INTEROPERABILITY IN SMART HOME MIDDLEWARE
The MPOWER Project

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Abstract: The paper describes the use of interoperability standards and interoperability frameworks in a smart / sensor home project. During the EU funded project MPOWER an open middleware platform will be developed which should speed up the task of developing and deploying services for persons with cognitive disabilities and elderly. The developed middleware has different interfaces where interoperability standards are required. The paper points out these requirements and presents solutions in the different layers of the Service-Oriented Architecture approach. In future, standards and defined interfaces are more and more needed because of the need for a secure and easy data and messaging transfer. The middleware will be developed non-proprietary and is open for different applications and sensor integration.

1 INTRODUCTION

Interoperability in smart home and sensor systems is a rarely unvalued field in research and development so far. There is hardly any activity in using standards and defined interfaces although this area of research deals with a lot of different sensors and sensor data from the medical field as well as from the domestic domain and data have to be transferred to "outside" systems.

The operating experience has shown that a change of thinking is unavoidable for a faster and more cost efficient development and for a more safe data transfer.

For an efficient development in the future it will be important to overcome proprietary systems and solutions for every single smart home environment. With the experience from the medical field, where a lot of initiatives have been working on the development and promotion of standards and frameworks for years, an adaptation of the smart home context is desirable.

The following benefits can be mentioned: Interoperable and semantic systems are vendor independent and e.g. different kinds of sensors can easily be integrated. This opens the market and speeds up the development and inner data transfer. Furthermore the interfaces for any legacy system or nursing system are defined. Thus data can be retrieved easily by any outer system, which fulfils the guidelines for the defined data format.

2 THE MPOWER PROJECT

MPOWER is a "Specific Target Research Project" (Contract number 034707), partially financed by the INFFSO DG of the European Commission.

The aim of the project is to define and implement an open platform to simplify and speed up the task of developing and deploying services for persons with cognitive disabilities and elderly.

With the start of the project an investigation of user needs was carried out. The aim was to gain knowledge about the needs of older people and people with dementia, in respect to technical IT solutions, which can support everyday living and to "aging in place". Before developing new technological solutions, an investigation of the user groups' needs and requirements was important.

When looking at the European society today, there are some striking trends: The growth of the older population, that is people over 65 years of age, is expected to rise in the decades to come. In general the health of older people is improving and life expectancy is rising in many countries.

This changing of the society in the next years reveals the need for a faster development of novel

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and innovative technology solutions which are providing applications for an ambient assistive living.

The MPOWER middleware follows the IBM Service-Oriented Architecture (SOA) approach using web services. Applications built in the SOA are based on services. A service is an implementation of a well-defined business functionality, and such services can then be consumed by clients in different applications or business processes. SOA-based applications are distributed multi-tier applications that have a presentation, a business logic, and persistence layers. Services are the building blocks of SOA applications. While any functionality can be made into a service, the challenge is to define a service interface that is at the right level of abstraction (Mahmoud, 2005).

Web services are software parts designed to support machine-to-machine interaction over a network. This interoperability is gained through a set of XML-based open standards, such as WSDL, SOAP, and UDDI. These standards provide a common approach for defining, publishing, and using web services (Mahmoud, 2005).

The idea in the MPOWER project is to evaluate use cases and features for elderly people and people with dementia, based on user scenarios. The assigned features are leading to services, which will be implemented as web services. The application developer will be able to develop applications based on these services more efficient. For demonstrating the middleware there are two demonstration sites planed. One demonstration site will be based in Norway. The Norwegian pilot Point-of-Care (PoC) application will show the connection to a legacy system, storing information about medical treatment, social treatment and care planning. The other trial Point-of-Care application will be implemented in Poland. This demonstration site will show the integration of different domestic and medical sensors.

3 INTEROPERABILITY

An essential aspect of an architecture is the establishment of technical standards. In general, standards define common elements, such as user interfaces; system interfaces, representations of data, protocols for the exchange of data, and interfaces accessing data or system functions. Technical standards provide a number of advantages for the systems architect.

The partners will promote standardization through aligning their work with ongoing development of HL7, security and interoperability standards. Standards are important because they are accepted by multiple vendors, thereby increasing the likelihood that a collection of systems from diverse sources will be able to interoperate.

