

Presence and Real Time Streaming Protocol (RTSP) for Feature-rich Session Continuity in the IP Multimedia Subsystem (IMS)

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Abstract—The IP Multimedia Subsystem has largely been standardized. Of critical importance is the development of services which exploit the rich functionality and deployment environment provided by the IMS. However, the age-old challenge of mobility management still persists at the IMS layer. While substantial research has been done focusing on this issue, the approaches taken have largely been at lower layers of the protocol stack. Recent higher-layer solutions, on the other hand, have not directly focused on the specific challenges and opportunities presented by IMS multimedia session continuity. Further, the expressive and feature-rich information from presence service, and the interactivity of the RTSP protocol have largely been ignored. This paper presents a proof of concept scenario-based analysis of how presence information and the RTSP protocol can be leveraged to provide an enhanced multimedia session continuity experience. It presents an introduction of the session continuity service, overviews related work and outlines the framework for an enhanced session continuity experience.

Index Terms — session continuity, feature-rich service scenarios, multimedia, RTSP, mSCTP, IMS

I. INTRODUCTION

The proliferation of multi-modal communications devices, the era of heterogeneous access networks, and the vast range of access-independent multimedia communication services present many interesting, yet technically challenging service scenarios. A feature-rich multimedia communication session between users would typically require: a) devices with many capabilities such as voice and video calling, instant messaging, file transfer, etc., b) QoS guarantees from the network, c) session-level mobility management, d) appropriate charging schemes, e) in-call session adaptation schemes (adding/removing/editing parts of the communication session), and f) a context-aware service environment.

One of the main challenges is session-level mobility management, which, although has enjoyed much attention from researchers, continues to be a hot topic. In the context of IMS, session mobility falls under the scope of service continuity.

Service continuity is one of the key requirements of the 3GPP Evolved Packet System [1]. It refers to the uninterrupted continuity of an ongoing communication session when a user's device changes radio access technologies (RAT). From a service perspective, mobility management aims to ensure session continuity with a maintained level of QoS when users move across access networks, administrative domains, or change devices.

Some of the earlier proposed solutions in literature can be grouped into their different approaches to this problem. Many address the problem as purely a mobility issue and focus on lower layer protocols such as Mobile IP (MIP), including its many derivatives and extensions [2], [3], [4]. Others propose cross-layer mechanisms which use information from different layers of the protocol stack [5], [6], [7]. A third body of work realizes that these approaches are insufficient when the mobility events are transparent to the IMS layer. They thus focus on higher layer (transport and application) protocols such as SIP [8], RTSP [9] and mSCTP [10].

Higher layer solutions have proved very attractive as they incorporate user-level information to manage a session during a mobility event. Further, a feature-rich service scenario will be realized when a communication session can be flexibly adapted, enhanced, or transferred across networks or devices based not only on mobility events, but also user preferences, their presence status, changes in device state, and changing network conditions. A key effort towards this is the current standardization work in 3GPP which specifies session continuity as a rendered service to IMS subscribers [11]. It aims to address terminal and session mobility issues when the mobility events are transparent to the IMS layer.

In this paper, we present a brief overview of the IMS multimedia session continuity service, discuss related work in literature and identify how current approaches have lagged behind in addressing the evolving challenges and demands of such feature-rich interactive communication services in the context of session continuity. We propose and validate through scenario test cases, enhancements to the multimedia session continuity service.

The following section introduces the session continuity service, section III outlines the proposed enhancements to the service, followed by the evaluation architecture in section IV. Sections V and VI present the discussion and conclusions of the paper.

II. IMS SESSION CONTINUITY AND RELATED WORK

A. Work in Progress Standardization

The multimedia session continuity service has three aspects: 1) packet switched to packet switched (PS-PS), 2) packet switched to packet switched in conjunction with packet switched to circuit switched, and 3) mobility of different components of a multimedia session between devices of the same user. The last scenario is a common situation whereby a user owns a number of IP enabled

devices and can access subscribed services using any device through different access networks. Specifically, it provides the ability to transfer an ongoing multimedia session from one device to another, with either all or only some of the media components (e.g. video only) being transferred. Some of the architectural requirements of the service are:

- Additional signaling load should be minimized
- Service disruption due to multimedia session continuity should be minimized
- When transferring multimedia sessions across networks, there should be no requirements of new functionality on the remote party
- Users not subscribed to the service should not be affected negatively.

