♦ IP Multimedia Subsystem Converged Call Control Services

Sheng Chen, Xiangyang Li, and Yigang Cai

With the IP Multimedia Subsystem (IMS) converging different access technologies in common multimedia packet core networks, Alcatel-Lucent developed an innovative standalone IMS converged charging call control service that allows the convergence of online/offline charging for the bearer layer, IMS subsystem layer, and service layer, with call control over different networks. The service provides real-time call/session control during the life cycle of the call/session for voice, data, and multimedia services, such as screening, advanced routing, third-party access, and calling card service. The converged service can interwork with different media resource functions to support IMS and legacy interactive voice response (IVR) and notification services. The converged service can interwork with the online charging system (OCS) to support session- and event-based online charging capabilities, with a charging data function (CDF) and a billing system to support real-time offline charging capabilities. © 2007 Alcatel-Lucent.

Introduction

As set forth in the 3rd Generation Partnership Project (3GPP*), the IP Multimedia Subsystem (IMS) provides a common core network having an access-agnostic network architecture for converged networks [1]. Service providers are accepting this architecture in next-generation network evolution. The IMS architecture was initially defined by the 3GPP to provide multimedia services to mobile subscribers over an IP network. IP networks have become the most cost-effective bearer networks to transmit video, voice, and data. IMS uses the advantage of IP networks to provide multimedia services for IMS subscribers on an IMS platform. The signaling used within IMS networks is Session Initiation Protocol (SIP) [2, 7]. The IMS defines the standard SIP interface between application servers, the IMS core network, the IMS subscriber database, and IMS billing/charging elements. These standards can reduce the network integration costs and let the subscriber enjoy more stable services. On the IMS platform, the traditional supplementary services, such as call forwarding, conferencing, and call waiting, are available for IMS subscribers. Also, many new data services, such as instant messaging, video calls, video on wait, and Web-based services, will also be available for IMS subscribers.

Service providers that operate one or more legacy networks may also implement new IMS networks. **Figure 1** illustrates a network architecture implementing both a legacy network and an IMS network. The legacy network includes a mobile switching center (MSC), an intelligent network (IN) service control point (SCP), an intelligent peripheral (IP), a short message service center (SMSC), and a home location

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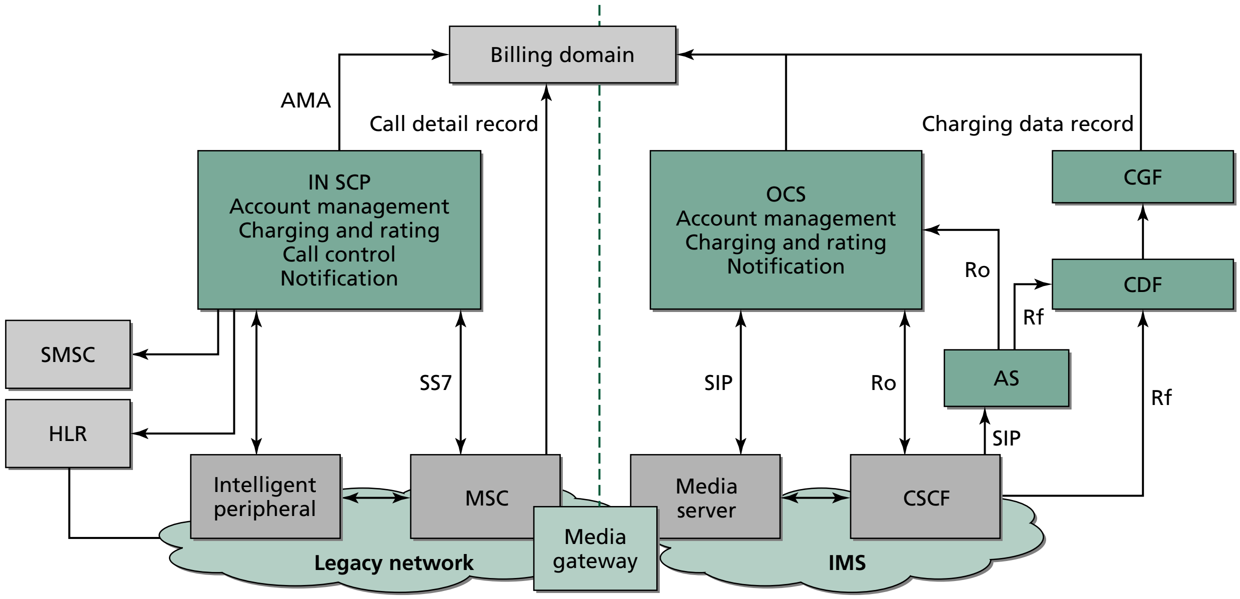
Panel 1. Abbreviations, Acronyms, and Terms

2G—Second generation
3GPP*—3rd Generation Partnership Project
ABO—Abbreviated dialing
ACR—Accounting requests
ANSI—American National Standards Institute
AS—Application server
AVP—Attribute value pair
BO—Billing domain
CAMEL—Customized Applications for Mobile Network Enhanced Logic
CAP—CAMEL application part
CCA—Credit control answer
CCR —Credit control request
COF—Charging data function
CDMA—Code division multiple access
CDR—Charging data record
CGF—Charging gateway function
CSC—Convergent service control
CSCF—Call session control function
CTF—Charging trigger function
GSM*—Global System for Mobile Communications*
GW—Gateway
HLR—Home location register
ID—Identifier
IMS—IP Multimedia Subsystem
IN—Intelligent network
INAP—Intelligent Network Application Protocol
IP—Intelligent peripheral
IP—Internet Protocol
IS—Interim standard
ISC—Internal service control
ISDN—Integrated services digital network
ISUP—ISDN user part
IVR—Interactive voice response
MMS—Multimedia messaging service
MS—Mobile station
MSC—Mobile switching center
OCS—Online charging system
PAC—Prompt and collect
PIN—Personal identification number
PSTN—Public Switched Telephone Network
Rf—Reference point of offline charging
Ro—Reference point of online charging
RTP—Real-Time Transport Protocol
SCP—Service control point
S-CSCF—Serving CSCF
SIP—Session Initiation Protocol
SMS—Short message service
SMSC—Short message service center
TLDN— Temporary local directory number
TS— Technical specification
USSD—Unstructured supplementary service data
VoIP—Voice over IP

register (HLR). The IMS network includes a call session control function (CSCF), an online charging system (OCS), a media server, a charging data function (CDF), a charging gateway function (CGF), an IMS gateway function, and an application server (AS). The SCP, MSC, OCS, and CGF communicate with the billing domain (BD). The BD typically comprises call detail record and/or charging data record (CDR) post-processing systems, such as the operator's billing system or billing mediation device. The media gateway may terminate bearer channels from a switched circuit network and media streams from a packet network. The media gateway may support media conversion, bearer control, and payload processing, such as encoding/decoding, echo canceling, or a conference bridge.

