DELIVERING SERVICES TO RESIDENTIAL APPLIANCES BY UTILIZING REMOTE RESOURCE AWARENESS

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Abstract**—***Service providers are nowadays offering a variety of services, and in particular multimedia content delivery. Besides, consumer appliances are increasingly becoming digitalized including support for communication networks. However, it is difficult, and in many cases impossible, to use these services with standard consumer appliances, such as TV and media player devices. Rather, usage is often restricted so that they can only be accessed through web browsers from PCs, mobile phones and similar terminals. This is unfortunate, because dedicated consumer appliances are often better suited to handle the content and thereby give consumers a better experience. Within this paper, three design approaches that support such services are described and compared, along with a prototype that shows this concept.*

Index Terms**—Residential network, IMS, SIP, presence, multimedia systems, service discovery**

I. INTRODUCTION

SERVICE PROVIDERS are nowadays offering a variety of services, and in particular multimedia content delivery. For example, Internet TV, Video on Demand (VoD) and real-time streaming of events, such as sport and concerts, can be enjoyed from the Internet. Besides, consumer appliances are increasingly becoming digitalized including support for communication networks. In [1] a use case for a personal media portal is described that shows how these two aspects can be combined. However, it is difficult, and in many cases impossible, to realize this use case by using these external services together with standard consumer appliances, such as TV and media player devices. Rather, usage is often restricted so that they can only be accessed through web browsers from PCs, mobile phones and similar terminals. This is unfortunate, because dedicated consumer appliances are often better suited to handle the content and thereby give consumers a better experience.

Within residential networks service discovery protocols (SDPs), such as Universal Plug & Play (UPnP) [2] and Apple Bonjour [3], are used to be aware and utilize resources and services, including those provided by consumer appliances. Through these SDPs, applications can be aware of and utilize services in the network. For service providers to be able to deliver content to consumer appliances they also need to be aware and have access to these appliances. However, because the SDPs have been designed to work only in local networks, service providers cannot directly utilize them. This limitation is, of course, good when it comes to illegitimate access to residential services, but it also denies service providers to discover and communicate with these residential services. Therefore, a solution to enable this legitimate remote access is necessary.

Remote service discovery, enabled with service presence, promises such a solution to this problem. Residential networks publish service presence information (including service status and a service description) to a central location. Authorized users, such as service providers, can utilize this presence information to access and use remote services [4]. Thereby, richer applications can be created that allow users to utilize their residential services together with their IM identity.

However, there are many different possible solutions based on these enablers. In this paper, we describe different solution approaches (Section IV) and compare them against each other (Section V).

II. A LOOK AT CURRENT SERVICE DELIVERY

Today, many service providers utilize web applications for user access to their services. With the advances of web technology, such as Ajax, rich applications can be created [5]. For online video services, such as TV2 Sumo [6], usually a web page is presented to users where the content is selected. Then, the content is shown in an embedded media player, where also the trickplay options, such as playback, are controlled.

However, the usability of the service is limited because it can only be consumed within a media player embedded in the web browser instead of an external target device. Notably, the media player selection step, part of the use case described in [1], is excluded. One workaround for this coupling is to fetch the Uniform Resource Identifier (URI) [7] from the information returned by the service and transfer it, using an ad-hoc mechanism, to the target device. Nevertheless, because many systems enforce access control and charging on content, such a workaround has limited effect. Additionally, such workarounds severely cripples the user experience.

Furthermore, it is also desirable to use different data channels for controlling the session and retrieving the content. For example, it should be possible to control the session using a mobile phone with a cellular link, while the media is received using a fixed broadband connection. This way, the user's identity on the mobile phone will be used for authentication, authorization and accounting (AAA) and session control, and it is freed from handling the media and forwarding it to the target device.

III. Common Enablers for Residential Service Delivery

Although there are different possible solutions for the delivery of remote services into residential appliances (see section IV), they share a set of underlying requirements. These requirements are fulfilled by some common enablers that will be part of any of the possible solutions. The enablers are introduced and explained within this section.

A. Signaling protocol for converged services

As implied in section II above, currently online services are delivered through web applications based on the Hypertext Transport Protocol (HTTP) [8]. This protocol has shown to be a great success and is widely adopted and used. However, the lack of a signaling plane becomes problematic when, for example, the service (i.e. the service data, e.g. media data in case of media services) is supposed to be transmitted to a different device than the one that has actually initiated the service and requested the data.

The Session Initiation Protocol (SIP) [9] is an application layer signaling protocol for managing sessions between multiple participants. Thereby, the service session can be controlled using SIP, while at the same time the media can be transported using HTTP.

