UbiHomeServer Front-end to the Ubiquitous Home Environment

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Abstract

To assist independent living of senior citizens at their homes, a large variety of systems are used. The most sophisticated solutions are built using ambient technologies. A number of technology platforms are designed to provide ubiquitous services for maintaining a high quality of life while reducing operational expenses. Interoperability between platforms at different levels, including GUIs' dependences on devices is still a major weakness of many modern solutions. In a given work a vision of the Ubiquitous Home Environment is presented with respect to the ICT Home Services delivery. An implementation of a serving engine developed at Oulu University of Applied Sciences – the UbiHomeServer – is described. An abstracted view to its front-end is introduced. Such abstraction may reduce GUIs' dependences on devices and thus increase an interoperability of a system.

Index Terms: Elderly, Senior Citizen, User Interface, Mobile, Smart Phone, Tablet PC, Touch Screen, Service, Ubiquitous, Home Environment.

I. INTRODUCTION

Ubiquitous Home Environment (UHE) is a user-centric set of systems that serve users in domestic environment and expanding its services to public and professional environments [1]. To ensure supply and maintenance of the ubiquitous services, the UHE operates over a variety of wired and wireless networks, and its networking infrastructure may include Body Area Networks, Resident Area Network, and Personal Area Network. Modern domestic environment is considered to be the Internet-enabled, covered with Mobile Networks (2/3+ G), and penetrated with Digital Broadcast (DAB, DVB-S/T/C). In addition to that an entertaining content may be brought to the UHE through a variety of generic and proprietary channels, typically TCP/IP-based (e.g. IPTV).

As it has been presented in [2] and [3], an essential part of the UHE is a serving engine. Serving engine may be implemented in a form of a dedicated in-house server, or built on a base of a modular framework that may be distributed among few computing devices. Typically the serving engine achieves interoperability with the UHE infrastructure through a variety of generic and dedicated modules. The serving engine should expose a number of GUIs to a selection of end-user or terminal devices. With respect to a domestic environment such serving engines sometimes referred as home platforms.

II. UbiHomeServer

A. Semantic Reality

Semantic Reality is a vision of information space that comprises the virtual and the real world and requires understanding of both for that purpose [4]. In accordance to the Semantic Reality vision, the physical world will be represented in cyberspace and information on human environment will become ubiquitously available on the Internet. Semantic Reality will provide an integrated information space following the design philosophy of the original Internet. That information space comprises community-driven agreement processes, emergent behaviour, and self-organization, while adding semantics as a key enabling ingredient [4].

To achieve the overall vision of Semantic Reality, the following technological issues need to be addressed [4]:

- Large-scale and open semantic infrastructures and flexible abstractions - to enable the design, deployment and integration of sensor/actuator networks and their data.
- Semantically enriched social network and collaboration infrastructures – to enable the targeted delivery of knowledge and information based on context description and actual user needs.
- Semantic description and annotation – to enable the flexible integration of information and (distributed) discovery of information.
- Emergent semantics, self-organization, and plug-and-play – to enable dynamic processes which support (semi-) automatic assessment of the levels of agreement and understanding as well as their correctness.
- Query processing, reasoning, and planning – to enable core functionalities to exploit the full potential of Semantic Reality.
- Integrity, confidentiality, reputation, and privacy – to enable the provided information to be resistant against technical errors and attacks, stored and transported in a secure way; that it would come from authentic and trustworthy sources and ensure the privacy of its providers and users.
- Vertical integration of business processes, middleware, sensor/actuator networks relying on the above-mentioned technologies and functionalities – to enable the full potential of the Semantic Reality.

Ubiquitous Computing is one of the domains – along with distributed systems, artificial intelligence, social networking, etc. – that the Semantic Reality integrates at a large scale. The context-awareness a central aspect of the Ubiquitous Computing [5]. In its turn, metadata is a key enabler of the context-awareness. Particularities of Middleware Systems for Context-Aware Applications are identified in [6]. Five guiding principles for building middleware aimed to support pervasive computing environments are the following [6]:

1. Balance between awareness and transparency.
2. Uniform Context Development Support.
3. Flexible Context Modelling Framework.
4. Context-triggered action.
5. Transparent support for ad-hoc communication.

