Title : **Providing Context Aware Services for a Digital Home Environment**

Key words :

Digital home, network services, network architecture, DLNA, UPnP, heterogeneous environments, context awareness.

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Description:

Today users need to use services anywhere, anyhow, anytime in a pervasive way. Devices are more and more smart, in the other side, services are more and more rich and complex. Even in home, users require the access, using different terminals (phones, game boxes, TV, computers), to multiple multimedia resources that can come from DVD, Blu-Ray, Media Servers, camcorder, Internet boxes, etc. (Figure 1)

In this thesis, we consider providing optimal and context aware network services in heterogeneous environments and in particular in digital homes where the heterogeneity could concerns terminals, users needs and services (data, content, live streams or complex network services). The aim is to improve existing systems and architectures and ideally propose a new one that provides personalized services dynamically adapted to the context of the user in order to improve its quality of experience (QoE).

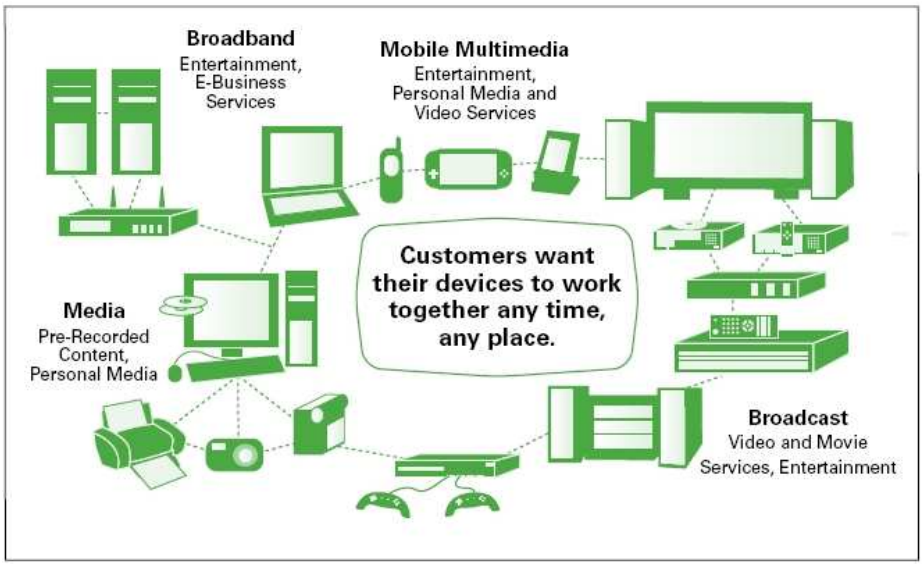

Figure 1: Digital Home Architecture

When studying existing systems and architecture for heterogeneous digital homes, the Digital Living Network Alliance (DLNA) [1] represents the ideal candidate. It is already integrated in about 74 % of existing home CEs but with only 6 % of users. This fact is due mainly to the complexity of the technology and the lack of intelligent components or services that help terminals and users to find, configure and connect their terminals in order to use the media content in the best possible and automatic way.

In such environments, when a device, typically a *Digital Media Server* (DMS) is added to the network it advertises services using multicast UPnP NOTIFY messages [2,3]. Three discovery messages are specified for the root device, two for each embedded device and one message for each service type in each device. Consequently, at each announcement interval, $3+2d+k$ messages are sent (one root device, d embedded devices, and k distinct service types). The NOTIFY message uses a duration (CACHE-CONTROL) for which the advertisement is valid.

Due to the unreliable nature of UDP, approaches used in the services advertisements, (applied in general within the UPnP Device Architecture [2]) recommends that devices should send each of the above discovery messages more than once. Also, advertisements must be periodically re-sent prior to a cache-control value. Similarly, when a control point (CP) [2] is added to the network, it searches for devices using multicast messages (for example M-SEARCH messages) sent more than once and periodically to guarantee that devices receive it. In DLNA, each device answers with $3+2d+k$ messages for its root device, embedded devices and service types. In addition to the discovery advertisement and discovery search, the CP retrieves descriptions of the discovered devices/services. It invokes actions on a device's services using SOAP. Device and service descriptions are usually written using the UPnP *Template Language* [2] based on XML and has usually an important size and is heavy to parse especially by mobile terminals.

With existing digital home systems and architecture, the number, the nature (UDP and multicast) and the periodicity of services advertisements can be inconvenient. In particular, when the user is unaware about this traffic or when he is not using any service inside the home network. Also, to be able to play one media resource, it is required that several messages and steps must be achieved. So, it is required for a mobile device, that joins the digital home, to support the multicast, UPnP Template Language parsing, SOAP protocol and the unreliable nature of UDP especially over a wireless access. Moreover, there is no guarantee that the original format and profile of the requested media resource will be supported by the end terminal of the user. This situation is not adapted to heterogeneous environments where rendering capabilities, access technology, bandwidth, congestion probability and power consumption are not the same for all the existing devices that can be connected through Ethernet, WLAN, Bluetooth, etc.

