IN-OSA Call Model Mapping for Circuit Switched Interworking with IMS

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Abstract— **In the Internet Protocol Multimedia Subsystem (IMS), call switching is provided by IP based call controllers. In addition the IMS architecture has to support circuit switched features for compatibility with existing PSTN networks. This requires the IMS switches operate as service switching points (SSP) for the public switched telephone networks (PSTNs), with intelligent network (IN) features. IN switches are set with a call model in each switch which provides access to distributed service logic. IMS uses the session initiation protocol, which has a state model that is different to the IN call model. There is a need for application servers (AS) on top of the IMS network to provide the necessary service intelligence to support IN services, as well as IMS services. This requires a mapping from the IN call model as well as the SIP state model to that understood by the AS. This mapping allows services to be transparently supported across both the circuit switched and packet switched networks. This paper examines a mapping between the capability set 1 (CS1) IN call model, and the SIP Invite Dialog, using the OSA/Parlay application server as the interworking function. In particular the Parlay Multiparty Call Control call model is used as the basis for the mediation.**

I. Introduction

A primary goal of an advanced service architecture is a standardised, open Application Programming Interface (API). An API offers the possibility of operator inter-operation, transportable code and cost effective service creation, rapid development of new services and a single adaptable platform able to interwork with a multitude of networks [1]. The OSA/Parlay API, as a result of industry co-operation, has been providing these benefits since the first set of interface specifications was published in 1998 [2].

IMS, the IP Multimedia Subsystem, is a SIP based telecommunications architecture that *enables* advanced IP services by means of application servers (AS) on top of the IMS network [3]. With three different AS envisioned in the 3GPP standards, as shown in figure 1 [1], [3], network operators must choose from:

- Use a CAMEL AS which supports the large number of legacy services for 2G mobile networks, but is inadequate for multimedia triple play services.
- Use a SIP application server, which whilst robust, is often a proprietary vendor implementation and thus more difficult to develop services on than a standardised platform, as well as not conducive to third party interworking. Circuit Switched services are not easily supported since state models differ.
- Use a OSA/Parlay gateway AS solution, which can interwork over multiple heterogenous networks, provide secure third party interfaces and web services, open standardised API for services, and cope with services ranging from the CS domain to IP multimedia streaming.

A key factor in the success of service interworking is the interworking of the call model, which can also be described as a protocol state machine [4]. The OSA/Parlay AS has a call model, which as will be shown, can be mapped to both circuit and packet switched networks. OSA/Parlay is thus the evolutionary path for service provisioning from a circuit switched domain to a packet switched IMS domain.

II. Call State Models

An abstraction of the call is required for any telecommunications service. Dobrowolski *et al.* [5] found that a call model can be found for any communication session. For simple request response type services the call model required is often simplistic type that does not require involvement of an application server.

Many simple CS services can be mapped to IMS without the need for an AS, however services with mid-call operations or media path interaction are considered to be easier to implement in application servers [4].

III. IN Service Triggering

Each Service Switching Point (SSP) within the IN network is armed with a trigger table, which is par-