Semantic technologies, particularly metadata, bring interoperability aspects to a new level. Thus operations with data models are more advisable in context-sensitive systems than row data exchange.

B. Service Delivery Paradigm

ICT Home Services are relevant to activities of such stakeholders as service providers and content suppliers for delivery of value-added services to modern households residing the UHE. With respect to interoperability, the following service categories were defined:

- Informative – one-way data flow from service provider or content supplier to
- Interactive – request-response model allowing purchase orders using a single customer ID from a single household.
- Fully interactive – advanced version of previous, allowing purchase orders using multiple customer IDs from multiple locations, taking into account a variety of preferences and customizations.
- Ultimate – is achieved using a variety of architectures, communication channels and protocols simultaneously.

It is also possible to define two groups of scenarios under which all the ICT Home Services may happen:

1. Call-for-services scenario. All newly-proposed services are automatically discovered and presented to the end-user via the UbiHomeServer GUIs. End-users may use interfaces of once- or periodically-occurred services (such as request for a transportation, refrigerator filling), or apply for scheduled services. Certain functionality may also allow a simplified way to expand/update or cancel/reschedule the services (cleaning, pushing snow, sauna time, meal delivery). Some of the services may be invoked automatically based on data obtained from dedicated devices and/or system awareness.

2. Inter-services scenario. A company that is specialized in providing supporting services of health- and supervising-care for nursing homes through their task-management system is able to get access to the UHE data, including personal, health and locally-stored or recently-observed medical data. By using this data, company's system may allocate tasks or initiate service request to a third company that uses the system. By providing real-time support for field workers, task-management system of that company is able to update a current state of a dedicated task with the most recent data from the UHE.

In order to implement such the ICT Home Services, a data exchange between stakeholders (their systems) and the UHE is needed. Thus knowledge management technologies are advisable to process data, retrieve information, and build knowledge. Higher level of semantics allows more intelligence of interoperability scenarios, but there is no guarantee that information systems of stakeholders are ready to interoperate at such levels.

Thus a need of a Service Gateway is occurred. The Service Gateway may be designed for information exchange and at the same time take care of such important aspects as data models, interfaces, authentication, security, privacy, and trust. Such vision of the Service Delivery Paradigm is shown in the Fig. 1.

From the point of the UHE, the Service Gateway may be considered as a cloud of data and thus form a back-end of the UHE.