The MSC is a switching element for the legacy network. The SCP provides service control functions, account management, charging and rating functions, and notification functions for the legacy network. The intelligent peripheral is a physical entity that implements the intelligent network specialized resource functions, such as voice announcements. The SMSC is adapted to transfer short message notification to a mobile subscriber via a short message delivery point-to-point format. The HLR is responsible for managing mobile subscribers. The HLR stores and manages subscriber information and part of the mobile information that allows incoming calls to be routed to the mobile subscriber.

Service call control of intelligent services in a legacy network is traditionally performed in the SCP. As an example, assume the MSC receives signaling for a call from a mobile subscriber. If the call requires intelligent services, such as for a prepaid call, the MSC queries the SCP for service control. The SCP includes



AMA—Automatic message accounting
AS—Application server
CDF—Charging data function
CGF—Charging gateway function
CSCF—Call session control function
HLR—Home location register
IMS—IP Multimedia Subsystem
IN—Intelligent network
IP—Internet Protocol
MSC—Mobile switching center
OCS—Online charging system
Rf—Reference point of offline charging
Ro—Reference point of online charging
SCP—Service control point
SIP—Session Initiation Protocol
SMSC—Short message service center
SS7—Signaling System Number 7

Figure 1.
Divergent service control and charging solution for convergent networks.

a charging and rating function that determines whether the mobile subscriber has units left in his/her account to place the call, and, if necessary, requests units for the call. If an announcement is needed, such as to inform the mobile subscriber of the number of minutes left in his/her account, then the SCP may instruct the intelligent peripheral to play an announcement to the mobile subscriber. If a text message is needed, then the SCP may instruct the SMSC to transmit a text message to the mobile subscriber. After providing the needed services, the SCP responds to the MSC with routing instructions for the call. The SCP also reports to the billing domain regarding charging for the call.

In the IMS network, the CSCF serves as a centralized routing engine, policy manager, and policy enforcement point to facilitate the delivery of multiple real-time applications using IP transport. The CSCF may have policies of its own but will interact with other entities for general policy management and policy enforcement. The OCS provides online charging for the IMS network [2–5]. Online charging is a process in which charging information for network resource usage is collected concurrently with resource usage, but authorization of the network resource usage must be obtained by the network prior to the actual resource usage. The CDF and CGF provide offline charging for the IMS network [2–5]. Offline charging is a process in which charging information for network resource usage is collected concurrently with the resource usage. At the end of this process, charging data records are generated and transferred to the billing domain. The media server provides a wide range of functions for multimedia resources, including provisioning of resources, mixing of incoming media streams, sourcing of media streams (for multimedia announcements), and processing of media streams. The IMS gateway is an interface between the CSCF and the OCS. The service control AS provides charging or other intelligent network service control as desired.

Service control in the IMS network is performed in the service control AS and the IMS gateway. As an example, assume the CSCF receives a SIP INVITE message to initiate a call session from a subscriber. If the call is a prepaid call, then the CSCF transmits SIP messages to the IMS gateway for service control. The IMS gateway or the AS queries the OCS for charging and rating for the call. If an announcement is needed, such as to inform the mobile subscriber of the number of minutes left in his/her account, then the IMS gateway and/or the AS may instruct the media server to play an announcement to the mobile subscriber. The OCS also reports to the billing domain regarding charging for the call.

One problem for service providers is having separate service control and separate charging when implementing both legacy networks and IMS networks. If new services and new service controls are implemented, the separate service control functions in the different networks have to be updated. Further, if charging or rating functions need to be updated, the separate charging functions of the different networks need to be updated. If there are separate charging service controls, the services will generate charging data records in different formats, which will require the billing domain to consolidate and reformat the CDRs. Updating and maintaining separate charging service control functions and separate charging functions can be costly and time consuming.

To overcome that shortcoming, Alcatel-Lucent developed a convergent service control (CSC) system—a brand new service control AS—that allows service providers to manage convergent call/session control and charging solutions for different networks. This can significantly protect the service provider's investment and save operations and maintenance costs. The convergent service control also enables the end user to have the same experience in different network environments. In this converged service control system, all the traditional IN services, e.g., 800 number routing and calling card service, are available to the SIP endpoints, and any new service control protocols introduced, the online charging system, and offline charging system will have minimal impact on the full charging capability reuse because of the unified standard charging interface application.

This converged service control system, which has never been deployed in traditional telecommunication wireline and wireless systems, creates a CSC architecture to support call/session control protocols for both legacy networks—such as wireline telecommunication networks and 2G Global System for Mobile Communications* (GSM*)/code division multiple access (CDMA) wireless networks—and IMS networks. The CSC also supports both online charging and offline charging via standard charging interfaces over Diameter [6]. This service control is not described in the 3GPP IMS architecture, so it is a unique solution.

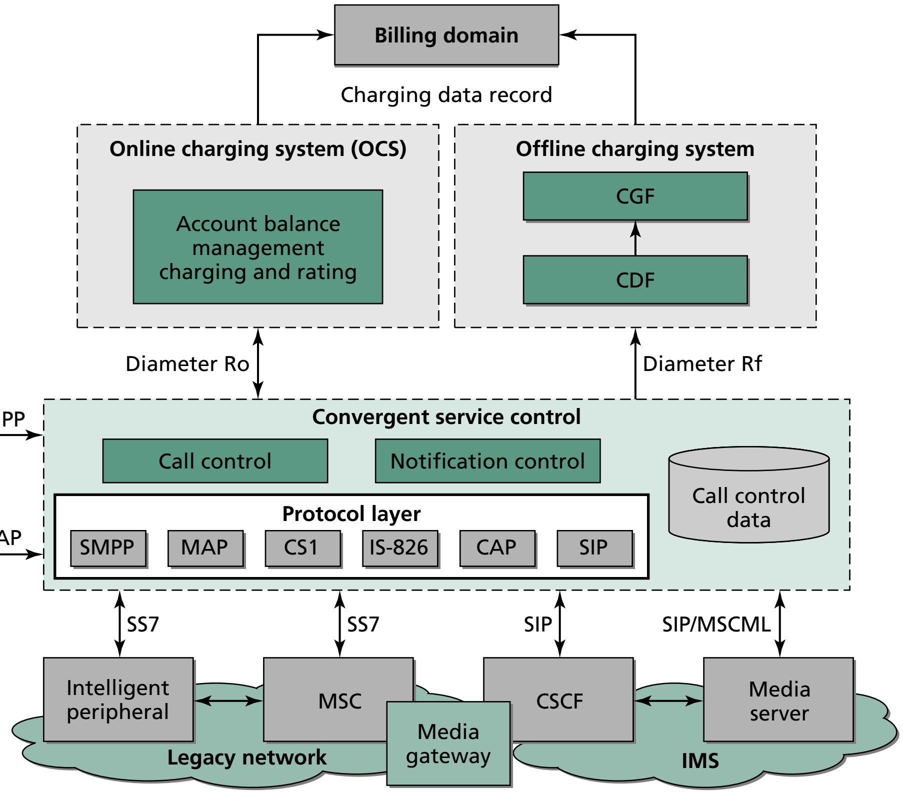
This paper presents an Alcatel-Lucent standalone IMS converged charging call control service that allows the convergence of online/offline charging for the bearer layer, IMS subsystem layer, and service layer, with call control over different networks.

