Semantic Context-aware Adaptation Platform Architecture

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Abstract

This paper describes some adaptation issues related to context-aware assembly of heterogeneous transformation services within a wide variety of mobile devices (laptops, smartphones and tablets). A reconfiguration platform named Kalimucho has been used on top of a peer-to-peer layer to carry on the whole (re)-deployment process. More importantly, we propose to use this platform which is mainly composed of P2P reconfiguration facilities in order to support conflicts detections, semantic and social-based assembly of relevant adaptation services and customization of quality adaptation paths. These facilities are analyzed and evaluated according to local and remote experimentations. Results show the efficiency and the effectiveness of our approach.

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1. Introduction

In classical approaches, an adaptation process supposes that all adaptation services are already available on each mobile platform. Such approaches own the following characteristics:

- **Static and syntactic adaptation**. Adaptation is made by initial criteria that will not change. However, neither automatic adaptation of heterogeneous services is discussed from the semantic point of view (*service location, service role, and service category*).
Predefined quality of Service. Adaptation approaches have defined different quality of service (QoS) properties. For instance, some of them minimize the computation cost for producing an adapted document, while others may maximize the proximity between the original and the adapted content. Usually, the quality of service of an adaptation framework is not customizable, in other words the quality of the adaptation process is usually predefined on a fixed set of properties.

Several studies investigate each of these architectures and indicate their respective strengths and weaknesses. Our approach follows a layered architecture. It is composed of three layers: the peer-to-peer layer offers reconfiguration-level services required by any P2P multimedia adaptation applications: like service-oriented reconfiguration, dynamic cooperation among groups and communication between mobile platforms, a contextual-deployment strategy. The Kalimucho P2P platform proposed by [6] implements this layer. The generic adaptation core layer provides semantic abstraction to hide the complexity and the heterogeneity of the underlying P2P medium and implements the following functionalities (1) - semantic representation of conflicts, (2) - semantic relevance determination facilities to discover adaptation services, (3) - flexibility for quality assembly of heterogeneous multimedia services. We will show in this paper that thanks to the semantic-social exchanges between users, the quality of adaptation process can be enhanced and improved.

The rest of this paper is organized as follows: Section 2 overviews the main adaptation approaches. Section 3 describes our adaptation architecture. Afterwards, results of an experimental evaluation of semantic social service discovery are presented in Section 4. Finally, Section 5 concludes the paper and presents ideas for future works.

2. Related works

Since the last decade, a lot of research has been proposed and usually grouped in four main categories:

- Server-side adaptation [4]: some devices may request a server to adapt some multimedia documents. Such adaptation is under its responsibility and could require advanced knowledge and skills about the connected users. In such a situation, the server usually becomes quickly tedious, overloaded and time consuming.
- Client-side adaptation [5]: each device may be able to adapt documents by itself. However, some of clients may not be able to execute multiple adaptation operations at a time due to their limited capacities, e.g., battery.
- Proxy-based adaptation [1]: a proxy is between a client and a server, and acts as a mediator. In this case, many communications may be done, since it negotiates the adaptation to apply.
- Peer-to-Peer adaptation [8]: the arrival of peer-to-peer technology strongly contributes to change the adaptation architectures. Multimedia contents, exchanges conflicts and services are indifferently distributed among mobile platforms. The distributed approach fits better with the different characteristics of the heterogeneous mobiles platforms. As a consequence, this approach takes all the advantages of the peer-to-peer paradigm load balancing, and more service choices.

Table 1 summarizes the characteristics of the identified adaptation architectures:

<table>
<thead>
<tr>
<th>Architecture Type</th>
<th>Centralized</th>
<th>Hybrid</th>
<th>Decentralized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptation management</td>
<td>Centralized</td>
<td>Centralized</td>
<td>Decentralized</td>
</tr>
<tr>
<td>Adaptation service distribution</td>
<td>Client-side</td>
<td>Peer-to-Peer</td>
<td>Peer-to-Peer</td>
</tr>
<tr>
<td></td>
<td>Service-side</td>
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<td></td>
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</tbody>
</table>

We prefer the decentralized approach that give more flexibly to select freely the adaptation locations. Consequently, we follow to execute adaptation processes in any mobile platforms, depending on the capabilities of the mobile platforms, QoS and the context application. We propose to use semantic and social information to enhance efficiency and flexibility of composition of heterogeneous adaptation components and enables applications to our adaptation platform to better guide the adaptation process.
3. Semantic context-aware adaptation platform architecture

3.1. General architecture

The proposed platform is built according to a layered architecture (Fig. 1). It is composed of three following layers:

- The **Kalimucho layer offers service-level functions**: (re)-deployment and reconfiguration strategy according to its system (Android, Laptop, computer desktop, CDC, etc.) with QoS requirements, management of groups, dynamic supervision of adaptation components, and communication protocols between mobile nodes. The Kalimucho platform provides low-level services for programming context-aware P2P in Java/Android code. It can be installed on desktop or laptop PCs, smartphones or tablets that support Java virtual machine. Its open source is well suited for programming high level context aware P2P services and applications.