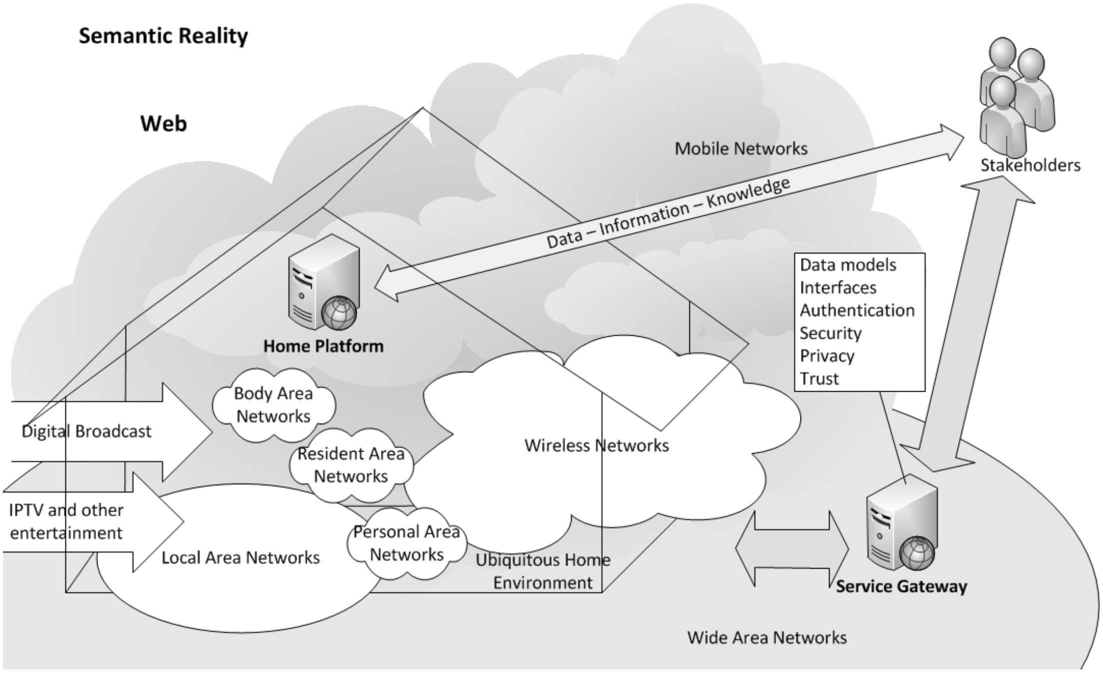

Fig. 1. Service Delivery Paradigm

C. UbiHomeServer

Oulu University of Applied Sciences (OUAS) group at PBOL has built own implementation of the serving engine, the UbiHomeServer [7], through the course of recent research and development projects. For sensing a physical environment, the UbiHomeServer interoperates with several Wireless Sensor Networks (WSN), including those that utilize 6LoWPAN protocol. Wi-Fi coverage of the living environment was defined to be essential. IPTV was concluded to be an important communication channel. As a core of the engine, an intelligent module that is based yet on a complicated algorithm was developed. Knowledge technologies, particularly such Semantic Web technologies as RDF, were considered in design.

Besides sensing environment with a variety of temperature, light and humidity sensors, the UbiHomeServer is able to change its behaviour by entering to one of the following modes (names are self-explanatory):

- Normal operation.
- Medical help is needed.
- Fire detected.
- Intruder detected.
- Night mood.
- User-out-of-home mood.

The UbiHomeServer offers a set of GUIs through which it is possible to interact with the UHE as well as consume and manage some of the ICT Home Services. Device recognition and content adaptation technologies were used to reduce end-user GUIs' dependencies on devices. The end-user GUIs utilize multimodal information presentation. Both, the UbiHomeServer, and GUIs are able to handle environmental changes dynamically.

A grid layout was chosen for the UbiHomeServer GUI design. Every service is represented by a button in a main view. The following options are available from a main view:

- Context-aware greetings.
- Voice guidance – inline help and service messages.
- Language selection.
- Basket of services – a repository of previously removed services.
- Settings.
- Time.

Clicking to an active button brings a chosen service interface that is implemented in a similar way as main view, and has own set of options. One off the options allows removal of currently invoked service to a service basket. Thus the removed service disappears from main menu, but occurs in the service basket.

Entire interface is implemented as low-hierarchical and intuitive. GUIs are designed for elderly people, but can be used by any age group including children of a school age.

The UbiHomeServer GUIs are designed for three categories of user terminal devices, which are:

1. TV (of any kind, connected to IPTV set-top-box).
2. Mobile (like smart phone, or tablet PC – with browsing capabilities).
3. Touch-screen (self-stand or device equipped with).

The UbiHomeServer operated GUIs offer similar user experiences regardless of a category of a device and thus form an identical front-end of the UHE. A main view of the UbiHomeServer front-end is shown in the Fig. 2.

Fig. 2. Main View of the UbiHomeServer GUI

The UHE front-end exposes the following modalities for information presentation:

- Textual (available on controls and/or on a title/info.
- Symbolic (some elements of controls; companies' logos).
- Colour (traffic light concept and supplementing colours).

– Sound (sound effects, alerts and audio signals).
– Voice (voice guidance, help and reading aloud).
– Visual (dynamic visual effects).

Several systems such as UbiPILL [7], UbiVID, and UbiTRASH robot, were made interoperable with the UbiHomeServer, and thus became to be integrated parts of the UHE. Safety Navigation [2], [3] is one of such systems.

D. Front-end Abstraction

Designing front-end in a way that it would be separated from the system core and be available to a variety of execution environments is one of the ways to address an interoperability. A problem of data exchange remains. The more sophisticated a functionality of user interfaces is, the higher data encapsulation in a vertical stack of the execution environment is required. As different services require different functionalities of user interfaces, a volume of encapsulated data is significantly increases. This is where unification and standardisation of data exchange helps.

