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Privacy-aware Nomadic Service For Personalized IPTV

Amira Bradai, Emad Abd-Elrahman, Hossam Afifi
RST. Telecom SudParis
Institut Mines-telecom, Telecom SudParis
Evry, France

amira.bradai@it-sudparis.eu, emad .abd-Elrahman @it-sudparis.eu, hossam. afifi@it-sudparis.eu

Abstract-User-Centric Personalized IPTV Ubiquitous and Secure Services (Up-TO-US) project provides nomadism and personalization in IPTV operated services. This paper proposes a novel architecture for nomadism combined with an extensive game to enforce identity exposure when a user accesses his/her services from outside the home domain. The goal of the game is to minimize the personal information divulgation outside his/her domain. The proposed algorithm is implemented within a nomadic architecture. For each client, our algorithm can customize the Electronic Program Guide (EPG) in a contextualized way. We analyze two main use cases in nomadic situations: local nomadism and inter-domain nomadism. All implementations are hypertext Transfer Protocol (HTTP) standard-based for compatibility issues with all Internet Protocol Television (IPTV) platforms.

Keywords-Nomadism; extensive game; IPTV; personalized service

I. INTRODUCTION

The advance in Internet Protocol Television (IPTV) technology enables a new model for service provisioning by moving from traditional broadcaster-centric TV services to a new user-centric TV model. This new model allows users not only to access new services and functionalities from their providers, based upon their profiles and contexts, but also to become active parts in the content personalization through contributing in building their dynamic profiles and their privacy. This IPTV model is promising in allowing low cost services for end-users and a revenue system for broadcasters based on personalized advertising methods, as well as new business opportunities for network operators and service providers.

A. UP-TO-US Project

The objective of the UP-TO-US project [1] is to elaborate, to prototype, and to evaluate an open European solution allowing IPTV services personalization over different IPTV systems (having different architectures and belonging to different network operators and service providers). The project assures content personalization according to each user context and the context of his environments (network and devices), while preserving his privacy, as shown in Figure 1.

UP-TO-US focuses on two use-cases for service personalization:

1. users in nomadic situations in a hotel, in a friend's home or anywhere outside his domestic sphere, (allowing the user to access his personalized IPTV content in a hotel for instance and be billed on his own bill "My Personal Content Moves with Me"), and
2. users' mobility in his domestic sphere (allowing the user to move around within his domestic sphere, while continuing accessing his IPTV service personalized according to his location and devices in his proximity "My Content Follows Me in a Customized Manner").

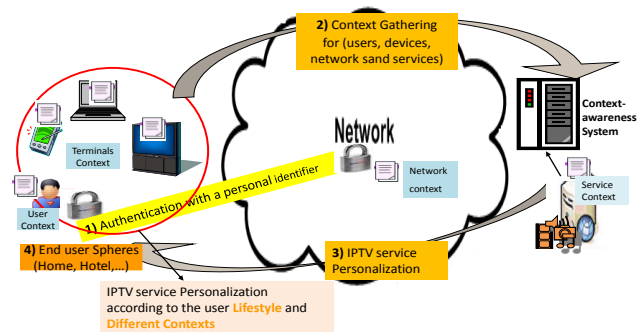


Figure 1. General visions of UP-TO-US project

In order to achieve the objectives of UP-TO-US, some enabler technologies were developed and integrated to different IPTV systems; these mainly include:

- A context-aware module capable of monitoring and gathering the user and his environment contexts and feed them in a dynamic manner to the IPTV system,
- A profiling management module, capable of constructing and dynamically updating the users profiles according to the various contexts, and

- A privacy management module that will be responsible for managing the different privacy levels for each user and protecting the user personal information. Consequently, personalized services could be provided in which content is selected according to users' preference, Quality of Experience (QoE) requirements, and different contexts, while fostering trust between viewers and broadcasters through an efficient privacy management, and thus encouraging viewers to participate actively in this interactive user-centric TV paradigm through allowing their continuous contexts gathering.

B. Personalized EPG

IPTV service personalization has been discussed in many works [7] [8] [9]. All those works focused on service personalization-based context-aware system.

With the new era of TV and different modes of diffusion like satellite/Triple and Quadruple play services offered by many service providers worldwide, there is a need to customize the huge number of channels. This customization is mandatory, especially in the nomadic places where users are away from their home networks.

Based on user profile, and on user and network gathered contexts, the personalization technologies can generate content recommendations for an individual as well as for a group of users. Recommendation algorithms can use content-based filtering technologies [12], collaborative filtering algorithms [13], or hybrid solutions combining content-based and collaborative filtering techniques [14][15].