- The **generic semantic adaptation core layer** provides abstractions to hide the complexity and the heterogeneity of the underlying service-based P2P principle and implements a semantic social-based service assembly strategy for each user according to its context, which is inferred automatically from user profiles and inferences rules based on the ASQ ontology [2]. Modules implemented inside this layer support new semantic social models, such as the following functionalities: (1) – conflicts detection, (2) deriving adaptation roles from conflicts description, (3) – semantic relevance-based discovery of services, (3) – automatic assembly of available services and (4) – customization and quality selection of adaptation path. By using the exported adaptation core layer, any multimedia documents can be adapted and customized according to user context changes.

![Fig. 1 System architecture P2P semantic social-based multimedia document adaptation.](image)

3.2. Enhancing expressiveness and relevance in adaptation processes

In our layered architecture, it appears that the adaptation semantic context-aware layer is the most important one because it implements the basic functionality for (re) assembling relevant services among nodes. Through the four
semantic P2P access, resource manager, profile manager, conflicts manager and adaptation manager roles implemented by four interlinked modules, the nodes own adaptation capabilities and cooperatively realize the adaptation process.

- **Semantic P2P access and social exchanges.** This module supplies common P2P access of at a high level while hiding the complexity and the heterogeneity of the associated low level operations. It is used to by a node to join an existing P2P network or to start a new one.

- **Semantic resource manager.** Each peer node stores several adaptation services, multimedia contents on the local file system. Peers would instantiate classes from the ASQ ontology and publish the resulting individual results as OWL files on their websites. This ontology defines common concepts as well as relationships among those concepts to represent multimedia data, service parameters (compression ratio, resolution, color number, etc.), semantic service information (service_role, media_type, action_type, version, resources needs, QoS parameters, semantics of input/output, location and time) and context constraints. One of our contributions is to improve the semantic service description to give more precision on a resource adaptation and to facilitate research. An adaptation service is represented by a set of information describing the necessary contextual constraints. It also describes the parameters for customizing the quality of service. The semantic information service enables comparison with other services of the same type.

- **Semantic generic profile manager.** This module manages user profile and user connections as well. We have chosen the SGP vocabulary in order to facilitate the description of constraints between different profile information. Moreover, information in SGP profiles, is hierarchically structured and thanks to the context services one may migrate the profile from one platform to another. Thanks to facet descriptions, user’s constraints associate different categories of profile information. Different categories about some device capabilities, the user context and the document characteristics that the target device is able to support can be described. The user can add, remove or modify easily and quickly certain characteristics in the profile file. Hence, user can require multimedia content corresponding to any contexts and any devices.

- **Semantic conflicts manager.** The conflicts manager module detects the conflict between the user profile and the multimedia document properties. Two descriptions are semantically equivalent if all the matching values between parameters are exact. Several conflicts may be identified when a device needs to play a multimedia document. If no conflict has been detected, no adaptation is needed. Otherwise, if some conflicts have been detected, it produces an adaptation guide containing adaptation directives, such as the supported codecs, the supported media types, the battery level, etc.

- **Semantic social-based adaptation manager.** This module provides the necessary semantic-based matching process for determining a combination of relevant adaptation services, which exploits the categorization of the ASQ ontology hierarchy to find suitable matches. For that purpose, it matches the semantic information described in the services (e.g., service_role, media_type_in, media_type_out, format_in, format_out, memory size, bandwidth level, service_location, service_time, QoS, etc.) and the adaptation produced by conflicts manager. There are three sub-modules in this component: the discovery module and the automatic adaptation plan generation module and the adaptation decision module.