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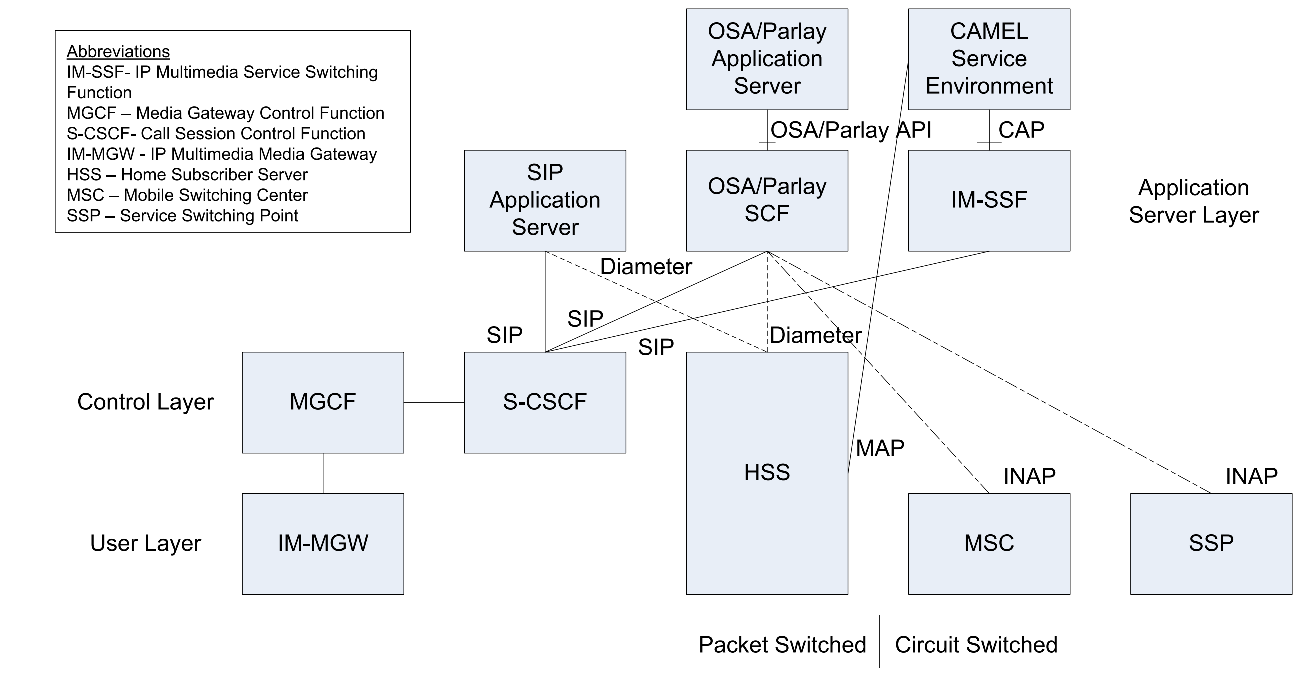

Fig. 1. IMS-CS OSA/Parlay Interconnection [1], [3]

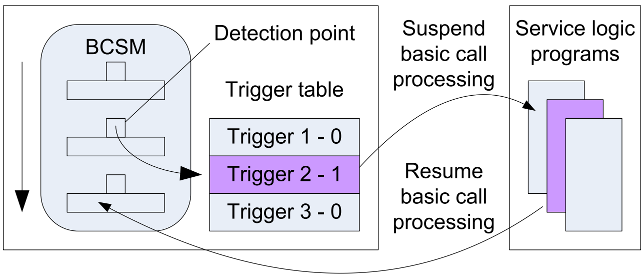

Fig. 2. Detection of IN service calls in the switch [6, pg. 65]

titioned according to the number of detection points within the Basic Call State Model. The trigger table, in addition to the detection points, contains criteria for each point, indicating the conditions which are necessary for a notification to be issued to the service layer, and how to process the trigger once activated.

When a detection point is triggered, the routing of the notification is queried to ensure the correct service logic program receives control. During call processing, the SSP steps through the BCSM and checks each detection point. If an active trigger is detected then the call execution is suspended and control is passed to the appropriate service logic program within the service control point (SCP), as in figure 2 [6].

The SCP service logic analyses the information it receives from the SSP and resolves how to continue processing the call. This decision is sent back to the SCP, and could result in a change in the state of the call. IN call processing is not limited to simple request response type transactions, but can also include other entities for extended durations, for example the switch may be prompted to connect the caller to an Interactive Voice Response unit for additional digit collection, or enable additional event detection points within the SSP for further service invocation.

A. *OSA/Parlay Application Server Triggering*

The OSA/Parlay gateway contains a number of network adapters, allowing the gateway to be connected to IMS entities as well as PSTN equipment, as shown in figure 1. The OSA/Parlay SCF behaves like an IN Service Control Point, controlling the resources of the switches based on the service logic in the AS.

In the case of a circuit switched application, the OSA/Parlay application requests the setting of a trigger point with the Call Control Manager object within the OSA/Parlay SCF. The OSA/Parlay SCS logic then arms the required trigger or event detection points within the switch. The OSA/Parlay SCS receives the detection point notifications from the underlying CS network when appropriate and presents it to the Call Control Manager, which creates an appropriate call leg object to represent the incoming trigger. The application is notified and the required logic is executed.