Converged Service Call Controls

The converged service control system advantageously converges service control for both the legacy network and the IMS network into a single system. The converged solution allows for more cost-effective operation and maintenance of the service control functionality of both networks.

Figure 2 depicts the architecture and functionality of the CSC for legacy networks and IMS networks. The convergence of service control and charging allows for real-time control over different networks through a common system. The CSC provides convergence of charging for the different networks. The convergence of service control and charging saves service providers operations and maintenance costs when operating different networks.

The converged service control system combines service control capabilities for different services, e.g., voice, data, and multimedia, on both the legacy network and the IMS network and supports both online charging and offline charging systems. In a traditional intelligent network, it acts as an IN service control



CAMEL—Customized applications for mobile network enhanced logic
CAP—CAMEL application part
CDF—Charging data function
CGF—Charging gateway function
CS1—Capability set 1
CSCF—Call session control function
HLR—Home location register
IMS—IP Multimedia Subsystem
IP—Internet Protocol
IS—Interim standards
MAP—Mobile application part
MSC—Mobile switching center
MSCML—Media Server Control Markup Language
OCS—Online charging system
Rf—Reference point of offline charging
Ro—Reference point of online charging
SIP—Session Initiation Protocol
SMPP—Short Message Peer-to-Peer Protocol
SMSC—Short message service center
SS7—Signaling System Number 7

Figure 2.
Convergent service control architecture with online charging and offline charging support.

point, while in an IMS network, it acts as a service control application server and an IMS charging gateway (IMS GW). The CSC enables the endpoints of an IMS network to enjoy traditional IN services, e.g., 800-number service and calling card service, and enables service providers' online charging systems and offline charging systems (the charging data function and the charging gateway function) to support both the legacy network and IMS network with seamless correlation of bearer and service layer charging with little integration effort by maintaining unified online/offline charging protocols according to the Diameter reference point of online charging (Ro) and the Diameter reference point of offline charging (Rf) [4, 6]. Various intelligent network protocols and service control signaling are fully handled by this convergent service control, and abundant reusable service control services, i.e., the traditional IN services, can be available for the SIP endpoints on the Voice over IP (VoIP) call. Any new service control protocols introduced, the online charging system, and offline charging system will have minimal impact with full charging capability reuse because of the unified standard charging interface application. In other words, any new charging/rating/balance management functionality enhancements in the OCS or the CDF/CGF can benefit all networks supported by the CSC.

The converged service control system is in communication with a legacy network and an IMS network. When in operation, the protocol interface receives call messages from the legacy network with legacy protocols, such as Intelligent Network Application Protocol (INAP), Customized Applications for Mobile Network Enhanced Logic (CAMEL), or the American National Standards Institute's (ANSI's) Interim Standard-41 (IS-41). The protocol interface converts the call messages in the legacy protocols and IMS protocol to a common protocol used by the converged service control system. The service controller receives and processes the call messages in the common protocol for the legacy network and IMS network to provide IN service control.

The converged service control system further includes a notification system. To handle notification, such as providing announcements for a prepaid call, the service controller generates notification messages to provide notification to subscribers in the legacy network and the IMS network. If notification is needed for calls in the legacy network, then the notification system controls an intelligent peripheral or text message server to provide notification to subscribers in the legacy network. If notification is needed for calls in the IMS network, then the notification system controls a media server to provide notification to subscribers in the IMS network. The CSC notification system also can act as a common interactive voice response (IVR) system.

The converged service control system further includes online and offline charging interfaces. To handle charging for calls, the service controller generates charging messages to provide online charging and offline charging for the legacy network and the IMS network. If online charging is needed for calls in either the legacy network or the IMS network, the online charging interface transmits the charging messages generated by the service controller to an online charging system. If offline charging is needed for calls in either the legacy network or the IMS network, the offline charging interface transmits the charging messages generated by the service controller to an offline charging system.

The CSC Service Capabilities

Convergent service control provides the real-time call/session control services capabilities that are available to wireline and wireless users and SIP endpoints during the life cycle of the call/session from the start of call/session to the release of call/session, such as

- Call/session screening
- Advanced routing, such as 800 number routing and abbreviated dialing (ABD)
- Real-time notification to end users
- Third-party access
- Calling card service

Convergent service control can address means to support traditional services provided by the intelligent network from SIP endpoints for an IP-host-to-phone call. No matter whether the call request originates from the public switched telephone network (PSTN) or from a SIP endpoint, services to the call are provided by the data and procedures that reside in the same convergent service control.

Freephone

The CSC freephone service translates an 800 number to an actual routing number based on the location of the access point. A telephone in the legacy network and SIP endpoints in the IMS network can fully share the same 800 number repositories and service.

Abbreviated Dialing

The abbreviated dialing function allows end users to subscribe to a list of abbreviated dialing codes associated with frequently called destination numbers. When users select the abbreviated dialing option from the access menu, they are offered a personalized menu choice of up to 10 destination numbers that can be dialed with a single digit.

If the end user accesses a destination number via a short code, then there are an associated system abbreviated dialing number and a subscriber abbreviated dialing number. The system abbreviated dialing number is specified by the service provider, and the end user abbreviated dialing number is specified by the end user and stored by the CSC.