These requirements aim to ensure that the service can be easily integrated into existing IMS networks. It should be fully compatible without requiring major modifications on the network or other end user devices.

The work in [11] defines a Multimedia Session Continuity Application Server (MMSC AS) located in the Applications and Services layer of the IMS. It provides service authorization, control and execution to IMS subscribers. The server hosts a session transfer operator policy which is used by the network for resource management, capacity optimization and network performance enhancement. The policy is communicated to subscriber's UEs, which they consult when initiating session transfer.

As session transfers are normally initiated by UEs, based on user preferences, control therefore lies mainly with the user, and not the network. The session transfer operator policy thus provides a way for the network to exercise tight control to minimize the effects of too many transfers during high traffic periods.

B. Approaches to Session Continuity

A large amount of research exists which focus on session mobility and session transfers. Traditional approaches mainly address the lower layer challenges of session mobility. The aim is to achieve bare minimum functionality of ensuring that a handover occurs from one network to the other. In [12], factors including monetary cost, network conditions, power consumption, QoS requirements, etc. are used as parameters for access network selection decisions. The aim here is to address the general problem of heterogeneous network connectivity, without necessarily focusing on session continuity. Notably, [13] proposes a SIP-based approach which uses event notifications to signal an impending vertical handover. The notifications provide the address, handoff probability, coverage status, and handoff type (vertical or horizontal). The aim here is also to minimize handoff delay, packet loss, and minimize additional CPU usage. Although focusing on SIP, the proposal would require considerable modification for a fully IMS-compliant deployment.

An important feature is discussed in [14] of sharing state information across different access networks. This exchange is performed by 'middleboxes' which are intermediary nodes in the respective networks, and aims to support service continuity. Before a handoff occurs, middleboxes use a context transfer protocol to exchange information such

as media protocol type, used ports, session ID, traffic type, new and old IP address etc, for the handoff-target network to prepare in advance for an incoming handoff. The results discussed show a successful session reestablishment after handoff, which again only shows functionality.

The IMS-based approach in [15] conceptualizes a Mobility Server, essentially a session continuity application server as discussed in this paper. It is also closely aligned with the developing IMS session continuity standard. The proposal however, is purely theoretical and does not provide any detail of validations, or proof of concept implementation performed.

Recent work, termed project IHMAS (IMS-compliant Handoff Management Application Server), is discussed in [16] which uses handoff predictions and application-layer content adaption, to provide "optimized vertical handoff management". The solution monitors link conditions, and when a handoff is predicted, it triggers IMS handoff signaling on the new network while still maintaining the ongoing session on the original network. Context information is then used to perform session adaptation for the conditions of the new network. Evaluations showed a successful handoff and adaptation of an audio stream across different networks. This work, however, was only limited to audio streaming handover, and did not consider video streams.

An RTSP-proxy is proposed in [9], which aims to reduce signaling latency. It caches responses from an RTSP server, and later mimics the server by replying locally to the client when it issues requests previously encountered by the proxy, thus shortening the signaling path. Although not directly focused on the IMS, this concept can be easily incorporated in the work proposed in this paper.

Another proxy-based approach is discussed in [10]. It exploits mSCTP's multi-homing capability by using a device's second interface to establish a second media path on a new network for handoff. Similarly, this approach could be investigated further for possible integration or interworking with the work presented in this paper.

III. FEATURE-RICH MULTIMEDIA SESSION CONTINUITY

A. Scenario-based analysis of Session Continuity and Session Transfer

The previous sections discussed the different aspects of multimedia session continuity, and described session transfer as an enabler for a seamless session continuity experience. The following scenario discussions aim to highlight an important distinction between the terms "seamless session continuity" and the "session transfer" function. Recognizing this seemingly slight, yet crucial distinction, yields better understanding and clarity when placing performance requirements on candidate protocols and solutions proposed for addressing session continuity issues.