B. Identity Management and the Generic Authentication Architecture (GAA)

Identity management is an important piece of next-generation networks that will be explained briefly in the following. The IMS operator deploys a Bootstrapping Server Function (BSF), and the application server (AS) provides as Network Application Function (NAF). If a User Equipment (UE) requests a service from the AS for the first time, the AS will demand that the UE must be authenticated using GBA. Thereafter, the UE and the BSF mutually authenticate using a shared secret. As a result, a pair of session keys is generated by the BSF, and one of the keys is delivered to the UE. The UE responds back to the AS with the received session key, where after the AS requests the BSF to authenticate the user by providing the session key. The BSF returns the authentication result and finally the AS approves that the UE is authenticated. Besides high security, this process has the advantage that it can be completed without the user having to type in a password.

C. Remote Service Awareness

The underlying method to make application servers aware of remote residential devices and their services is based on an extension to the IETF's Presence model [10] termed *Service Presence*. This extension is based on the transport and provision of service related information through SIP networks, such as IMS. Information about devices and services discovered in one network environment are transported via the common communication infrastructure to another, remote network environment. For that it uses an extended presence data model including generic descriptions for services, including a service access interface description, parameters, and service state values. This allows a presence watcher in the application server to be aware of the remote devices and services.

The architecture that realizes this Service Presence concept includes four logical nodes, as explained in the following.

1) *Service Presentity:* A residential appliance like a Digital Media Renderer uses a Service Discovery Protocol (SDP) mechanism (for example, UPnP) to publish its own services within the residential environment.

2) *Service controller:* The Service Controller is an entity that discovers services, using the same SDP mechanism as the service providers, and controls or uses them.

3) *Service Discovery Gateway (SDG):* The SDG is responsible for the discovery of services in its vicinity (via SDP) and for the publication of their presence to make them available for remote access.

Furthermore, it can subscribe to receive service presence information from other SDGs.

4) *Service Presence Server (SPS):* This node is introduced in the core network to support the SDGs by collecting service presence information from them. This offloads the SDGs with the task of notifying all presence watchers.

IV. Design Approaches

In the following, three design approaches are presented that support using residential services as part of a session. These approaches differ in the point of time when the selection of the target media player happens compared to the content selection in the service, provided as web application: before the content selection, after the content selection, and an integrated selection (i.e. both happen in the service's web application). As will be shown, this opens up for different roles for the nodes involved in the session.

Common for all solutions is that GAA (see III.B) is used to handle authentication and authorization between the service and the user when necessary. In addition, only requests are shown to simplify the sequences.

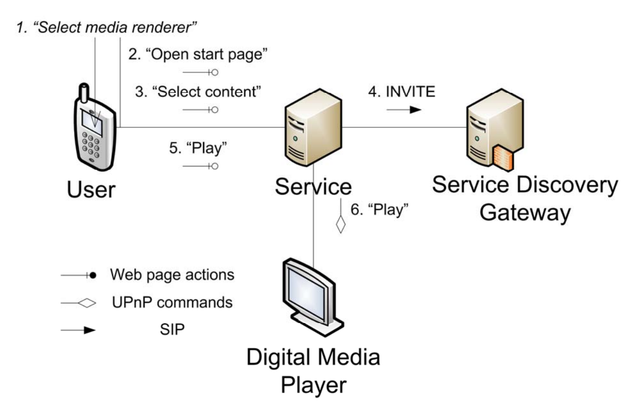

Fig. 1 Pre-selection solution.

A. Pre-selection of the target device

In this approach, the user selects the target device before contacting the service provider. This minimizes the changes required to the web application, and, in particular, to the user interface because it does not need to be adapted to media player selection. Therefore, it can be used to add ad-hoc support for device selection. For example, an application for device selection can run on the user's control terminal, such as a Java MIDlet [11] running on a mobile phone.

After target device selection, this application is responsible to contact the user's service provider and transmit information about the selected device. This can simply be achieved by starting a web browser that shows the service's start page.

Next, in the service provider's web application the user selects the desired content. After selection, the web application establishes a session with the SDG for controlling the target device. Moreover, in this session the web application can control the target device using its control protocol, such as SOAP [12] if it is an UPnP-device. Playback can then be controlled using the service's web application. Alternatively, the playback control can be transferred to the user's control terminal. However, such control transfer is out of scope for this paper.