The focus of the thesis concerns the use and access of services (in particular services involving media content and streams) by heterogeneous devices and network access methods in order to enable and optimize the use of services and improve the QoE of the user.

The objective is to deliver, in a fast and simple way, the service that the user wants and that the target terminal can understand. Otherwise required adaptations should be applied on the original service. With technology advances in the electronics sector, home networks can include a wide variety of consumer electronics that can have very different specifications compared to mobile phones widely considered in the existing profiling description models.

On the other hand, the explosion of media standards and formats makes the existing profiles either incomplete or heavy to process due to the inclusion of information related to the devices' support of such formats in addition to the characteristics of markup languages (already considered). Also, we can observe that many old or obsolete media formats still stored in existing profiles repositories which makes existing profiles huge with a lot of unuseful (sometimes incorrect) stored data.

According to the previous observations, the work has to study and find best approaches that should be oriented towards:

1. The consideration of the profiling descriptions regarding the access network, the service (with media resources) and the terminals
2. The study and the improvement of existing architectures and norms related to digital homes with high heterogeneity

Regarding the context and profiling descriptions, the proposed approach should consider :

a) The generalization of the profiling model to any terminal that can access or deliver data to another terminal (the model must be as generic as possible),

b) Improving the level of device friendliness for network services, content and application such as the efforts done for mobiles within the Mobile Web Initiative [4], and

c) Optimizing the profiles descriptions with useful and well structured information. Furthermore, a particular attention must be taken in the matching process that aims to check if the targeted context is able to render the media requested by a user. The matching process must be flexible even if the profiles repository is incomplete or the vocabulary (used in describing the profiles) is not as expressive as required by current and future heterogeneous devices and formats [5].

From the architecture and network view, the aimed architecture should:

a) Avoid unnecessary traffic resulting from periodic services advertisements such as the UPnP *NOTIFY* and *M-SEARCH* messages.

b) Find equilibrium between distributed models and client-server models in order to allow only the transmission of messages useful in the response of a received user's request. The Client-Server model implies that one media services discovery is triggered after the reception of one user request. Therefore there is no need for multicast advertisements. In this case, advanced cache strategies should be studied in order to optimize services discovery. The negative impact of UPnP advertisements and Search messages in DLNA-like environments with heterogeneous and large networks is already studied in many works such in [6,7].

(c) The delegation of complex functionalities, not compatible with the access network technology or the terminal capabilities to an intelligent component of the architecture that performs them when it is required. This intelligent component can exist in the digital home itself or outside.

Another issue is how to manage the descriptions and knowledge when the number of considered contexts is very important [8] and how to avoid media adaptations when if it is feasible. In a universal media access system, the offline production of several versions of the same media is not realistically feasible, more efforts should be put into the content encoding by following formats that are easily accessible and adaptable with heterogeneous contexts such as the scalable extension of H.264 (SVC) and the W3C Synchronized Multimedia Integration Language (SMIL) for rich multimedia presentations.

Further improvements should be expected for the user quality of experience in media access at home. In particular, by enriching the context handling with user centric preferences. Adding the user preferences and profiles should consider the heterogeneity of users in home (e.g., by distinguishing different members of a family) and provide them with personalized services. This would be benefit for the traffic optimization, by delivering only needed content, and speeds up the presentation of the discovered media content. First experimentations using the UNIVERSALLY prototype [9,10] have shown that the number of discovered media resources can be very important. Consequently, the segmentation/pagination of media content delivered within a service can be optimized if the discovery and the presentation of media resources are based on the user's context [10].

Bibliography:

[1] Digital Living Network Alliances: DLNA Overview and Vision Whitepaper 2007, www.dlna.org
[2] UPnP Forum: UPnP Device Architecture 1.0, April 24, (2008)
[3] UPnP Forum: UPnP AV Architecture:1, September 30, (2008)
[4] W3C Mobile Web Initiative, http://www.w3.org/Mobile/.
[5] Euzenat, J., Shvaiko, P.: Ontology Matching. Springer, Heidelberg, (2007)
[6] Liong, Y. L. and Ye, Y. H.: Effect of UPnP Advertisements on User Experience and Power Consumption, Proc. of the IEEE CCNC, pp. 91-97, (2005)
[7] Mills, K. and Dabrowski, C.: Adaptive jitter control for UPnP M-Search, Proc. of the 38th IEEE International Conference on Communications, Vol. 2, pp. 1008-1013, (2003)
[8] Lemlouma, T., An Overview of the MUP Repository's Identifiers.
http://people.irisa.fr/Tayeb.Lemlouma/mup/UNIVERSA
LLY_identifiers_repository_version_01_2012.txt.
[9] Lemlouma, T., UNIVERSALLY: A Context-Aware Architecture for Multimedia Access in Digital Homes, 5th International Conference on Advanced Infocomm Technology (ICAIT'12), July 25-27, 2012, Paris, France
[10] Lemlouma, T., Improving the User Experience by Web Technologies for Complex Multimedia Services, 8th International Conference on Web Information Systems and Technologies (WEBIST), 18-21 April, 2012.