Being able to provide service logic for both the IMS and IN domain simultaneously ensures that the OSA/Parlay gateway is able to best support services in all migration scenarios.

IV. SIP SERVICE TRIGGERING

IMS triggers services in a similar fashion to CS networks, the initial information string is analysed, compared to the trigger table, and if appropriate the application server is notified. The IMS elements can be divided into multiple planes as shown in figure 1, where it is clear that IMS is a call/session signalling protocol network, and as such does not have any advanced service intelligence without the application servers. However service activation is more flexible in IMS as each user has a individual profile that is analysed to determine the unique service requirements of the user.

For the case of IMS service triggering, all the required OSA/Paraly trigger detection points are stored in the HSS as service information data, which is loaded into the S-CSCF as user specific initial filter criteria upon user registration. Service-triggering information is presented in the form of initial filter criteria [3]. Initial filter criteria have trigger points, as well as service point triggers. The filtering in the S-CSCF is based on the initial request messages such as REGISTER, INVITE, SUBSCRIBE, and MESSAGE [7].

The users' initial filter criteria are downloaded to the appropriate S-CSCF, either on user registration for an event, or on initiating a call. The S-CSCF then passes relevant messages to the OSA/Parlay SCF which updates or creates the required state information for the call leg object, and triggers application logic.

V. OSA/Parlay-CS Mapping

We consider IN capability set 1 (CS1), as this demonstrates the principle of operation, which can be extended for more complex call models. Mapping from the CS1 BCSM to the OSA/Parlay MPCC Call Leg object state transition is performed considering the state entry and exit events. Not all notifications received from the CS network correspond to a transition. OSA/-Parlay has defined a limited set of notifications from the MPCC Manager to the corresponding Call Leg objects.

Both the CS1 call state model and the OSA/Parlay Multiparty Call Control call state model have half call models, separating the originating and terminating cases. Many of the CS1 detection points correspond closely with OSA/Parlay notifications. The call state mapping for the originating basic call state model is shown in figure 3. Note that the OSA/Parlay call state model has been simplified for the sake of clarity and does not show all the possible transitions. We demonstrate that the CS1 call state model detection points can be mapped as shown in table I.

The call state mapping for the terminating basic call state model mapping is shown in figure 4, again a simplified state model is shown. CS1 BCSM detection points can be mapped as proposed in table II.

From section III and IV it is clear that there has to be a mapping from the underlying network state model to a corresponding OSA/Parlay MPCC Call Leg object.

VI. OSA/Parlay-SIP Mapping

SIP Dialogs are used to model the state of SIP calls, in particular the INVITE initiated dialog. In an Internet Draft by Rosenberg *et al.* [8] a dialog finite