B. Post-selection of the target device

This solution takes the opposite approach of the pre-selection solution. First, the user starts by opening the web application of the service, as described in section II. However, instead of the media being rendered in the user's web browser, the service sends a SIP INVITE request to the user to establish a session that will include the media flow. This INVITE request can be handled in two ways by the user's application:

1) **Gateway as terminal**
   It can terminate the SIP dialog by acting as a gateway and communicate with the target device by itself. For example, for this communication UPnP can be used. This approach is illustrated in Fig. 2.

2) **Refer to a gateway (i.e., a SDG)**
   Based on the user's selection the application may reply with a REFER request that refers the service to an SDG, along with information on which device to use. This SDG should handle the request by setting up remote connectivity to the device so that the service can communicate with it.
   It should be noted that the user could refer to an SPS instead, because that node will redirect the request to the appropriate SDG. The communication flow is shown in **Error! Reference source not found.**.

A crucial difference between these two options is that the former option requires the user's device to be capable of controlling the target device, while the latter option only requires SIP to communicate with the Core Network.

Moreover, as the former approach requires the terminal to communicate with the device itself additional resources are required. Nowadays low-end phones are not equipped with such resources, and therefore we do not consider this option suitable for low-end phones.

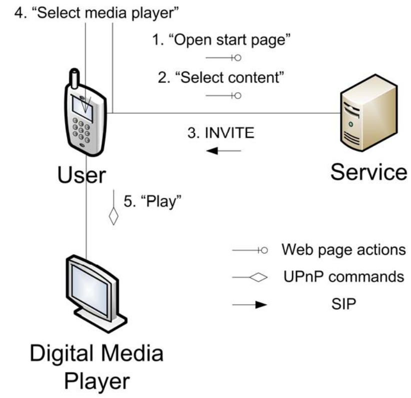

Fig. 2 Post-selection solution, alternative 1.

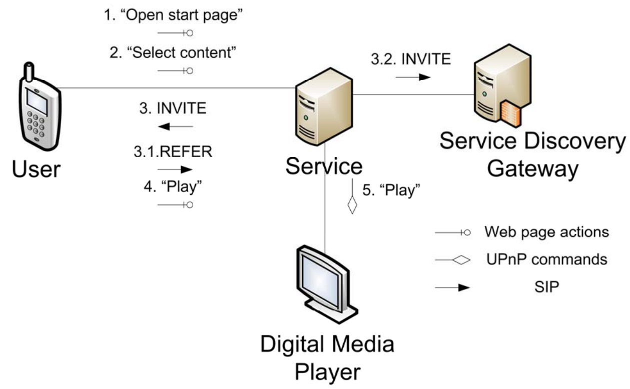

Fig. 3 Post-selection solution, alternative 2.

C. Integrated selection of the target device

In this solution, the selection of the target device is integrated with the rest of the user interface. Therefore, after authentication and authorization of the user, the online service provider will acquire the available target devices using remote service discovery.

As illustrated in Fig. 4, the user starts by connecting to an online service using web-based technologies (step 1). Furthermore, the online service retrieves service presence information for relevant services from SPS (step 2). This step can be achieved in different ways, such as querying it for all the user's available media renderers supporting a suitable format. Next, the user selects the content and the media player(s) to be used for this session. Furthermore, included in the service presence information received from SPS is the address of the remote service's service discovery gateway (SDG). This address is used to establish a remote service usage session between the online service and the remote device(s) selected.

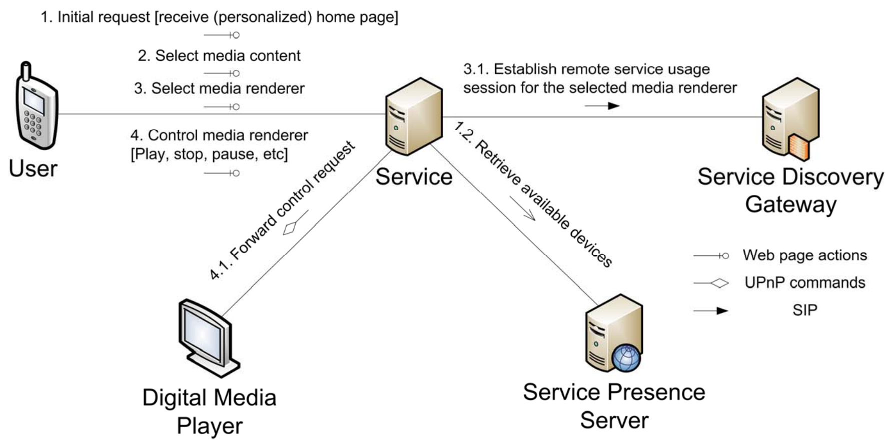

Fig. 4 In-selection approach.