Scenario 1: A user is involved in a video call using a video-enabled cellphone in an outside environment, served by a 3G network. They then enter their home network and decide to transfer the multimedia session, in part or as a whole to the higher bandwidth home IP network, to which a larger screen device is connected. The session transfer is

initiated either manually by the user, or by preset preferences, or any other appropriate mechanisms.

In this scenario, the user may strictly require seamless session continuity during the session transfer, i.e. the media continues to flow smoothly without interruption during the transfer to the new device.

Scenario 2: A user is watching a VoD stream through a device in one location, e.g. WiFi hotspot using a laptop. The user then decides to leave the WiFi coverage area but wishes to continue the stream on a PDA while on the move, using 3G coverage. As the user packs up the laptop, the session need only be transferred to the PDA without the strict requirement of seamless session continuity, i.e. the media can be halted, while session transfer information is transferred to the new device, after which the flow is then reestablished. This is a case of session transfer, without the strict requirement of continuous media flow imposed by seamless session continuity. This clear distinction between session transfer and session continuity, better informs the performance requirements placed on a candidate solution.

It is clear from the above analysis that in the first case, the protocol chosen for performing the transfer must ensure continuous media flow, to ensure no user-perceivable discontinuity in the media during the transfer. There are various approaches in literature [18], [19], which use make-before-break, in which a duplicate media path is established towards the new device before terminating media flow on the original device. A high-level view of this is shown in Figure 1.

It should be noted that the diagram is only indicative, and thus only reflects the essential signaling messages. In brief, it shows a request from UE-1 to UE-3, to transfer the session to UE-2. UE-3 immediately initiates the transfer, and UE-2 acknowledges and establishes media flow with UE-3. The UE-1 to UE-3 media flow is then terminated.

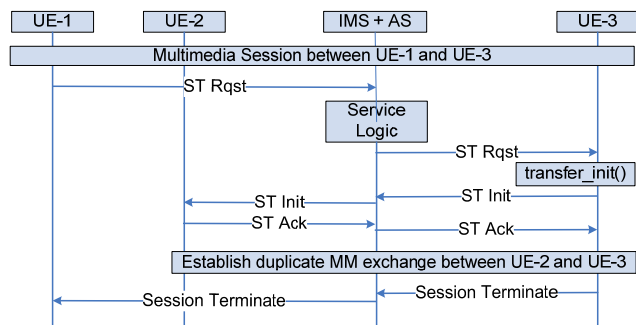


Figure 1: Make-before-break session transfer

A second approach is break-before-make; where the media flow is discontinued on the original device, and then immediately reestablished on the new device. The challenge here is to minimize the duration of the discontinuity to as near to zero as possible.

B. Presence-Enhanced Multimedia Session Continuity

Traditionally, session mobility and handovers are triggered by degrading network conditions, such as loss of coverage and low QoS [12]. Factors such as user preferences and session transfer operator policy [2] introduce more customization and add more intelligence to the handover or transfer decision.

Both the calling and called party are subscribed to the session continuity service. The multimedia communication session between the calling and called party is affected by both the session transfer operator policy and the configured user preferences settings on the UEs.

However, this information alone is insufficient to yield a feature-rich session continuity experience. A more dynamic approach is to incorporate presence information [17], a rich service-enabler that can provide much more customization and automation of the management of incoming session transfers and call terminations. The incorporation and integration of presence information with other services has gained a lot of interest and led to the rich communication suite initiative [21], [22].

In the context of session continuity, the communication parties publish their session transfer management information, to which the application server subscribes. It is thus notified of each party's status regarding willingness to communicate, and at which device they wish to be contacted. An extract of the simplified presence information is shown below.

```
<?xml version="1.0" encoding="UTF-8"?>
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:mmsc="urn:ietf:params:xml:ns:pidf:mmsc"
  entity="sip:bob@mmscontinuity.test">
  <tuple id="Cellphone">
    <status>
      <basic>open</basic>
    </status>
    <contact priority="0.5">
      <teluri>tel:+27-12-345-6789</teluri>
    </contact>
    <note>Emergencies only!</note>
  </tuple>
  <tuple id="UCTIMSClient">
    <status>
      <basic>open</basic>
      <contact priority="0.85">
        <mmsc:p-
gruu>sip:bob@mmscontinuity.test;gr=mylatestcellphone</mmsc:p-gruu>
        </contact>
        <mmsc:capabilities voice="true" video="true"/>
      </status>
    </tuple>
    <tuple id="IPTV">
      <status>
        <basic>closed</basic>
      <contact>
        <mmsc:p-
gruu>sip:bob@mmscontinuity.test;gr=myiptvscreen</mmsc:p-gruu>
        </contact>
        <mmsc:capabilities>
          <mmsc:audio surroundsound="true"/>
          <mmsc:video highdefinition="true"/>
        </mmsc:capabilities>
      </status>
    </tuple>
  </presence>
```