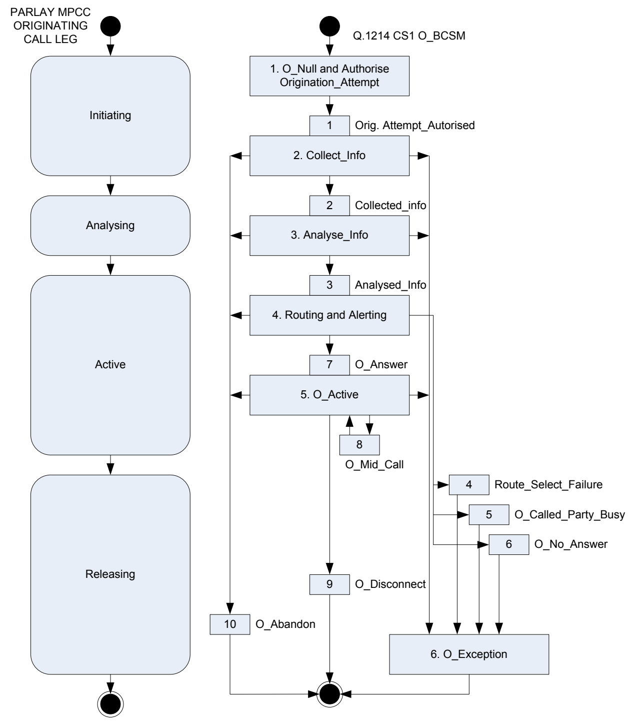

Fig. 3. CS1 Originating BCSM and OSA/Parlay MPCC Originating Call Leg Mapping

TABLE I
ORIGINATING DETECTION POINTS AND OSA/PARLAY MPCC NOTIFICATION MAPPING

IpAppMultiPartyCallControl-Manager.reportNotification-(Originating_Call_Attempt_Authorised)	Orig_-Attempt_Authorised
IpAppMultiPartyCallControl-Manager.reportNotification-(Address_Collected)	Collected_Info
IpAppMultiPartyCallControl-Manager.reportNotification-(Address_Anaylsed)	Analysed_Info
IpAppMultiPartyCallControl-Manager.reportNotification(Answer)	O_Answer
IpAppMultiPartyCallControl-Manager.reportNotification-(Redirected)	O_Mid_Call
IpAppMultiPartyCallControl-Manager.reportNotification-(Originating_Release)	Route_Select_Failure O_Called_Party_Busy O_No_Answer O_Disconnect O_Abandon

TABLE II
TERMINATING DETECTION POINTS AND OSA/PARLAY MPCC NOTIFICATION MAPPING

IpAppMultiPartyCallControl-Manager.reportNotification-(Terminating_Call_Attempt_Authorised)	Term_-Attempt_Authorised
IpAppMultiPartyCallControl-Manager.reportNotification(Answer)	T_Answer
IpAppMultiPartyCallControl-Manager.reportNotification-(Terminating_Release)	T_Called_Party_Busy T_No_Answer T_Disconnect T_Abandon

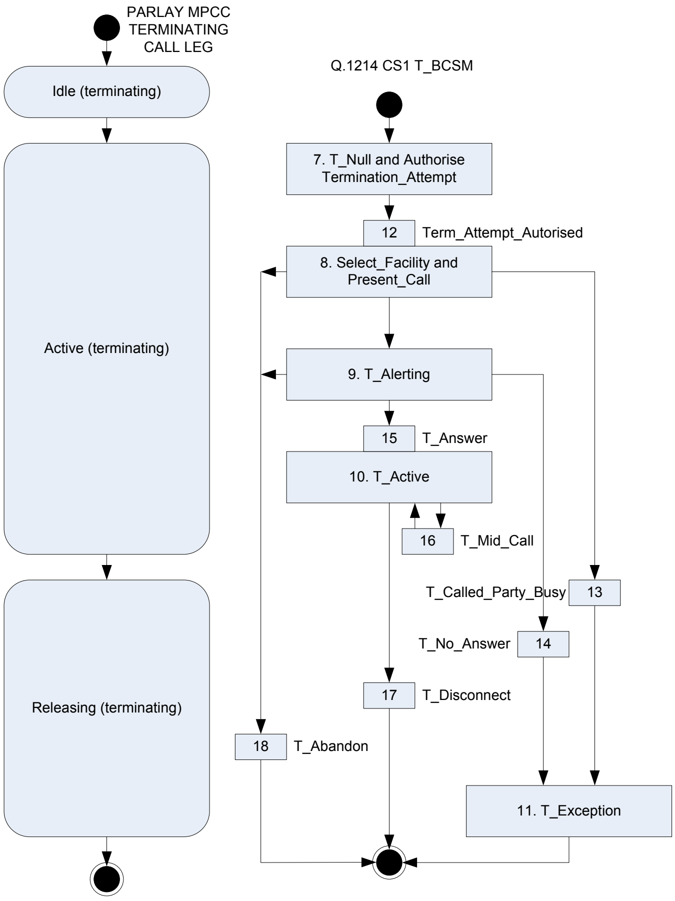

Fig. 4. CS1 Terminating BCSM and OSA/Parlay MPCC Terminating Call Leg Mapping

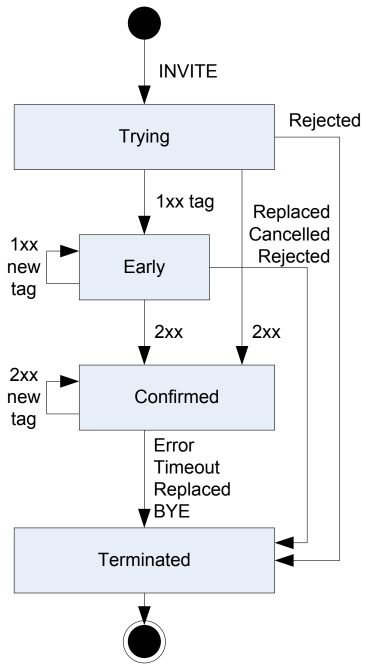

Fig. 5. SIP INVITE Dialog FSM [8]