V. COMPARISON OF THE DESIGN APPROACHES

The approaches proposed in Section IV above have positive and negative sides, and those will be described and compared in this section. A summary of the comparison is given in Table 1.

A. Session control terminal involvement

Criteria description: Whether the session control terminal must handle the content/media or not.

Only alternative one of the post-selection approach requires that the session control node must handle the media.

B. Integration with existing systems

Criteria description: The amount of work expected to integrate a solution with an existing system.

Alternative one of the post-selection solution is conceived to be easiest to integrate with existing systems, because it leaves most of the work to the client. All the other solutions require the service to extend the functionality to be able to control the media player, such as UPnP control point logic.

It is expected that both the pre-selection and the alternative two of the post-selection solution will require the same amount of integration work.

Nonetheless, the in-selection approach is conceived to be most difficult to be integrated with existing systems because it requires changes in the user interface and that the signaling flow changes as it must now contact more nodes.

C. Change content selection without restarting the session control

Criteria description: Whether the user may change to use different content without having to restart from the beginning of the flow.

With alternative one of the post-selection it is not feasible to change the content selection, because the service gives away control of the media flow to the user. For the other approaches it is possible to change the content selection as the service will be able to control the media flow.

Table 1 Comparison of the different solutions.

Criteria	***Pre-selection***	***Post-selection, alt 1***	***Post-selection, alt 2***	***Integrated selection***
Session control terminal involvement	No	Yes	No	No
Integration with existing systems	Middle	Easiest	Middle	Most difficult
Change content selection without restarting the session control	Yes	No	Yes	Yes
Transfer ongoing sessions	No	No	Yes	Yes
Hardware requirements	Depends	High-end	Low-end	Low-end