Listing 1: Presence information for feature-rich session continuity

Listing 1, for example, informs the session continuity service to direct incoming calls and transfers primarily to the user's IMS client. A social presence status informs watchers that the telURI is to be used for emergencies only, while also publishing device capabilities of the preferred UE for IPTV.

From the network's perspective, strict control of network resources is enforced by the transfer policy; this is illustrated in Figure 2.

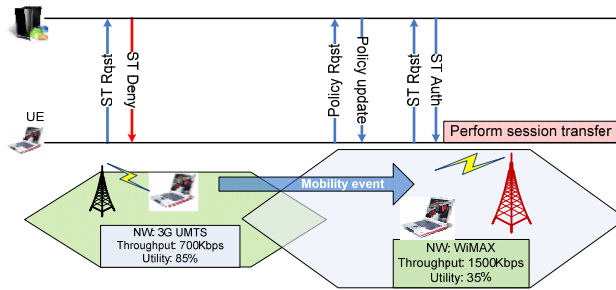


Figure 2: Session Transfer Operator Policy. Note how the network conditions affect the UE's permission to initiate a session transfer.

The transfer policy prevents the initial transfer request due to resource management purposes. The UE moves to a less utilized network, queries an updated policy, which then allows it to proceed with the desired transfer.

Based on up-to-date presence information and the session transfer policy for each subscriber, the AS makes appropriate decisions regarding which registered UE is chosen for call terminations.

C. RTSP for Feature-rich Session Transfer

RTSP is a feature-rich media control protocol enabling the user to perform VCR-like commands on an on-demand multimedia stream. It gives the user commonly expected remote control powers when watching a video.

It can establish and control one or more time-synchronized audio/video streams. The protocol defines a session between a client and a server identified by a session ID. It is independent of the underlying media delivery protocol and can thus use a connection-oriented or connectionless transport protocol [23].

It is this transport layer independence and powerful media control features, blended with rich presence information and the session transfer policy which are the basis of the proposal in this work. The scenarios discussed in the following section, together with the service requirements mentioned in the previous section will illustrate how the modus operandi of RTSP can be exploited to provide a rich session continuity experience for the user within a multi-device heterogeneous network environment.

IV. ARCHITECTURE AND EVALUATION PLATFORM

A. Testbed Architecture and Tools

This section describes the tools used in the evaluation. These include the UCT IMS Client [24], the FOKUS Open IMS Core [25], and an application server based on the SailFin project [26], a JSR289 compliant SIP Servlet technology based on the Sun GlassFish application Server [27].

UCT IMS Client: This is an open source freely available IMS client, developed to be used in conjunction with the FOKUS Open IMS Core. The client is extended with session continuity functionality, enabling it to initiate and receive session transfers.

FOKUS Open IMS Core: This is an open source implementation of the core IMS elements, namely, the

Home Subscriber Server (HSS), the Proxy, Interrogating, and Serving Call Session Control Function (P/I/S-CSCF).

IPTV: The IPTV implementation is an experiment currently under development which uses an Indirection server, and a 3rd party RTSP-enable media server. The open source Darwin streaming server is used as the media server.

MMSC Application Server: The application server is a JSR289 SIP Servlet application deployed on the SailFin application server.