Help Desk Call

The end user can make a call to a help desk when assistance is required. The CSC will play a standard announcement to the caller to indicate the call is being routed to the help desk and the call is then connected to a service provider–provisioned help desk number.

If a help desk online charge has been provisioned, then the CSC will send a real-time charge request to the OCS via Diameter Ro to apply the charge to the subscriber's account.

Voice Mail

Service providers can specify the voice mail digits in the CSC. The specified routing numbers replace the dialed numbers when a subscriber dials a voice mail short code or his/her own telephone number to retrieve voice mail, or when an incoming call is routed to the subscriber's voice mail system for voice mail deposit because the subscriber is not reachable.

Third-Party Access/Calling Card Service

The CSC supports third-party access for wireless and wireline users and SIP endpoints. This can be used in cases when the end user's mobile phone cannot be used, or in cases when the end user wishes to use a wireline phone but have the call charged to a prepaid account, or the account is a calling card account that can be used by users to make calls and apply charges on it.

When end users dial a specified access number, they are connected using third-party access. Users are then prompted for their prepaid/calling card account identifier (ID) and personal identification number (PIN). After successful completion of the authentication procedure, users can dial a destination to make the call and apply an online charge to their prepaid/calling card account in the OCS. Menu options that can be accessed from the same number include features to

- Change the PIN
- Recharge the account in the OCS
- Request account information, e.g., balance and expiry date
- Transfer balance from/to another account

If an invalid account ID or associated PIN is entered, the caller will hear an appropriate terminating announcement or be connected to the help desk.

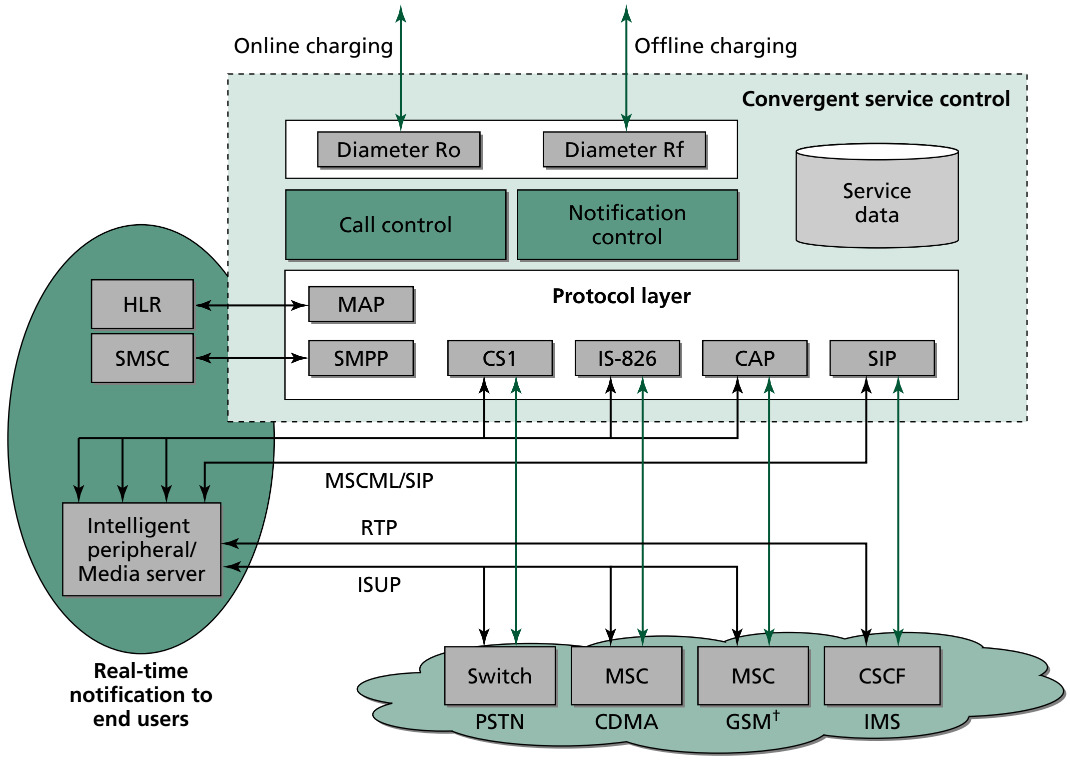
The CSC Common Notification and IVR System

The CSC has the capability of providing a common notification control system to adapt to different resource control protocols, such as the PSTN wireline Intelligent Network Application Protocol (INAP), CDMA wireless intelligent network IS-771 protocol, GSM wireless intelligent network CAMEL application part (CAP), and SIP (see **Figure 3**). The common notification control layer in the CSC covers different characteristics from the different protocol implementations, provides unified common control over the real-time notification service, and enables the notification service independently of the detailed network implementation. This convergent notification control capability significantly reduces the service provider's investment, as well as operations and maintenance costs.

The common notification control system allows interactive voice response service features. It will interact with end users to play courtesy announcements, handle prompt and collect functions, and generate warning tones. In a circuit switched network, the intelligent peripheral will be controlled by convergent service control via an out-of-bound intelligent network protocol, such as INAP, IS-826, or CAP. The intelligent peripheral also supports inbound ISDN user part (ISUP) signaling to communicate with the different core networks (such as GSM, PSTN, and CDMA) for voice information transmission from/to end users. In packet data networks, such as Voice over IP networks, the media server, which can be physically integrated with the intelligent peripheral, is controlled by the convergent service control via the SIP protocol. The Real-Time Transport Protocol (RTP) will be used to transfer the packet-based multimedia notification to the end user.

The CSC supports various end-user notification methods. Service providers can specify the method of notification, e.g., short message service (SMS), voice announcement, and unstructured supplementary service data (USSD) text, and the call points, e.g., precall, midcall and postcall, associated with the notification. In addition, the CSC supports multilingual variable complex notification, e.g., time, duration, amount, and currency.

A service provider can specify using voice announcements for the low-balance warning and short



CAMEL—Customized applications for mobile network enhanced logic
CAP—CAMEL application part
CDMA—Code division multiple access
CS1—Capability set 1
CSC—Convergent service control
CSCF—Call session control function
GSM†—Global System for Mobile Communications†
HLR—Home location register
IMS—IP Multimedia Subsystem
IP—Internet Protocol
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MSC—Mobile switching center
MSCML—Media Server Control Markup Language
PSTN—Public switched telephone network
Rf—Reference point of offline charging
Ro—Reference point of online charging
RTP—Real Time Transport Protocol
SIP—Session Initiation Protocol
SMPP—Short Message Peer-to-Peer Protocol
SMSC—Short message service center

†Registered trademarks of GSM Association.

