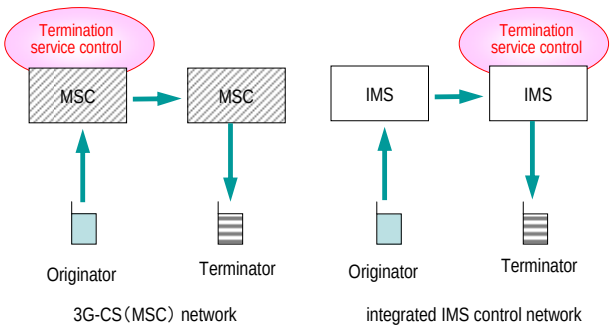

Fig. 11: Comparison of service control systems

B. Issues and required conditions while systems are mixed

Subjects concerning the architectural differentiation in the coexistence phase are described below.

Case 1: Communications from the 3G-CS integrated IMS network to the 3G-CS (MSC) network

While call termination service control is performed by the network on the terminator side in the case of the integrated IMS network, call termination service control is performed on the originator side in the case of the 3G-CS (MSC) network, so there is no service control entity on the terminator side and no service control is performed.

Case 2: Communications from the 3G-CS (MSC) network to the integrated IMS network

Call termination service control is performed in tandem by two systems on the 3G-CS (MSC) network and the integrated IMS network.

To solve the above-mentioned subjects, an efficient method is required that concentrates control functions in the integrated IMS network without affecting the existing 3G-CS (MSC) network.

C. Service control system that solves migration issues

For the integrated IMS network, we propose a system to absorb the architectural differentiation by holding the following functions.

- Function at HSS to manage the visited network (3G-CS (MSC) or IMS)
- Functions at CSCF/AS on the originator side to analyze the visited network where the termination user exists and execute call termination service control.
- Functions at MGCF to add call origination network information
- Functions at CSCF/AS on the terminator side to analyze the call origination network and suppress call termination service control.

Specific methods for solving issues are indicated below(Fig 12):

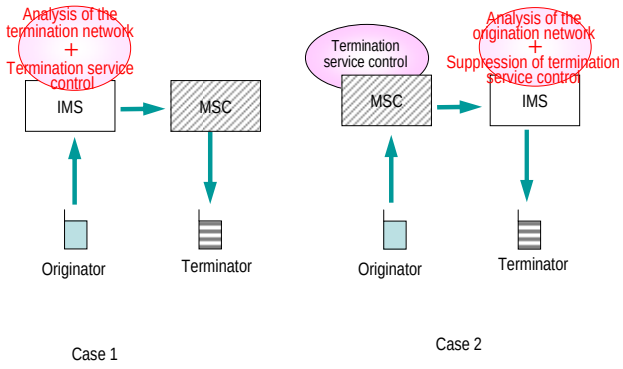

Fig. 12: Proposed service control system that considers migration periods

Case 1: Communication from IMS integrated networks to 3G-CS (MSC) networks

With the network where the user is registered to HSS at the time of location update, the CSCF/AS on the originator side obtains the network information on the terminator side from HSS and performs call termination service control when the termination user exists in the 3G-CS network.

Case 2: Communication from 3G-CS (MSC) networks to IMS integrated networks

Call termination service control on the IMS side is suppressed by notifying network information on the originator side to the integrated IMS network. In this case, network information is given from MGCF so that it does not affect the currently existing 3G-CS (MSC).

This proposal makes it possible to secure the migration of systems, one of the required conditions.

VIII. CONCLUSION

In this paper, we proposed a network architecture and call control procedure for controlling 3G-CS services in an integrated network based on IMS. In this proposal, by defining a CS-GW that performs conversions of 3G-CS and IMS protocols, it has become possible to accommodate existing 3G-CS UE in IMS networks that are not dependent on access networks. In the control procedure, the parallelization of signal processing at the CS-GW has solved the issue of shortening connection times. In addition, by proposing service controls that manage and analyze networks for originating and terminating users during mixed network periods of migration from existing networks, it has become possible to achieve smooth migration.

In the future, we plan to perform quantified measurements of connection times and make comparisons with other technologies (e.g. IP Multimedia Subsystem Centralized Services [9]).

REFERENCES

[1] 3GPP TS22.228, “Service requirements for the Internet Protocol (IP) multimedia core network subsystem (IMS); Stage 1”, V8.5.0, 2008

[2] 3GPP TS23.228, “IP Multimedia Subsystem (IMS) Stage 2”, V8.5.0, 2008

[3] A. Cuevasm, J.I. Moreno, P. Vidales, H. Einsiedler, “The IMS serviceplatform: a solution for next-generation network operators to be morethan bit pipes”, IEEE Communications Magazine, Volume 44, Issue 8,Aug. 2006, pp. 75-81

[4] Kumudu S. Munasinghe and Abbas Jamalipour “A Unified Mobility and Session Management Platform for Next Generation Mobile Networks”, in Proc. of IEEE GLOBECOM 2007

[5] 3GPP TS25.413, “UTRAN Iu interface Radio Access Network Application Part (RANAP) signalling”, V7.9.0, 2008

[6] 3GPP TS23.002, “Network architecture”, V8.2.0, 2007

[7] 3GPP TS24.008, “Mobile radio interface Layer 3 specification; Core network protocols; Stage 3”, V8.2.0, 2008

[8] 3GPP TS24.010, “Mobile radio interface layer 3 Supplementary services specification; General aspects”, V7.0.0, 2007

[9] 3GPP TS23.292, “IP Multimedia Subsystem (IMS) Centralized Services”, V8.0.0, 2008