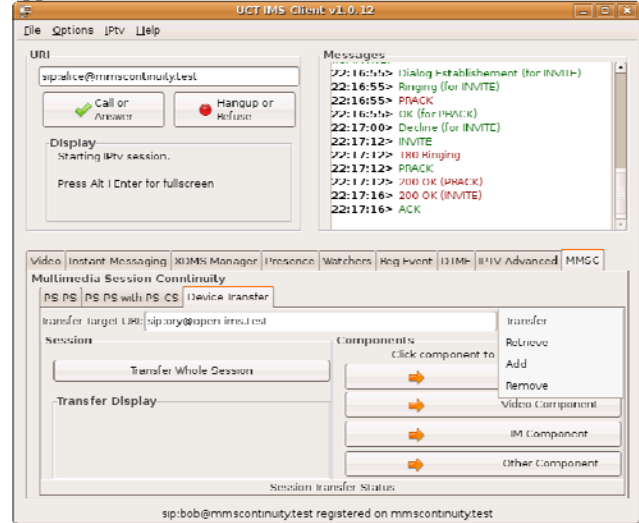


Figure 3: Session Continuity Functionality for UCT IMS Client

Figure 3 shows the IMS Client with buttons for performing voice, video and instant messaging session transfer.

Figure 4 shows how the application server is integrated to the IMS test-bed. It is added through a web console to the IMS core, which links it with user profiles, service profiles, and filter criteria.

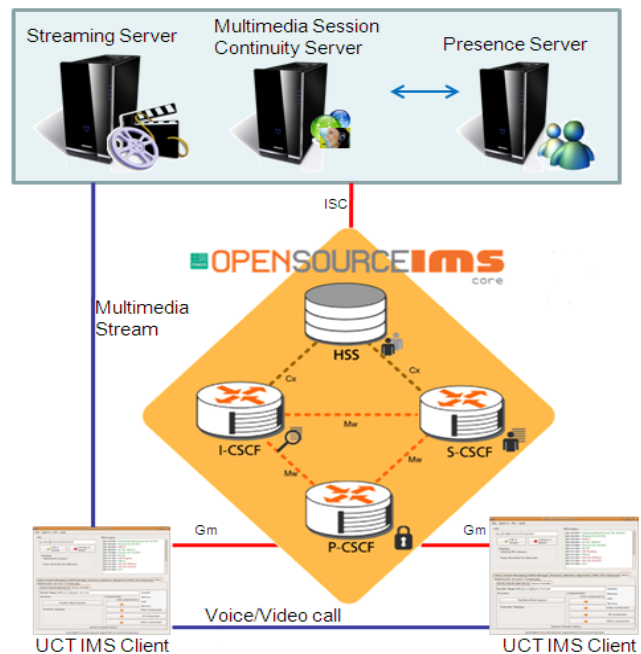


Figure 4: Integration of the IMS Core, the Client, and Application Server

B. Scenario Implementation

A proof of concept scenario implementation is shown in Figure 5. In this scenario, the application server is subscribed to UE-2's presence status. A user has two UEs, UE-1 and UE-2. UE-1 is the preferred device for video on demand, and UE-2 is mainly used for video calls.

In the diagram, the session continuity server subscribes to the user's presence status. When the invite is issued for IPTV, the session is anchored at the server, which allows it to extract information useful for session transfer. After establishing the video stream, UE-1 sends a SIP publish message, indicating that the user is watching a video. This information is then sent to all watchers subscribed to this event, which includes the session continuity server.