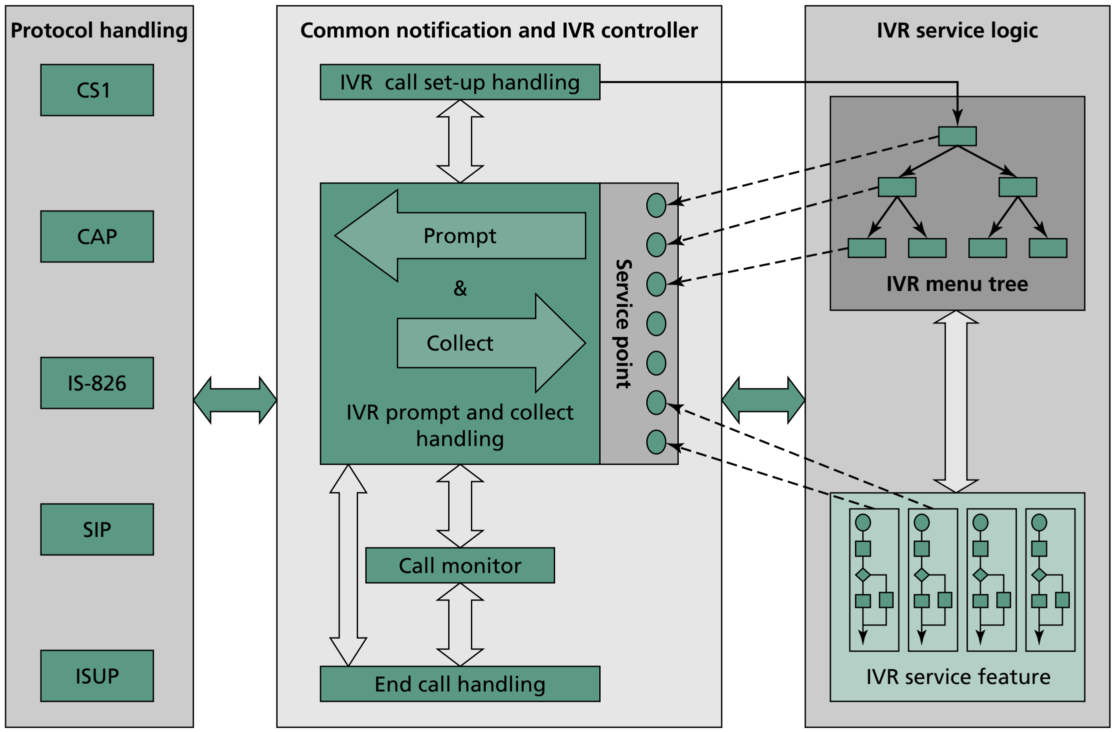
Figure 3.
CSC notification control architecture.

messages for postcall call duration notifications. Service providers can use multiple notification methods at the same time if required, or they can choose not to send notification.

The CSC provides a common IVR controller within the notification system to support the various IVR service features. The common IVR controller allows the service feature operation independently of the core network. The common IVR controller provides the following capabilities (see **Figure 4**):

- Call set-up handling
- Prompt and collection handling
- Call monitoring
- End call handling

Call start handling provides the capability to authenticate the subscriber account, and establish the call parameter for the IVR service feature use, such as call location zone, time zone, and roaming/home roaming. The call start handling will extract the IVR number to access the IVR menu tree.



CAMEL—Customized applications for mobile network enhanced logic
CAP—CAMEL application part
CS1—Capability set 1
IS—Interim standards
ISDN—Integrated services digital network
ISUP—ISDN user part
IVR—Interactive voice response
SIP—Session Initiation Protocol

Figure 4.
Common notification and IVR controller.

The IVR prompt and collect (PAC) is often invoked by the IVR menu transverse logic and the IVR service feature logic. The IVR menu transverse logic invokes the PAC to prompt the end user to the next step. On the basis of collected digits, the end user can transfer the other node in this IVR menu tree for further operation. The IVR service feature invokes the PAC to perform the specific service feature logic. Each location within the service logic, where a prompt and collect is desired to be invoked, is defined as a service point ID. The service point provides a uniform mechanism to allow the service provider to define the various PAC control rules. Each service point ID contains the following PAC control attributes:

- Maximum number of digits to collect
- Minimum number of digits to collect
- Interpretability, which indicates whether the announcement is interruptible or not interruptible
- Number of reprompts, reprompt announcement ID, and final reprompt announcement ID (these parameters control the number of times the service logic reprompts the user according to the content in the reprompt announcement ID, or the final reprompt announcement ID)
- First digit waiting timeout period, which indicates the timeout period for the first digit collection before the operation will be treated as an error
- Interim digit timeout period, which indicates the timeout period between dialed digits before the operation will be treated as an error
- End of reply digits, which indicate the dialed digit(s) that will cause the collected digits to be returned to the IVR call control
- Cancel digit, which indicates the dialed digit(s) that will cause the last collected digit to be deleted

- Accouchement group capability, which provides the group of announcements, including maximum and minimum announcement ID, and variable decimal digit announcement capability
- Dialed digit conform process, which specifies data for prompt and collect operations that require the user to confirm the supplied digits are correct by using the telephone keypad

On the basis of the announcement ID or data from the service feature, and the PAC control rule attribute data under this service point ID, the IVR controller will use the internal unified PAC operation to deliver this data set to the protocol layer for further message packaging, which is further prompted to the end user. The IVR controller will collect the digits supplied by the end user, then pass them to the IVR service logic for further handling.

The IVR controller is ignorant to the data semantic from the service logic; it is used only for the prompted data value from the service logic to control the prompt behavior. At the same time, the IVR controller only parses the digits collected from the network and passes them to the service logic for handling. This kind of capability enables the IVR controller to adapt to various networks and various service features.

The call monitor feature enables the IVR controller to maintain the IVR call state machine, which provides real-time monitoring of the IVR control status. An end call handling process is required for the network resource release procedure when the end user has exited from the IVR service.

The CSC Online and Offline Charging

Converged service control enables the service providers to support a unified real-time online/offline charging capability for the call/session in different network environments. Combined with the OCS, it can support session-based online charging capabilities: i.e., the credit control is applied during the whole life cycle of the call/session by having the CSC continuously reserve service units from the OCS. If credit is exhausted in the middle of the call, i.e., the CSC cannot request additional service units from the OCS, the CSC terminates the call/session by a release message to the service control protocols. For special services with surcharges, e.g., abbreviated dialing, the CSC can request the OCS to apply a surcharge by an event-based online charging interface. For example, in addition to the normal time-based call charge, the abbreviated call could be charged a one dollar access fee. The CSC can send a Diameter Ro event-based charging request to the OCS to indicate it is for an ABD surcharge; then the OCS can determine how much should be charged, one dollar in this example, to the balance of the user.