  - **Semantic-social services discovery module.** To aid in the determination of an appropriate set of services, in this phase assigns to each service a relevant score. Each peer collects the relevant score of its neighbors regardless of the level of the neighbor. Based on its relevant score (QoS) and the previous experiences of its neighbors. The vote given by a user “i” which measures the quality of the adaptation service “s” as follows:

\[
V(S, i) = \frac{\alpha \cdot \text{Benefit}_{\text{media type,media characteristics}}(S, i)}{\beta \cdot \text{Cost}_{\text{energy,load, memory, time}}(S, i)}
\]

where \(\alpha\) and \(\beta\) are coefficients that allow the user to specify the importance of each quality criteria. The quality function is customizable and parameterizable according to different needs of users and context parameters. Cost
is parametrizable according to context parameters like CPU load, energy saving, low bandwidth, etc. and the benefice is parametrizable by specific media parameters like compression ratio, frame rate, resolution, etc. Each peer broadcasts the votes attributed to its neighbors. After receiving the votes, each node determines the service weight as follows:

\[
Score_{x,i} = \varphi \left( \sum_{S_{x,i} \in N_i} V_{S_{x,i}} \right) + (1 - \varphi) \cdot V(S,i)
\]  

(2)

where \(V(S,i)\) refers to the vote given by the user’s “i” ε users influenced by other users votes \(V(S_{k,i})\). The user’s weight history is considered as the \(\varphi\) and the actual user context as the \(1 - \varphi\). This metric is widely used in the service of similar user’s adaptation task, while it balances the computation cost and the performance. Each node broadcasts its weight to its neighbors. During the discovery phase, the nodes use these weights to select relevant quality adaptation service. The advantage of this technique of vote lies in the fact that the importance of a node must be determined by the node itself and all its neighbors instead of using the local properties alone. More votes a node accumulates, the more important it is in the entire network.

- **Automatic adaptation plan generation module.** From the set of services discovered by the discovery module and the adaptation guide, it generates possible chains of services. In order to establish the sequence of services, our ASQ ontology is used. This ontology provides the semantic relationships (dependency, substitution, equivalence) between adaptation services and roles. It also specifies the correspondences between the roles and the service semantic information.

- **Adaptation decision module.** This module is responsible of selecting the best path after calculating the score of each adaptation path. The comparison of score adaptation paths allows us to select the best path. In this case the values of a quality formula are used for classifying the relevant adaptation paths that have potential benefit.

The main objective of our approach is to improve the efficiency and accuracy. This objective is achieved through finite sets of semantic relevant adaptation services, well consideration of user’s opinions and various users’ contexts. In the next section, we will experiment these enhancements.

4. Evaluation and performance

The SGP profile is implemented in RDF (Resource Description Framework) and Protégé Editor [7]. This language supports creating and managing RDF/XML descriptions for mobile applications, independent of their programming language, and provides a common language for describing semantics with RDF and have been used successfully to define profiles and to valid models of complex systems [8]. Our platform is able to automatic assembly semantic relevance adaptation services. For each new context changes, the context model is tested and validated with the semantic constraints defined by the profile at runtime. The adaptation planner then inferred the appropriate adaptation path.

The first experiment is to test the feasibility of our approach. We have evaluated our approach which includes quality service semantic level and social service level on local and remote configurations. Each peer participates in the discovery and sharing services with the other peers in the P2P network. Each peer periodically broadcast a conflict message for a socially semantic-based chosen specific adaptation service and records the returned response. The delay measured (Fig.2) includes the time for transmitting the conflict, locating the required adaptation service, and running the service. Fig. 2 shows out some results, we have considered almost 30 java adaptation services. We have also measured the computation cost of the inferred adaptation paths. In Fig. 2, the average maximum cost is about 15 ms while the average minimum cost is about 80 ms. This behavior is in conformance with Kalimucho platform where local recommendation are automatically and periodically spread in the peer group every 20ms. In the remote configuration, any peer can directly communicate with any other, is fully decentralized. Results obtained are similar to local Kalimucho evaluation results, with an increase of about 15ms.
The experiments are conducted to compare our approach with similar semantic P2P multimedia document adaptation [8] which is P2P semantic based adaptation for mobile heterogeneous environment. Fig. 2 shows the evaluation results, meaning that our approach turns out to be the best. Compared with, the computation times of our approach increase slowly than [8] when the service repository increases. This result is practically significant as well related to the two aspects: one is the QoS for balancing the benefits of output quality and the revenue of adaptation cost guided by semantic services relationships and the other is our proposed context-based social modeling reduce the composition time when only reduced relevant services set is early selected.

![Fig. 2 Response time under various adaptation approaches.](image)

5. Conclusion

This paper discusses issues related to the multimedia semantic social adaptation topics. We presented several approaches that characterize the adaptation and the dynamic composition process like adaptation architectures and categories. We also described our platform enables dynamic adaptation process. This platform follows a layered architecture and is based on a decentralized semantic peer-to-peer model. The semantic-social information play a central role in discovery, dynamic selection, dynamic composition and substitution of services. The experiment shows that our approach outperforms adaptation ratio and time response. In the future, we plan to investigate towards using cloud computing to improve the performance of the service composition.

References