To do this task, the recommendation system will be in charge of calculating the most interesting videos or channels for each client through her/his Electronic Program Guide (EPG). The EPG is the way to guide and inform the IPTV viewers by their interesting channels and programs. To customize an EPG in contextualized way is one of main objectives in UP-TO-US project. This customization is mainly depending on four types of context information, as shown in Figure 2:

- **User Context:** The information concerns the user location.
- **Network Context:** The information concerns the environment like network parameters.
- **Service Context:** The information concerns the service adaptation and its delivery status, coding, definitions (High Definition, Standard Definition or Low Definition).
- **Terminal Context:** The information concerns the device capabilities and its screen resolution.

A. EPG format

In UP-TO-US, we send and receive the EPG in XML format, as shown in Figure 3. The information in this list

could be live TV channel, Video-on-Demand (VOD), programs or the Top-K favorites programs for the client.

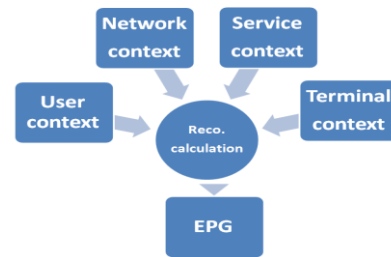


Figure 2. EPG calculation based context information feed to Recommendation System

```
<up2us:EPG>
<up2us:ListProgramDescription
xsi:schemaLocation="urn:tva:up2us:2012Up2us.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:tva="urn:tva:metadata:2011"
xmlns:mpeg7="urn:tva:mpeg7:2008"
xmlns:up2us="urn:tva:up2us:2012">
  <up2us:Options>Top_K</up2us:Options>
  <up2us:ProgramDescription>
    <up2us:ProgramInformationTable
metadataOriginIDRef="IMDB">
      <up2us:ProgramInformation
programId="crId://abc3/xyz24">
        <up2us:BasicDescription>
      </up2us:ProgramInformation>
    </up2us:ProgramInformationTable>
  </up2us:ProgramDescription>
</up2us:ListProgramDescription>
</up2us:EPG>
```

Figure 3. XML format for EPG in up-to-us

D. Nomadic access

Quality for Nomadic Access (NA) solutions are based on the network integration between different service providers (i.e., managed services operators) who are proposing key-point in geolocation solutions for video services delivery (IPTV or VOD) to their nomadic clients.

Customers are searching for service personalization anywhere/anytime/anydevice.

In a nomadic scenario, we may have two modes of service accessing, as shown in Figure 4:

- **Managed Mode:** the operators could guarantee the service for the clients according to the user service and context profile. In this scenario, the QoS/QoE trends can be adjusted and end-to-end controlled by network operators.
- **Unmanaged Mode:** which means accessing from Internet and in this case we must have Multi Criteria Decision Making (MCDM) for the quality and the cost to decide which is suitable for the user and which is suitable for the network. Based on the calculations and decisions conducted by this system (Decision Makers), the user can choose the best

service (which is a nomadic service) and the network could assign its best resources.

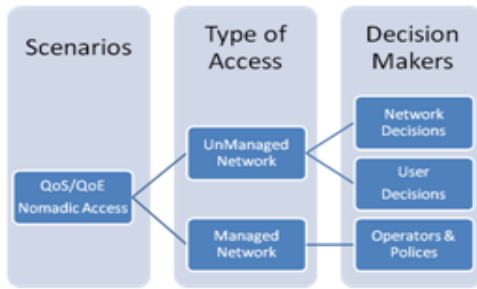


Figure 4. Quality aspect in IPTV nomadic access

The main objective of nomadic access for IPTV service is to overcome the challenges of obtaining the same service anywhere, anytime and on any personal device. Moreover, nomadic service adds the means of obtaining the service from any operator. The aspect of TV Everywhere [2] started some years ago and achieved high acceptance from many IPTV clients. Also, the report [2] showed that by soon, a large percent of the customers will be able to access to TV Everywhere services through their current providers only.

The rest of this paper is organized as follows. Section II highlights the nomadic architecture components and the implemented scenarios in the project. Privacy aspects are handled in Section III. The proposed game solution is presented in Section IV with some highlighting on privacy in personalization. Then, the paper is concluded in Section V.