When combined with an offline charging system, the CSC also can support a real-time offline charging capability. The CSC can convert the real-time service control protocols, i.e., IN protocols and the SIP protocol, to a standard offline charging protocol according to Diameter Rf. The CDF can generate a charging data record based on the offline charging protocol. This solution conveys the charging information of a circuit voice call in the Diameter attribute value pair (AVP) service-parameter-info to maintain flexibility with the interface.

Online Charging

Online charging is a process in which charging information for network resource usage is collected concurrently with that resource usage in the same fashion as in offline charging; however, authorization for the network resource usage must be obtained by the network prior to the actual resource usage. The authorization is granted by the online charging system upon the request from the network.

With the support of the CSC, the online charging system can support mechanisms for the following:

- Online bearer charging to access/core network entities based on the Ro interface from the CSC.
- IMS online session and event charging via the Ro interface from the CSC.
- Online charging of applications/services that are provided to subscribers via service nodes (outside the core network), e.g., multimedia messaging service (MMS); the online charging interface to be supported is Ro.
- Correlation of bearer, service, and IMS online charging.

- Account balance management to external account management servers, e.g., recharge server.
- Generation of charging data records and transferring to the operator's postprocessing system.

When receiving a network resource usage request via intelligent network protocols or an internal service control (ISC) interface, the CSC assembles the relevant charging information and generates a charging event that is communicated to the OCS in real time. The OCS then returns an appropriate usage authorization. The resource usage authorization is limited in its scope, e.g., volume of data or duration. Therefore, the authorization has to be renewed from time to time by the CSC as long as the user requests the network resource usage. The CSC enables the OCS to support charging for legacy network resources with its unique Diameter Ro interface.

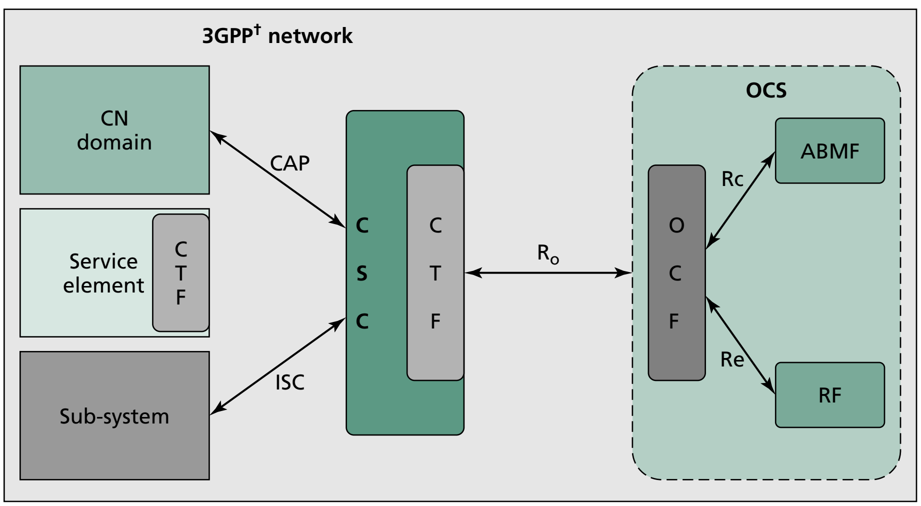
Figure 5 and **Figure 6** demonstrate how the CSC fits into the online charging architecture defined in 3GPP TS 32.240 [2] and TS 32.296 [3].

For IMS networks, the serving-CSCF supports online charging using [2–4]:

- The ISC interface, i.e., if the application server addressed over ISC is the IMS gateway function, or
- The Ro interface directly instead of the ISC, if the IMS gateway function is integrated within the S-CSCF.

On the basis of 3GPP TS 32.225 [4], the support of the ISC as the charging interface to the IMS CSCF requires additional functionality to be provided by the OCS. The support of Ro as the charging interface to the OCS requires additional functionality to be provided by the IMS CSCF.

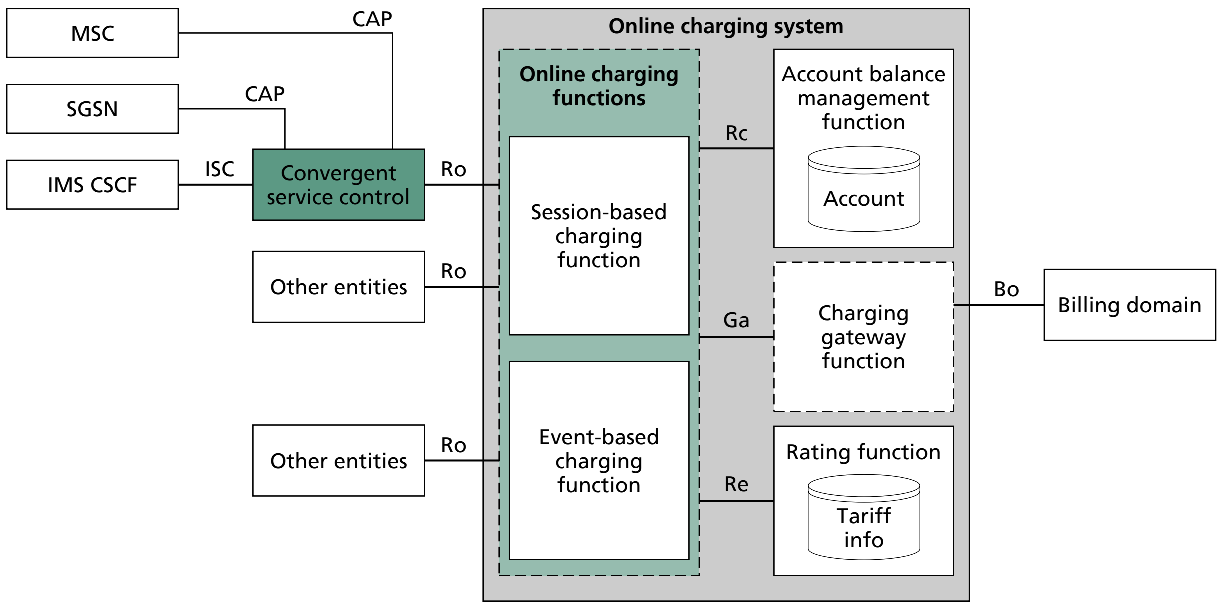
By introducing convergent service control as the IMS charging gateway between the IMS CSCF and



3GPP†—3rd Generation Partnership Project
ABMF—Account balance management function
CAMEL—Customized applications for mobile network enhanced logic
CAP—CAMEL application part
CN—Core network
CSC—Convergent service control
CTF—Charging trigger function
ISC—Internal service control
OCF—Online charging function
OCS—Online charging system
Rc—Reference point between OCF and ABMF
Re—Reference point between OCF and RF
RF—Rating function
Ro—Reference point of online charging
TS—Technical specification

†Trademark of the European Telecommunications Standards Institute.