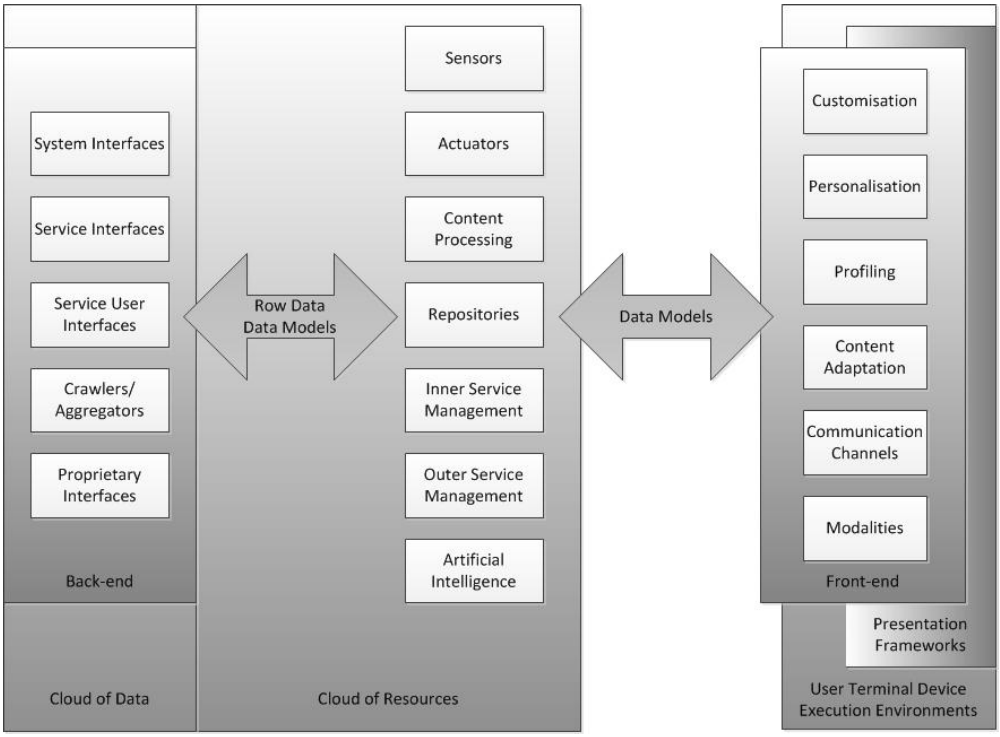

Fig. 3. Front-end Abstracted Disposition

First step is to build a generic map(s) of service data. A second step is to align data of existing services to the map(s). A third step is to review a functionality of interfaces, and build a Presentation Framework(s) supporting defined data model(s). Presentation framework may vary depending on the execution environment.

Data models may be developed to be very advanced – to include overhead information for service functionality, such as customisation and personalisation, profiling, content adaptation, communication channels and modalities.

As it has been described above, the back-end of the UHE forms cloud of data supplied by the stakeholders, or retrieved from the Internet. Thus it operates with outer data –with respect to the UHE. In its operations it may require an availability of certain modules:

- System Interfaces – for between-system interoperability.
- Service Interfaces – dedicated to certain services.
- Service User Interfaces – web-enabled or other GUIs for service providers and content suppliers.
- Crawlers and aggregators – to obtain web content.
- Proprietary interfaces – for closed proprietary systems.

A cloud of resources includes sensors, actuators, content processing modules, repositories, inner and outer service management, and an intelligent core. The cloud of resources operates with both, outer data, and inner data of the UHE, and also instantiate data models required for the front-end functionality. Inner data of the UHE includes results of real world measures as well – that are performed by sensors. Thus cloud of resources is where a merge of virtual and real worlds of domestic environment happens and immediately affects to the front-end.

An abstracted disposition of the UbiHomeServer front-end is shown in the Fig. 3.

III. Conclusion

A description of both, service delivery paradigm and the UbiHomeServer are given. An abstracted view to the UbiHomeServer front-end is introduced. A distinguished property of such abstraction is an utilisation of data models for front-end operations. Mapping heterogeneous data to a smaller number of data model allows a use of a smaller number of presentation frameworks, which reduces significantly a development effort. Within the UbiHomeServer implementation, such abstraction essentially reduced GUIs' dependences on devices and thus increased an interoperability of the system.

More practical tests with different implementations of serving engines are needed to justify a validity of the front-end abstraction model. Standardisation of existing data models, reference architectures of modules that use them, and front-end abstraction is still an issue to solve by an entire ICT community. Loose architectures able to work with a variety of data models bring more operational freedom, but require more development effort.

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