II. NOMADIC ARCHITECTURE

Nomadism is an equivalent term to roaming services, but without mobility [3]. Nomadic services allow the user to access to his personalized IPTV content in any place in his domestic and outside and to be billed on his own bill. The collaboration between operators helps in providing nomadic IPTV services in the context of cloud computing as explained by Abd-Elrahmen and Afifi in [4]. Moreover, the interconnection for IPTV terminals in visited networks with different services scenarios is explained in [5]. Through that, we can get the service either by home, visited or third party operator.

In UP-TO-US, the proposed components of the nomadic service and personalization are implemented in C language. We used HTTP to communicate with the context-aware and the user profile servers. The core network and IPTV service platform is achieved through HTTP and DIAMETER [6] protocols.

We achieved the nomadism through integrating Nomadic Service Module (NSM) in the IPTV platform. This NSM has two parts:

- **NSM client:** this part is integrated in the Set-Top-Box (STB) to add the nomadic features in the software (or hardware) client.
- **NSM server:** this server is the gateway function for nomadic services in operator network. Also, it is responsible for nomadic decisions, user domain searching and all inter-domain actions.

A. Use Cases Analysis

In our implementations, the client is software STB [1] developed by one of the project partners (Orange Labs). Then, we integrated our client module (NSM Client) in this STB. The client acts as hub for all requests and answers concern the nomadic access. The interconnection point for any type of access whatever nomadic or not is called IPTV Service Selection Function (SSF), which is also the gateway for IPTV platform.

In this part, we analyze two nomadic use cases; local and inter-domain as follows.

1) Local Nomadism

When the user resides outside his home but within his operator network, the NSM of visited and home network are the same. The initialization phase for searching user rights to access nomadic service in the visited locations is explained in the sequence shown in Figure 5. All messages sent and received in HTTP format to guarantee compatibility and standard issues. The client initiates the Nomadic Client Request (NCR) and waits the answer from the NSM server as Nomadic Service Answer (NSA). In case of faked login, the 'VALUE1' attribute will return 'NOT ALLOWED'.

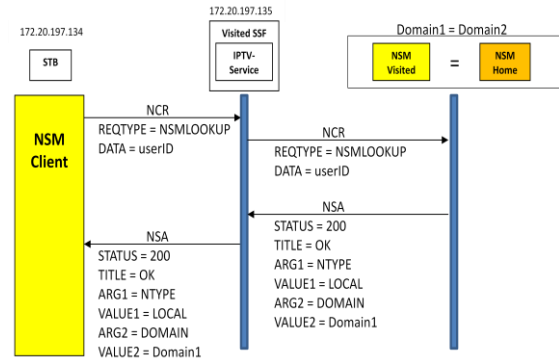


Figure 5. Users access their services outside their homes from their home operator (same domain)

2) Inter-domain Nomadism

Figure 6 illustrates the sequence diagram for initialization phase in case of inter-domain access. In this case, we have different domains; so, the visited NSM has the responsibility of searching which home network should be contacted.

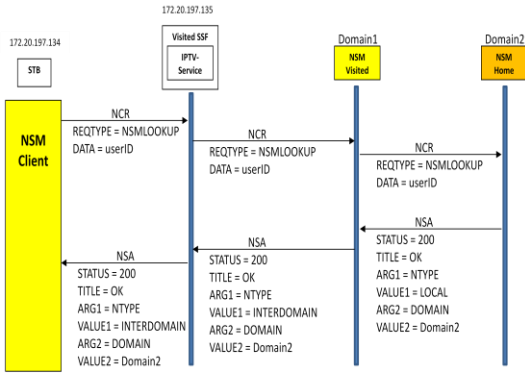


Figure 6. Users access their services outside their homes from another operator (different domain)

Then, the home NSM is responsible for service confirmation and checking users' rights with other modules in UP-TO-US.

III. PRIVACY ASPECTS

There exist many risks in storing personal information in online systems. These data may be used fraudulently to perform different attacks against its owners. Many devices may be used to deceive and defraud customers on social networks. There are many ways that information on social networks can be used for purposes other than what the user intended. Data can be obtained through many different means like for example eavesdropping.

Recommendation operations and context-aware system like the ones defined within our UPTOUS project rely on the use of an exhaustive amount of information provided implicitly or explicitly by the user. The more generous and detailed the personal data is, the more accurate the preferences inferred from the usage history are. In the case of our system, the information required from the user in order to perform a personalization operation covers a wide range of aspects. Many users choose to mask their real identities. Masking may be done via anonymity (providing no name at all) or pseudo-anonymity (providing a false name). By establishing anonymous profiles or alter egos, users decouple the different types of profiles they have defined. The main purpose is to keep a strict separation between the online person and the offline individual. However, it is still very difficult to separate the different identities or profiles defined for every user.