Figure 5.
CSC in 3GPP† TS 32.240 online charging architecture.



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GPRS—General packet radio service
IMS—IP Multimedia Subsystem
IP—Internet Protocol
ISC—Internal service control
MSC—Mobile switching center
OCF—Online charging function
OCS—Online charging system
Rc—Reference point between OCF and account management
Re—Reference point between OCF and rating function
Ro—Reference point of online charging
SGSN—Serving GPRS support node
TS—Technical specification

†Trademark of the European Telecommunications Standards Institute.

Figure 6.
CSC in 3GPP† TS 32.296 online charging architecture.

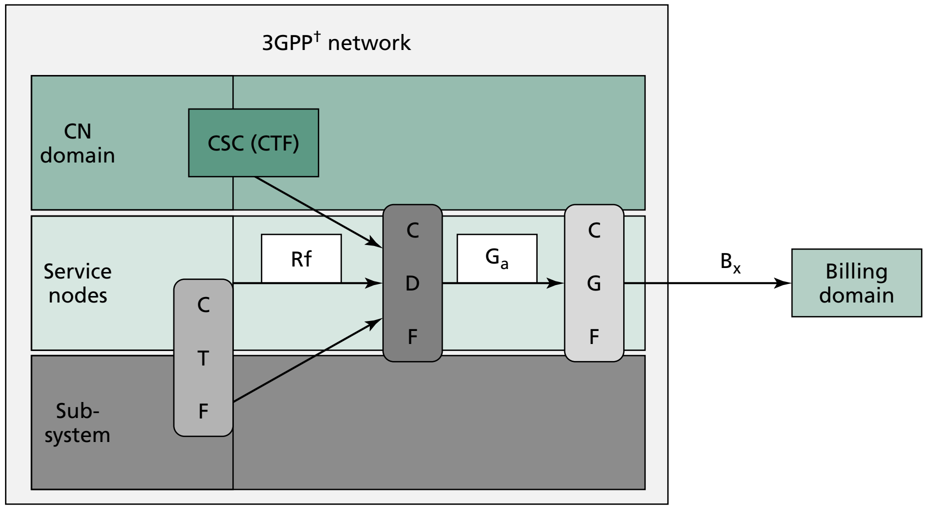
the OCS to translate the ISC interface to a standard Ro charging interface, service providers can easily support IMS session charging by the OCS, as demonstrated in Figure 5 and Figure 6. In addition, the OCS can support a unique Ro interface to provide online charging service for different networks.

In conclusion, the CSC enables the OCS to support charging for both a legacy network and an IMS network with its unique Diameter Ro interface.

Offline Charging

Offline charging is a process in which charging information for network resource usage is collected concurrently with that resource usage. The charging information is then passed through the offline charging system (a chain of charging functions). At the end of this process, CDRs are generated by the network, then transferred to the billing domain. The convergent service control acts as the charging trigger function (CTF) to support convergent offline charging for both the legacy network and the IMS network via a standard Diameter Rf interface, as depicted in **Figure 7.** This figure shows how the CSC is built into a 3GPP offline charging architecture. The offline charging system also comprises the charging data function and charging gateway function. The charging trigger function in the CSC translates traditional IN protocols to Rf and minimizes the impact to the legacy networks.

For IMS offline charging, the offline charging functionality is based on the IMS network nodes'



3GPP†—3rd Generation Partnership Project
Bx—Reference point between CGF and billing domain
CDF—Charging data function
CGF—Charging gateway function
CN—Core network
CSC—Convergent service control
CTF—Charging trigger function
Ga—Reference point for CDR transferring
Rf—Reference point of offline charging
TS—Technical specification

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Figure 7.
CSC in 3GPP† TS 32.240 offline charging architecture.

reporting accounting information upon receipt of various SIP methods or ISUP messages, as most of the relevant accounting information is contained in these messages. This reporting is achieved by sending Diameter accounting requests (ACR)—such as Start, Interim, Stop, and Event—from the IMS network elements to the CDF.

On the basis of real-time IN protocols, either ISUP or SIP, the convergent service control supports the real-time offline charging interface Rf—accounting requests Start, Interim, Stop and Event—to send the call/session-charging request to the offline charging system with the full resource usage information. The offline charging system will generate charging data records and transfer the CDR files to the billing domain.

The CSC Example Call Scenario

Figure 8 shows a typical CSC call scenario supporting IN IS-826 [8] triggered call origination in a CDMA network.

1. The serving MSC receives a mobile station (MS) call origination with dialed digits.
2. The serving MSC detects the Origination_Attempt_Authorized trigger and sends an ORREQ to the CSC associated with this trigger.
3. The CSC determines the subscriber is valid and authorized to make a call and then sends an orreq to the serving MSC to indicate that call processing shall continue. If the location information is available in the message, it should be stored for location-based service control services, e.g., call screening or advanced routing.
4. The serving MSC analyzes the dialed digits and prepares to route the call. The MSC detects the Calling_Routing_Address_Available trigger and sends an ANLYZD to the CSC associated with this trigger. At this point, the CSC can apply enriched service control services to the call, e.g., call screening or advanced routed.
5. The CSC identifies the subscriber as having online charging service active and sends the credit control