Definition of *interoperability* in ISO/IEC 23282-0: *Information Technology Vocabulary, Fundamental Terms: "The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units"*

Interoperability can be achieved through:

- the implementation of standards,
- the usage of predefined sets of business procedures,
- the usage of accorded file formats and protocols for data transmissions.

4 INTEROPERABILITY IN MPOWER

Inside the MPOWER framework different interfaces for implementing interoperability standards and guidelines have been identified. Interoperability is important for every interface where data is transferred outside the closed system. Concerning the Service-Oriented Architecture (SOA) approach, messaging guidelines for data transfer between the different services are also a need of interoperability.

The following chapters will describe these three interfaces where interoperability needs in the MPOWER framework are identified and where and how standards are used.

4.1 Interoperability in Point of Care Systems

Homecare and Point-of-Care systems that are available today, usually provided by one single vendor, suffer under proprietary data and messaging transfer and lack very often in respect to data exchange and interoperability with other systems, especially third party systems.

A series of "health informatics, Point-of-Care" standards are being developed in a concerted approach between ISO, IEEE, IHE, and other major players in the field. These efforts are targeted towards implementing interoperable measurement

systems in healthcare, for example laboratory, intensive care and telemonitoring purposes as well as home care. The standards provide architectural components, information models and services (ISO/IEEE 11073-10201), and also methods for data exchange, both wire based, and wireless (ISO/IEEE 11073-30300).

Although the IHE started implementing the framework for health applications, the communication structure could also be used as well for homecare applications for elderly and persons with dementia. This could easily be done since there are already structures for Point-of-Care devices as well as for information sharing with legacy systems or care provider systems. The benefit would be the accordance to established standards and standard frameworks. It is clear that there is an advantage because of already established Point-of-Care communications from the medical field (blood pressure, temperature etc.). So the existing standards have to be extended for the homecare use cases and devices. Of course the whole IT structure and the cross-enterprise-document (XDS) sharing defined in the IHE framework could handle personal health data and information, which could be, depending on the use cases, important for medical help.

The ISO 11073 offers plug-and-play and a functional as well as a semantic interoperability between sensor systems and aggregation systems. In this standard all functions and use cases in patient oriented health care and of course in some aspects of smart homes for elderly are object orientated modelled already. That means a so-called domain information model is constructed where the device, the functionality, the measured data, settings, alarm functions, patient information and interfaces are defined. Furthermore there are codes for all information elements defined as “nomenclature” (ISO/IEEE 11073-10101) and “data dictionary” (ISO/IEEE 11073-10201).

The communication standard POCT-1A is implemented in the ISO 11073.9 and is specialized for patient near Point-of-Care. In principle the functionality of POCT1-A could be realized with HL7, but the functional range of the HL7 structure is in some cases (single sensors) too highly dimensioned. So it could depend on the special function that should be realized between the sensor (according sensors often have a restricted hardware) and the local controller. Because of a clear defined message communication the unique interpretation of the standard is guaranteed. POCT1-A is a flaring of HL7 not a competing standard.

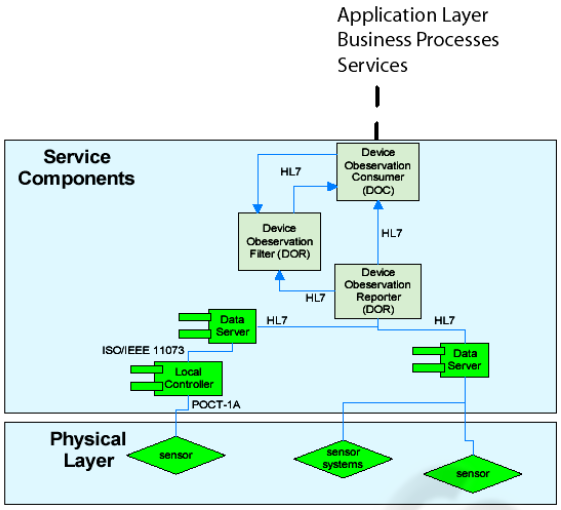

Figure 1: The Service Components Layer and the Physical Layer in the SOA approach.