Privacy protection is a critical issue for personalized IPTV services acceptability by the users.

That is why the privacy layer in the proposed system supports a multi-identities mechanism. Each person holds multiple identities (each one with unique user Identity (Id)), depending on the user preferences about different data disclosure settings.

After authentication process has been accomplished for a subscriberId, a sessionId has been returned to the User Domain (UD).

Identities are used internally, while deciding which data is available for a personalization operation. UserId is only exchanged with the service domain in those interactions that involve users performing crud operations on identities. The Privacy Layer consists of:

- **Multi-identity Mechanism:** manages which identity (userId) is active at a moment for a person
- **Privacy Control/ Settings:** determines which information about the user behavior should be considered while inferring preferences
- **Users' Multi-Identities and Privacy Policies DB:** this database contains all data required by the privacy layer to perform its functionalities.

UP-TO-US has defined two different user domains: domestic and nomadic. Users in nomadic scenarios generally visit a platform different than the one they usually do; hence, they can't be sure about who else is using the same network and which information is available for others. Therefore, situations where nomadic scenarios are involved require a higher level of privacy than domestic situations. Privacy is one of the most important issues in our evolving information age, where technological developments lead to intensive processing and storage of personal information. In this context, users have increasingly strong concerns about their sensible data stored, processed and travelling without having means to control their disclosure. The challenge consists then in providing each user with a control of his privacy-sensitive data and in guaranteeing the application of the appropriate privacy rules all along the lifecycle of these data. This should also allow the end-user to handle the famous privacy dilemma underlined by A. Westin [16]: "Each individual is continually engaged in a personal adjustment process in which he balances the desire for privacy with the desire for disclosure and communication of himself to others, in light of the environmental conditions and social norms set by the society in which he lives". Indeed, each end-user needs to self-position between the two following extremes:

- Widely expose his personal data in order to take benefit of personalized services, but taking risk regarding his privacy and
- Hide his personal data, but without benefiting from such complete personalized services.

IPTV Systems should support various privacy levels defining how personal data can be accessed and used.

In Table I, for every case study, a level of privacy is required. Therefore, the Privacy Control/setting module will translate the privacy policies required by the user into privacy information with respect to the service provider and to third parties.

A simple model could be adapted to some use cases according to the level of protection, as shown in Table I:

- **High privacy level:** no action authorized for the service provider (trace collection and automatic update) neither share information with third parties.

- **Average level:** service provider allowed to collect usage history and to automatically update preferences accordingly, but no sharing with third parties is allowed.
- **Low level:** service provider is allowed to collect usage history, to automatically update preferences accordingly and to share both of them (preferences and usage history) with third parties.

TABLE I: STUDY FOR DIFFERENT USE CASES PRIVACY LEVELS

Privacy Level / Use Case	My personal content follows me	Social media interaction	My TV content Away from Home (Nomadic)
High level			•
Average level		•	
Low level	•		

As shown before (in Section III. A), UP-TO-US adopts multi-identity mechanism and the privacy control will manage the divulgement of the information and profiles. The system handles different types of sensitive information like the name of the user, birth date, gender, specific location, contact information, history of visits, impairments, etc. Therefore, it is mandatory to implement a system to manage correctly the access to this information, assuring a determined level of data privacy chosen previously by the user and completed at the time after accessing the service.

IV. THE PROPOSED MODEL FOR PRIVACY

This proposed model facilitates identity exposure in nomadic situations. The question is how to choose the identity to expose.

We model the interaction between a user and a visited service provider as an extensive game [10], as show in Figure 7. An extensive game means that a user and a service provider take turns to make decisions and take actions.

We can model the extensive game as follows.

Two players: The user and the visited service provider.

A set of outcomes: in our example, there are the five outcomes: (Propose, Finish), (Propose, Abort), (Quit), (Accept, Abort), and (Accept, Finish).

Each player chooses and takes one action. The user and the service provider have their preferences, which will be represented by payoff values.

We believe that users want to maximize their privacy, while they access recommendation services. Service providers want to acquire more users' personal information while they provide services. We define their payoff functions as follows.