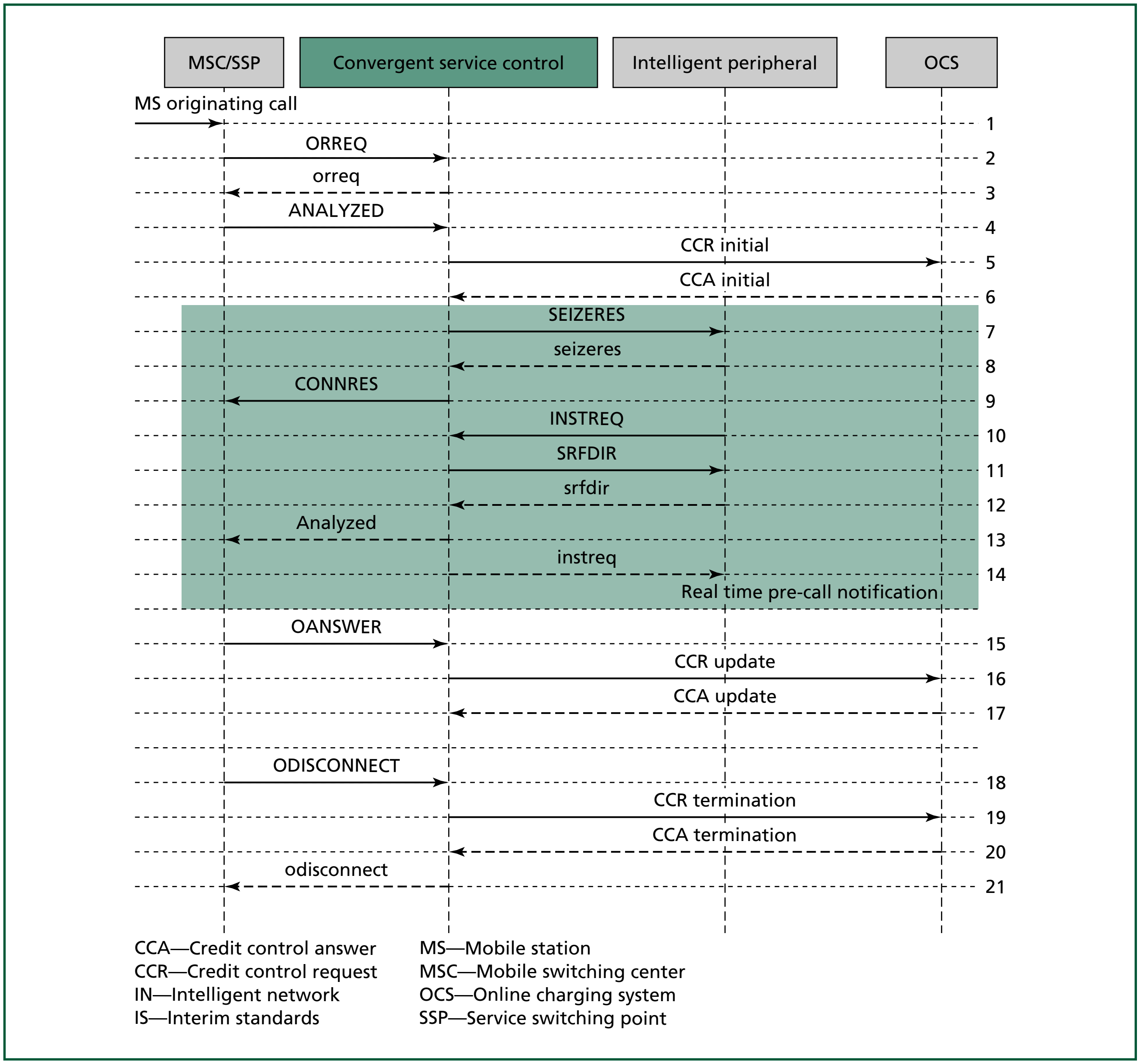

Figure 8.
Example scenario of call origination with real-time charging for IN IS-826 trigger.

request (CCR) to the OCS to initiate the charging session.

6. The OCS determines that the subscriber's account balance is sufficient for the call to begin and that a reserved quota exists for the call. The OCS sends the granted quota and other charging/account information to the CSC. The quota can be either volume of data or duration.
7. The CSC determines that the service is to play a precall announcement regarding the residual balance and the cost of the call. The CSC sends a SEIZERES to an intelligent peripheral to request the resource.
8. When the IP receives the SEIZERES, it allocates a temporary local directory number (TLDN) to the appropriate resource. The TLDN is returned to the CSC in the seizeres.
9. The CSC sends a CONNRES to the serving MSC with instructions to set up a call leg to the IP using the TLDN. The serving MSC sets up the call leg to the IP.

10. When the call is detected at the IP, the IP sends an INSTREQ to the CSC to request processing instructions.
11. The CSC sends an SRFDIR to the IP with the ANNLIST/execute script parameter, indicating the announcement should play. The IP plays the announcement indicated by the ANNLIST/execute script parameter.
12. The IP sends an empty srfdir to the CSC.
13. The CSC sends an anlyzd to the serving MSC. The serving MSC releases the call leg to the IP.
14. The CSC sends an instreq to the IP to conclude the CSC-IP conversation.
15. The serving MSC extends the MS originated call. The call is answered by the called party. The serving MSC detects the O_Answer trigger and sends an OANSWER to the CSC associated with this trigger. Upon receipt of the OANSWER, the CSC sets the call start time and starts the timer based on the duration of the quota size returned in the CCA from the OCS.
16. If the quota timer times out, the CSC sends the CCR update request type to the OCS to request additional quota.
17. The OCS determines the new rate and reserves the new quota for the call. The granted quota is sent via the CCA update back to the CSC. The CSC restarts the quota timer to monitor the call usage. The call is cut through and connected. Note that steps 16 and 17 might repeat each time the granted quota is exhausted at the CSC.
18. The (calling) MS ends the call. The serving MSC detects the O_Disconnect trigger and sends an ODISCONNECT to the CSC associated with this trigger.
19. Upon receipt of the ODISCONNECT, the CSC sums the call usage and sends it to the OCS.
20. The OCS calculates the total cost of the call and applies the charge to the subscriber's account.
21. The CSC sends an odisconnect to the serving MSC. The serving MSC releases the call.

Conclusions

This paper previewed a concept of systems and methods to provide converged service control and converged charging in legacy networks and IMS networks. A converged service control system includes a protocol interface and a service controller. The protocol interface receives call messages from both legacy networks and IMS networks and converts the call messages to a common protocol. The service controller then processes the call messages in the common protocol to provide service control to the legacy networks and the IMS networks. The service provides real-time call/session control during the life cycle of the call/session for various legacy and IMS services. The converged service control can interwork with the OCS to support session- and event-based online charging capabilities, and with the CDF and billing system to support real-time offline charging capabilities. The converged service control also interworks with different media resource functions to support IMS and legacy IVR and notification services.

*Trademarks

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