state machine is presented that combines the state for both the case of the originating UAC and terminating UAS. This dialog models state from the initial INVITE message through to the disconnecting BYE message. We assume that all provisional responses have a tag for dialog identification. The `Proceeding` state can then be ignored, and any provisional 1xx response causes a transition to the `Early` state, as shown in figure 5.

A mapping is required between the SIP state machine and the OSA/Parlay state machine if OSA/Parlay is to provide services as well as service interworking between the IMS network and the CS network. Thus we propose a mapping as shown in figure 6. The MPCC originating states `Initiating` and `Analysing` correspond to the SIP dialog state `Trying`, since an INVITE message causes a transition to `Trying`, and similarly CreateAndRouteCallLeg() originates a call leg. The `Early` and `Confirmed` states correspond to the MPCC Call Leg `Active` state, as a provisional SIP response corresponds to a OSA/Parlay Address Analysed or Answer notification. The mapped states do not overlap and clear boundaries are preserved in the mapping as recommended by Vermuri *et al.* [9].

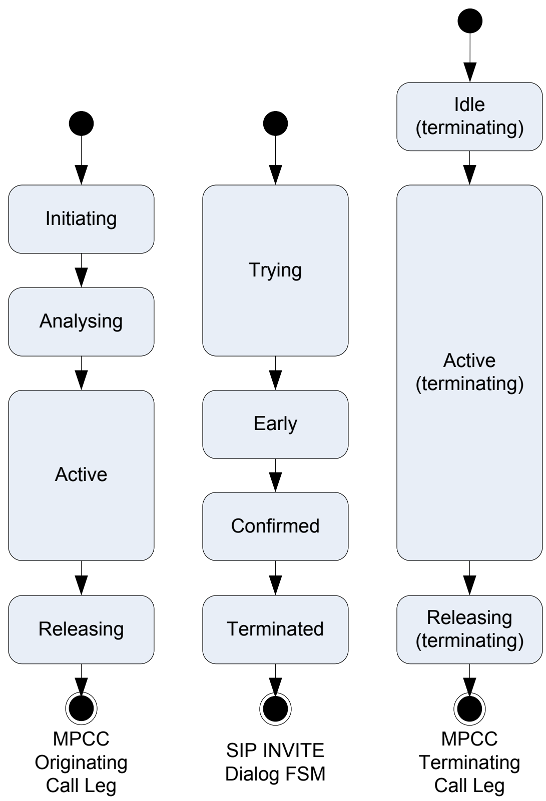

Fig. 6. SIP INVITE Dialog FSM and OSA/Parlay MPCC Mapping

VII. CS-IMS INTERWORKING EXAMPLE

The following examples show how interworking between a circuit switched and IMS network can be performed with the supervision of the OSA/Parlay application server. In these examples both the case of a call originating from the circuit switched and IMS domain are examined. Whilst not all messages are shown, the alignment of the corresponding state models is highlighted with respect to the proposed mappings.

In the following examples the OSA/Parlay gateway is broken into a number of elements: the SIP Server and IN CCF/SSF to enable translation between IN ISUP and IMS SIP; the Service Capability Server logic to deal with detection point processing; the MPCC manager and associated call leg objects for the multi-party service capability feature; and lastly the OSA/Parlay Application logic contained within the OSA/Parlay AS.