A user's payoff function, U , and a service provider's payoff function, S , at each node are, respectively:

$$U = \text{Access} - \text{Exposure} \quad (1)$$

$$S = \text{Provide access} + \text{Exposure} \quad (2)$$

From a user's perspective, "Access" brings him constant amount of benefit for a service, which is independent of his personal information exposure. The "exposure" component in (1) reduces the benefit as "exposure" increases. The service provider does not get enough identity information from a user and aborts. Then, the benefit is zero. As we can notice from (2), the more the user exposes, the more benefit a service provider receives.



Figure 7. User' strategy in inter domain situation

We use the nomadic access in hotel as an example to explain the game (inter domain access). Alice has a subscription and is in nomadic situation. She wants to access to her channels. Alice provides her pseudo name. The visited service provider asks for her name. Then, Alice makes a decision: Alice may quit the service; she may accept the request and gives her name; or she may propose other options. Let's suppose that Alice proposes to provide only pseudo name.

Now, it is the service provider's turn to take decision. Suppose the service provider either aborts the checkout service or finishes the transaction. Therefore, there are five outcome cases. In case 1, Alice provides only her pseudo name, and the service provider finishes the transaction. In case 2, she provides only his pseudo name, and the service provider aborts the process. In case 3, she quits the checkout process. In case 4, she gives her name, and the visited service provider aborts the transaction. In case 5, she gives her name and the transaction finishes.

In Figure 8, Alice's preference is $\{1\} > \{5\} > \{3, 2\} > \{4\}$. That is, Alice prefers to get the same service by giving only his name.

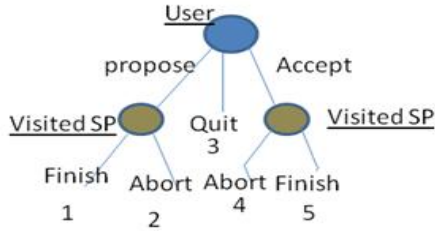


Figure 8. Extensive game between the user and the visited SP

She also prefers to get the service than not get it, even at the price of giving her name. Her least preferred outcome is that she gives her name without getting the service.

It is possible that two or more outcomes have the same preference. For example, {2} and {3} have the same preference for Alice. A subgame perfect nash equilibrium [17] is such that players' strategies constitute a nash equilibrium in every subgame of the original game.

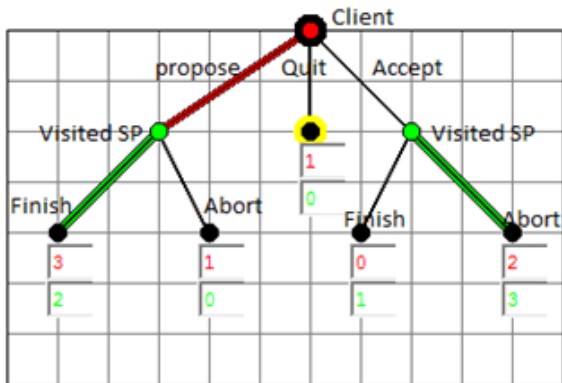


Figure 9. Online tool solution for the proposed game

This subgame is represented in red and green color in Figure 9. This subgame is unique and obtained by a Java tool [11] to affirm our analysis. In Figure 9, the payoff values for the user and the service provider in $(Propose, Finish) = 3, and 2$, respectively.

The analysis may be found by backward induction [10]. It is common method for determining subgame perfect equilibria.

To begin the process of backward induction, we assume that the client and the service provider will choose their preferences to reach an outcome (determined by the payoff functions).

We must start from the bottom of the game and we walk through our example in Figure 9. The service provider may choose «Abort» or «Finish». «Abort» gives the service provider a payoff of 0, where as «Finish» gives him a payoff of 2. Thus, he will choose «Finish». Similarly, in the right, the service provider will choose «Finish» with a payoff of 3. He provides the service. In our example, the client may choose «Propose», «Quit», or «Accept».

From our previous discussion, the client's best choice is «Propose».

The process continues until the root of the game is reached.

In our example, we have reached the root of the tree. So, the user chooses «Propose», and then the service provider chooses «Finish». It is the subgame perfect equilibrium, the optimal choices for the client and the service provider.

V. CONCLUSION

This paper proposed a gateway to IPTV roaming services through nomadism. We presented the architecture of nomadic IPTV platform through UP-TO-US project. Moreover, we presented service personalization through EPG customization. This customization is depending mainly on four contexts (user, network, service and terminal). Also, we studied the privacy issue and its effects on service personalization. The sensitive information about users could reference the privacy-personalization phase in IPTV access especially in nomadic situations. For future work, we want to analyze more use the recommendation aspects using our proposed extensive game.

ACKNOWLEDGMENT

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