Figure 1 shows the Service Components Layer and the Physical Layer in the SOA approach. The Service Components Layer contains the POC framework provided by the IHE with the Device Observation Filter, the Device Observation Reporter and the Device Observation Consumer.

The advantage of the CEN/ISO/IEEE 11073 is that it is the only comprehensive system of Point-of-Care medical device communication standards. The modality categories range from real-time-operating medical equipment to Point-of-Care test devices. Wired as well as wireless IR and RF network technologies are supported. If healthcare providers and management organizations want Point-of-Care to record transparency of information, then they must demand medical device interoperability. In addition to the core development bodies, the activity coordinates regularly with other health information activities (HL7, NCCLS, IHE and DICOM).

4.2 Interoperability to Legacy Systems

One of the key problems in healthcare and Point-of-Care is the lack of interoperability among different healthcare systems (service interfaces) at the one side and among diverse device examples and aggregation / computation systems (device interfaces) on the other side. Interoperability standards and frameworks would also advance the exchange of data and information between two system-interfaces respectively services as well.

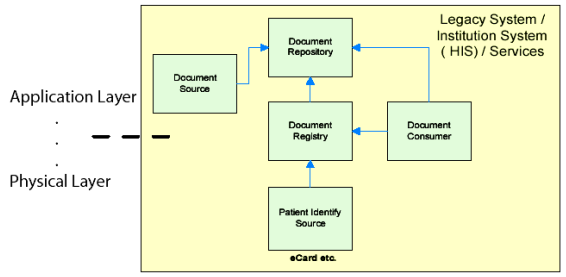

Figure 2: IT Infrastructure Technical Framework provided by the IHE.

Figure 2 shows the IHE Framework for Legacy Systems. The Document Source is connected to the middleware. The Documents Source could be any kind of health record as for example the Clinical Document Architecture, a XML schema developed by the HL7 group for store the HL7 messaging context in a document format. The Document consumer will be stakeholder who is interested in viewing the data or viewing parts of the patient related data, e.g. a doctor or a nurse. The identification is provided by the Patient Identity source; i.e. a registration as it could be managed by the eCard (www.chipkarte.at, 2007) in Austria for example.

4.3 Interoperability between Services

Between the services all medical data will be transferred in the well defined HL7 messaging. All contexts concerning non medical data e.g. the domestic sensor data will be transferred in a common XML schema with SOAP actions.

5 RESULTS

5.1 The Operational System Layer / Physical Layer

Based on the service oriented architecture model from IBM (Arsanjani, 2004) the interfaces for the interoperability have been integrated. For the development concerning the MPOWER middleware platform the layers of services and service or enterprise components are of interest.

The physical layer or operational layer consists of sensors as well as sensor systems, which provide a collected set of information. Through the operational layer there is of course also the possibility to have an access on existing custom built applications and legacy systems as well as for instance other object-oriented implementation like older legacy which are providing miscellaneous data on the physical layer from bottom up.

The physical layer in the SOA approach represents the whole sensor layer, which provides the information of the smart house. This will be medical data like blood pressure as well as non-medical data like status sensors (door open, door closed, etc.).

5.2 The Enterprise Components Layer / Service Components Layer

The enterprise components or service components layer uses typically container-based technologies such as application servers to implement the components, workload management, high availability, and load balancing.

For future applications it must be guaranteed that different sensors or different sensor systems from different vendors could be connected to the system. In this layer device components will also be implemented. Based on the IHE framework the device components are defining the communication interface to the different services, which need detailed information of one or more sensors or sensor systems. The important interoperability interface for connecting different sensors and sensor systems to the system will be the data server in the service component layer. The data server will only accept data and information from registered sensors, which means that a sensor has to connect to the system. According to the ISO 11073 standards the sensor or the sensor system has to communicate its domain information model. The domain information model contains the following information: the device or sensor name, the functionality, the measured data the sensor will provide, settings, alarm functions and if possibly patient information (for instance when thinking of patient monitors or other complex measurement systems where such data are provided).