In the first example a call is made by a circuit switched subscriber towards a subscriber in an IMS network, as shown in figure 7. The circuit switched originating Initial Address Message (IAM) is forwarded to the OSA gateway, which determines that a trigger has been set and notifies the SCS logic, the SCS logic processes the notification and informs the call manager object in the MPCC service capability function. It is assumed that triggering is done from the home network, ie there is an INAP connection to the OSA/Parlay gateway. A new call leg object is created to represent the originating leg, and its state is set to `Active`, as corresponding to the mapping in figure 3. The application is notified and creates a call leg object for the terminating party with the required information, the state set to `Active`. Call processing for the originating call leg is resumed, resulting in a `Continue` INAP message to the switch, resuming basic call processing. The IAM is sent to the media gateway control function which translates it into an INVITE, creating a dialog in the `Trying` state. Once a provisional ringing response is received, the `Early` state is entered, and an address complete message is returned to the exchange switch, resulting in the terminating BCSM going to the `T_Alerting` state. A 200 OK message is received by the MGCF when the call is answered and the terminating half of the BCSM transitions to the `T_Active` state, after reporting the t_answer detection point and alerting the application.

In the second example a call is made from the IMS network to a circuit switched subscriber, as shown in figure 8. An INVITE request sent from the IMS subscriber is identified by the S-CSCF initial filter requirements as requiring OSA/Parlay application processing. The S-CSCF proxies the INVITE to the OSA/Parlay SCS using the ISC interface. In our example the application requires the OSA/Parlay SIP part to operate in a B2BUA mode for maximum call control, thus there is a logical terminating user agent for the INVITE message, which is set to the `Trying` state. A call leg object is created to represent the call in the OSA/Parlay SCF, and its state is set to `Active`, as in figure 6. The application is invoked, and an additional call leg is created, which is set to the `Initialising` state. The call leg is requested to route the call to the specified destination, and the call leg state changes to `Analysing`. The OSA/Parlay SCS is required to act as a local user agent, proxying the modified received INVITE message to the destination. The originating user agent state is set to `Trying`, and the INVITE is sent to the MGCF. The MGCF translates the SIP INVITE into an IAM, and once the circuit switched party answers, a 200 OK message is returned. This results in the SIP call state in the originating user agent to transition to `Confirmed`. The OSA/Parlay call leg object is informed and enters the `Active` state, as per figure 6. The application is informed of the circuit switched party answering. The 200 OK message sent to the IMS subscriber and after the acknowledge voice communication can take place via the IM-MGW.

VIII. CONCLUSION

We have examined the role of the OSA/Parlay application server in the IMS network, supporting the transition from a circuit switched IN network to IMS. The Parlay AS is shown to be able to support services in both the IN domain as well as the IMS domain. We have shown a mapping is required between the IN BCSM, the Parlay AS and the IMS SIP state model, and provided mappings between the models. Our proposed mappings preserve state boundaries, and do not overlap, ensuring that ambiguous states do not occur. Examples of CS originated and IMS originated calls are given to show the role of the OSA/Parlay AS in the interworking of the call models.

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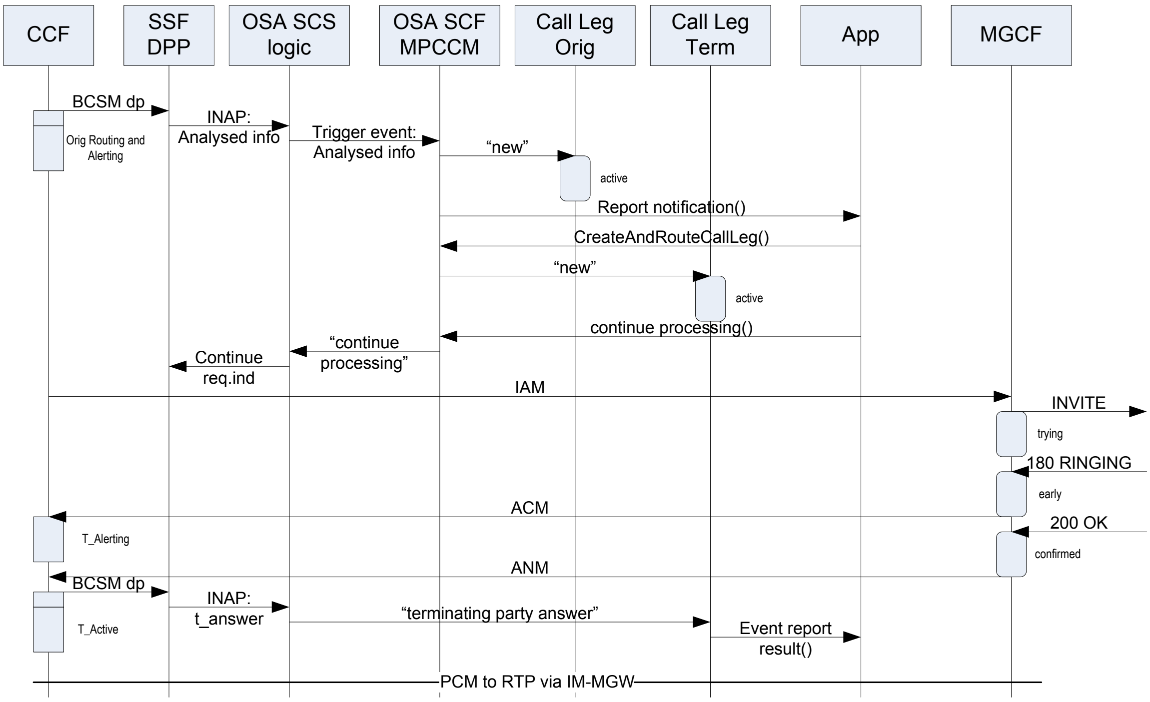