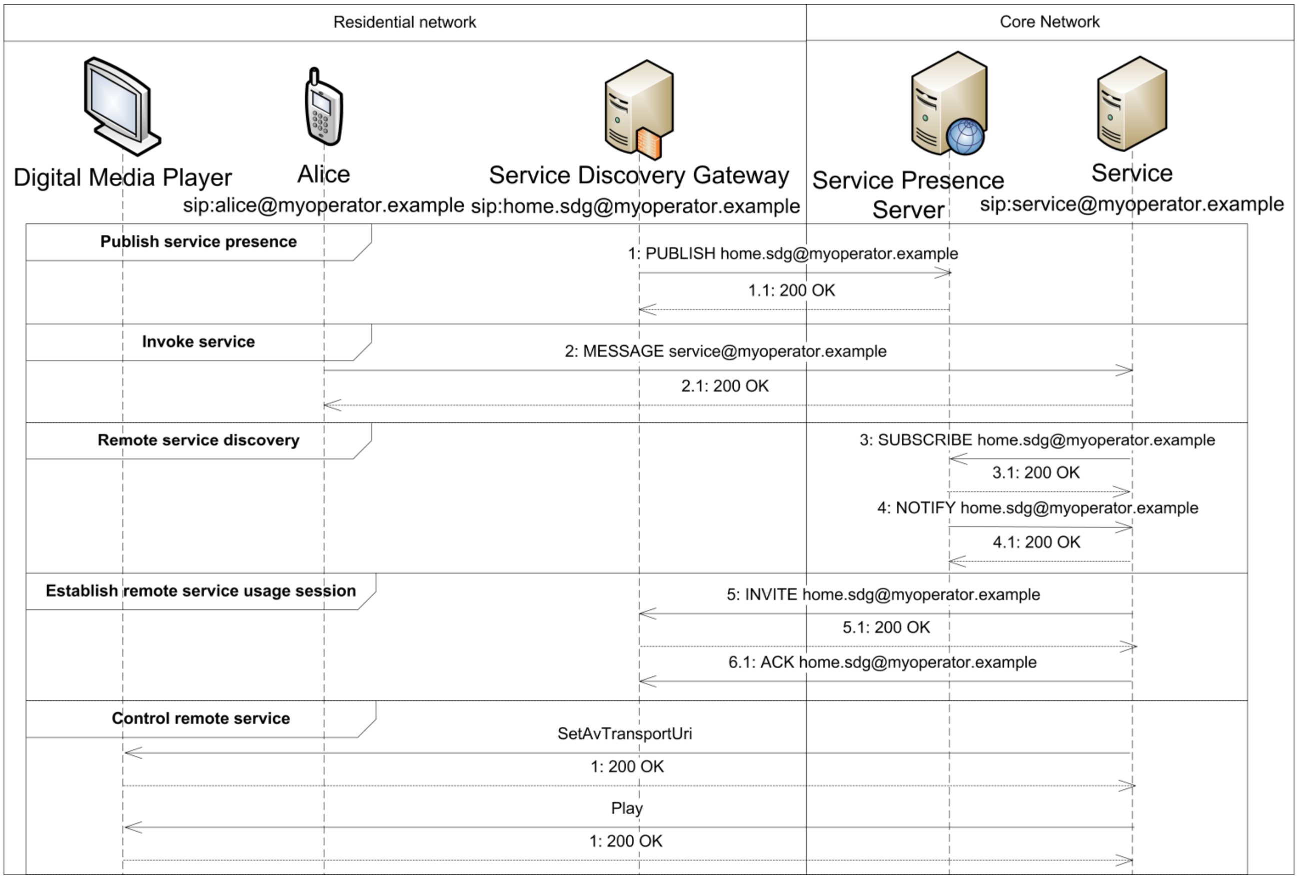

Fig. 5 Prototype signaling flow.

D. Transfer ongoing sessions

Criteria description: Whether it will be feasible to transfer an ongoing session to a different target device.

Both the pre-selection solution and alternative one of the post-selection solution does not support this criterion. The session must be restarted and then select the new target device.

E. Hardware requirements

Criteria description: Whether the solution requires high-end, mid-end or low-end terminals.

Alternative one of the post-selection solution requires most hardware capabilities, as it must handle the media and be able to directly control the media player device.

Depending on which mechanism the pre-selection solution uses for target device selection it may also require high-end hardware, such as Wi-Fi support for discovery.

VI. Service Delivery Prototype

For a proof of concept, a simple prototype system based on the post-selection approach, alternative 2, has been developed. This prototype shows whether it is possible to let an external service control a residential network, based on user request. As shown in Fig. 5, the prototype includes a service that will simply display a picture on a media player of the client when requested.

In the following, first an overview of the components are given followed by an outline of the signaling flow, and finally core network configuration is described.

A. Components

1) *Digital Media Player:* A UPnP Media Renderer device.
2) *Service Presence Server:* A presence server that supports the service presence extensions.
3) *Service Discovery Gateway (SDG):* This implementation of an SDG discovers local UPnP devices and publishes their presence to the Service Presence Server. In addition, it supports remote usage of these devices by adding port mappings to control requested devices.
4) *Alice (client):* This client sends a MESSAGE-request that includes the address of its SDG. In our implementation the "Test Agent " tool from the Ericsson Service Development Studio (SDS) was used.

Here, our client-side implementation differs from how it is described above, where it is a converged application instead. Another difference is that the service does not send a REFER-request but rather uses the SDG-address included in the MESSAGE-request sent by the client. This also limits the selection choice of the client, as it does not include any specific device to be used.

5) *Display Image Service:* Processes MESSAGE-requests and displays a picture on the first available Digital Media Player of the client.

B. Signaling flow

As a pre-requisite, there must be a Digital Media Player located in the residential network. The SDG discovers this device and publishes its presence status with the Service Presence Server (step 1 in Fig. 5).

To invoke the service the client sends a MESSAGE-request with a body set to the IP Multimedia Public Identity (IMPU) of the SDG (step 2 in Fig. 5). When the service receives this request it first retrieves the available media players from the service presence server (step 3 and 4 in Fig. 5). Finally, it establishes a remote service usage session with the SDG (step 5 in Fig. 5) that it uses to control the device to display a picture in the final phase.

C. Core network configuration

The Picture display service is provisioned with a Public Service Identifier (PSI), which, amongst other uses, the client uses to send a MESSAGE request to. In addition, an initial Filter Criteria (iFC) is created for the service presence service so that PUBLISH and SUBSCRIBE requests are routed to it.

VII. Conclusion

In this paper, three design approaches for delivering services to residential appliances have been described and compared. The prototype shows that the concept of using remote resource awareness to deliver services to residential appliances works as expected.

As the comparison shows, the three design approaches fit different scenarios, for example whether it will be a completely new service or if support will be integrated with an existing one. Nonetheless, in the future it should be investigated the scalability requirements of these design approaches, as that is very important when such services will be used by many concurrent clients.

A. Future work

The prototype is too simple to cover the whole end-user experience promised in this solution. For example, there is no good media selection and session control implemented.

Furthermore, there are both security and privacy aspects that needs to be investigated further for this work. As described in section IV GAA can provide authentication and authorization. However, how to ensure the privacy of the users, secure transfer of media, transfer of session control, and more are left for future investigation.

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