If a single sensor with a restricted possibility of processing power and memory capacity should be connected to the system the POCT-1A protocol standard is the recommended interface technology. The POCT-1A standard is optimized for the communication between sensors / devices and an observation reviewer or local controller. The protocol is XML, so it has the advantage for an easy interpretation to HL7. As mentioned before there are ambitions to integrate the POCT-1A into the HL7 v3.0 standard. The POCT-1A will be an add-on to the HL7 for e.g. memory restricted devices.

5.3 The Service Layer

In the service layer the different services for interoperability are present. The services could be used for the different business processes and interact with each other. The work of the interoperability group in the MPOWER project will be to provide services, which are the interface to the "outside" of the smart house. There will be services for document translation or extraction to provide medical relevant data for more comprehensive document sources like patient reports or health records. The export of the medical relevant data to a health record will be provided with ebXML and SOAP protocols and stored in a HL7 CDA adaptive format.

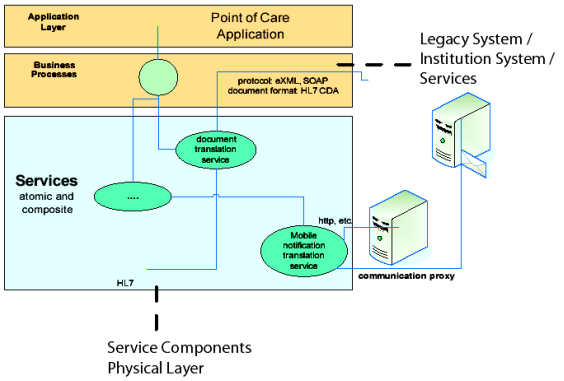

Figure 3: The Application Layer, the Business Processes Layer and the Service Layer in the SOA approach.

Figure 3 shows the Application Layer, the Business Processes Layer and the Service Layer and the connection to "outside" server proxies.

To have the option for providing information and data or a part of the smart house data to a healthcare delivery organization belonging to a clinical affinity domain (e.g. community of care) the cross-enterprise document sharing (XDS) defined by the IHE will be of interest. Within the XDS a federated document repository and a document registry create a longitudinal record of information about a patient within a clinical affinity domain. This profile is based upon ebXML registry standards, SOAP, HTTP and SMTP. By looking at these standards the MPOWER middleware platform could also provide interfaces and standards where a data exchange to such "outside" frameworks will be easily possible.

There will be services for mobile notification services like SMS and Email. The interfaces for these needs will be presented by services, which will make the translation of the different formless notification and alarming needs. It will be part of the Proof-of-Concept application, making the demonstration, to set up the "outside" proxy, connected to the interface services provided by the interoperability working group, for the respective use case. The legacy system / institution is connected to the service layer of the MPOWER middleware because in this structure the legacy system is an external system where an interface for a possible data exchange should be provided. As mentioned above it must be clear that if the legacy system, which could be a hospital information system as well as any other proprietary system, the interface is in the operational layer.

5.4 The Business Processes Layer / Choreography Layer

In the business process composition or choreography layer different compositions and choreographies of services exposed in the services layer are defined. Services are bundled into a flow through orchestration or choreography, and thus act together as a single application. These applications support specific use cases and business processes (Arsanjani, 2004). According to the use cases a business process could access different services.

5.5 The Application Layer

The application developer will develop graphical interfaces for end users conjunct with invocations of service components as well as handling of business processes. Several use cases will be demonstrated during the MPOWER Proof-of-Concept applications.

6 CONCLUSIONS

Interoperability standards in smart home applications are not widely used and implemented. Different sensor systems and applications in the medical field have shown that standards and defined interfaces are needed for a satisfying message processing and data transfer. Proprietary systems are restrictive and there is no sharing of information. However the trend in Europe points to more non-central information admittance. More and more people are medically treated at home and telemonitoring is a growing IT field. Therefore novel sensor and medical data sharing applications have to be open for any data sharing. Integration of sensors from different vendors and information sharing to different legacy systems is required.

To meet these requirements it is not sufficient to have one fixed setup of individual components for the sensor system. Practical systems must be able to change within given limits, and still be able to fulfil their purposes. Different elements from the repository (sensors, processes, documents etc.) must be changeable by different vendors with similar properties. This goal can only be achieved through working together on integrating standards.

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