Fig. 7. Circuit Switched Originated Call to IMS subscriber

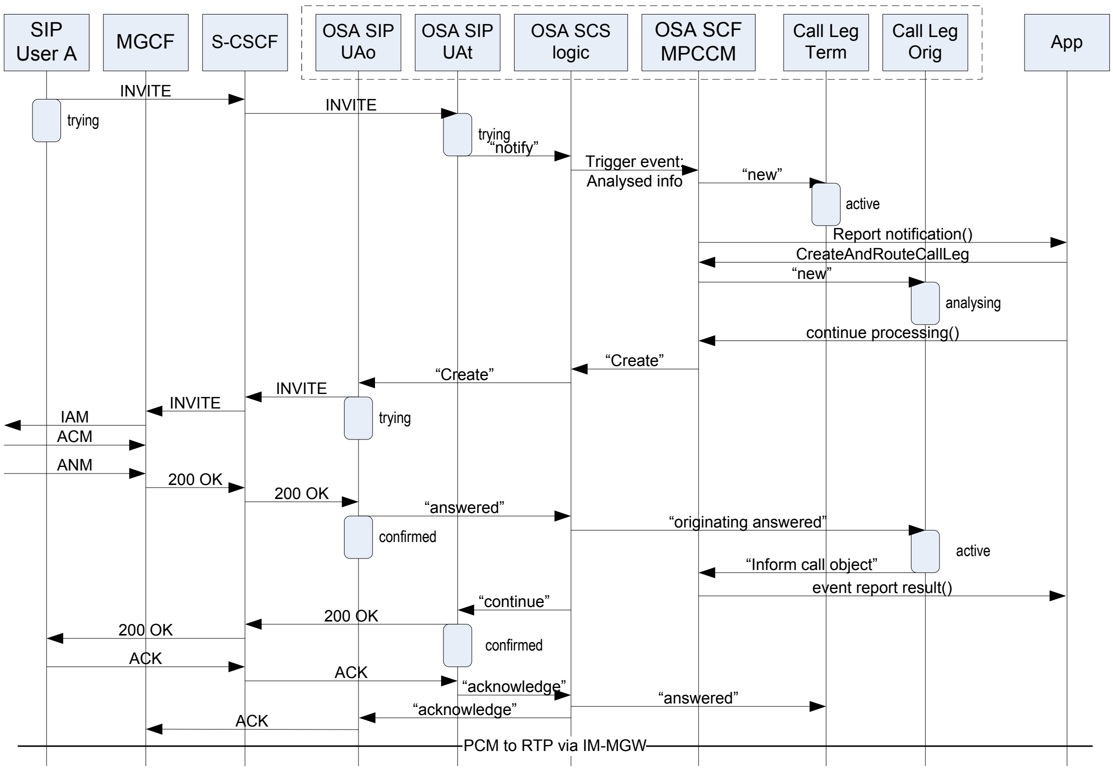

Fig. 8. IMS Originated Call to Circuit Switched subscriber

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