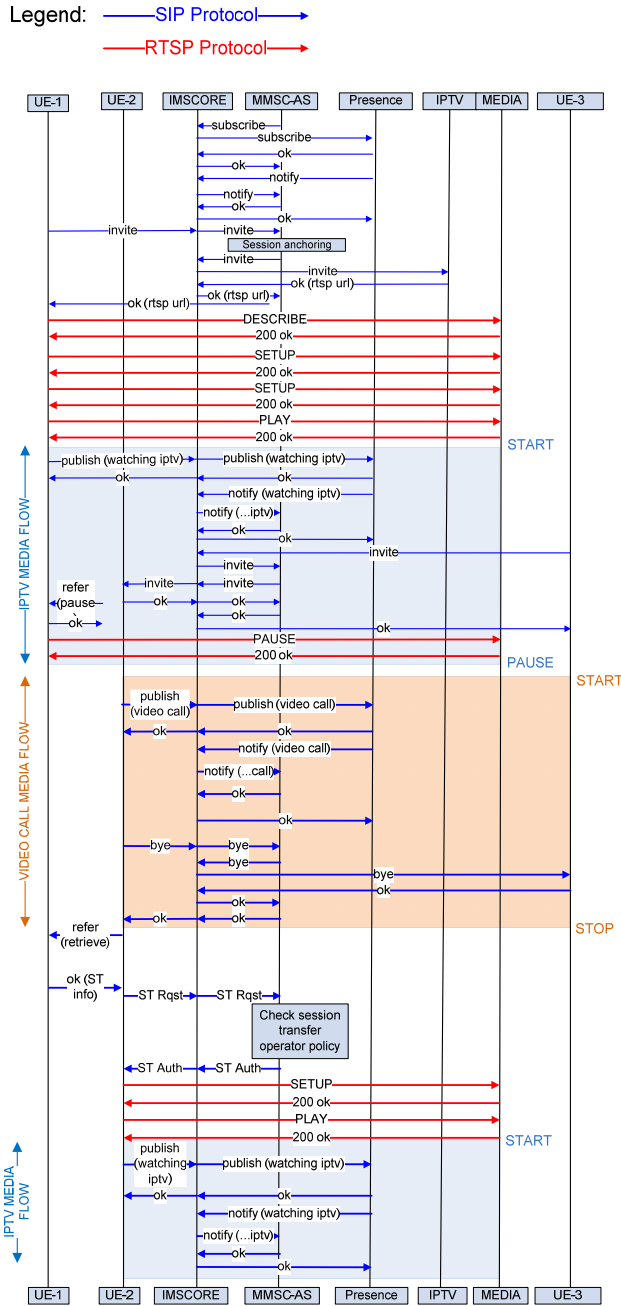


Figure 5: Signaling for Feature-rich Session Transfer Scenario

When a UE-3 calls the user, the application server sends it to UE-2 which is the preferred device for video calls. UE-2 takes the call and instructs UE-1 to pause the IPTV session. The presence information is updated by UE-2 to reflect that the user is now on a video call, and all subscribed watchers are informed of this. After call termination, the user decides to leave and continue the IPTV session on UE-2. UE-2 then sends a SIP refer message to UE-1, with session transfer information indicating session retrieval. UE-1 replies with the required session transfer information, such as media URL, the session ID, and related SIP and RTSP information.

UE-2 uses this to request a session transfer, which is checked against the transfer policy by the session continuity server. The transfer is authorized and UE-2 proceeds with the RTSP signaling to resume the media flow. This is then followed by the normal presence information update, which now indicates that the user is watching IPTV on UE-2. It should be noted that the normal SIP ACK messages are intentionally omitted from the figure to preserve space.

V. DISCUSSION AND ANALYSIS

A key indicator of the effectiveness of a solution is how it compares to the original service requirements. The implementation is therefore evaluated against the session continuity requirements mentioned in section II.

The implementation introduces presence to IMS session continuity, a service enabler which is already IMS compliant. This ensures compatibility with existing IMS deployments. Further, the session transfer signaling in this scenario occurs between the UE-1 and UE-2, without requiring any new functionality on UE-3. The remote UE, therefore, does not require any upgrading for session continuity functionality. Media flow is halted when an incoming INVITE message is received. This pause in media flow is in fact a feature of the RTSP protocol, which allows a media stream to be paused and resumed during play.

This enhanced session continuity service is subscription-based. The application server signaling is, therefore, only invoked for users subscribed to the service.

VI. CONCLUSIONS

The standardization of multimedia session continuity service has provided a solid point of departure for tackling the age-old challenge of session continuity. While a number of solutions have been proposed to this problem, they have mainly focused on media manipulation protocols which only aim to manage packet flow, redirection, buffering and delay. Further, none have attempted to address the session continuity scenarios identified in the developing 3GPP standard.

We have presented a novel approach to enhance the multimedia session continuity service, which uniquely blends the rich functionality of the RTSP protocol, a powerful service enabler – the presence service, and the standards-proposed session transfer operator policy. The work has shown that a much more enhanced, dynamic and interactive session continuity experience can be realized, while ensuring compliance with the specified service requirements in the developing 3GPP standards on multimedia session continuity.

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