SERVICE-ORIENTED ARCHITECURE OF MACEDONIAN HEALTHCARE INFORMATION SYSTEM

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ABSTRACT

Introduction of information technology in healthcare system may eventually enhance the overall quality of national standards. The success in current healthcare system requires reengineering of healthcare infrastructure for Macedonia. For this, there is a high requirement in Macedonia to invest in IT infrastructure to provide interoperability in healthcare information system (HCIS).

Also, integration of IT with healthcare system may lead to open connectivity at all levels, ensuring that patient information is available anytime and right at the point of care, eliminating unnecessary delay in treatment, avoiding replication of test reports, improving more informed decisions and hence leading to improved quality of care. With this intent, this paper attempts to present software design patterns for Service Oriented Architecture (SOA) and its related technologies for integrating both intra and inter enterprise stovepipe applications in healthcare enterprise to avoid replication of business processes and data repositories.

We aim to propose a common interoperability framework for enterprise wide applications in Macedonian HCIS.

Keywords. healthcare systems; SOA, ESB, HCIS, interoperability, HSI.

I. INTRODUCTION

Healthcare organizations [10] often face the challenge of integrating diverse and geographically disparate information technology systems to respond to changing requirements and to exploit the capabilities of modern technologies.
Hence, systems evolution, through modification and extension of the existing information technology infrastructure, becomes a necessity.

HCIS requirements [9] differ from other existing applications. The gap between existing application and medical care needs makes it more complex. To get the maximum benefit of ubiquitous healthcare system it is necessary to build a middleware between different ubiquitous applications which can play an important role in management of data and information processing. To enable medical personal for real-time triage, correlation with hospital records and long-term observation of patients is necessary, while sharing the most accurate and real-time patient information.

HCIS, Electronic health records and health information exchanges are necessary components of the information infrastructure to support a reformed health care system. HCIS can be defined as “a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system”. Information systems play a significant role in helping to improve health and health care, and in planning and financing of health care. The relationship between the participants locally, regionally and nationally requires that information is shared for planning, funding and treatment purposes.

This paper takes a process perspective of healthcare delivery within and across organizational boundaries and the presents a disciplined approach for evolving healthcare systems towards a SOA using the enterprise service bus (ESB) middleware technology for resolving integration issues and the business process execution language for supporting collaboration requirements in Macedonian’s Healthcare system.

The paper is organized as follows: in section II we describe the current situation in Macedonian HCIS in section III we describe design patterns for SOA and ESB; in section IV we present a proposed architecture of health system of interoperability. In section V, we evaluate the proposed architecture, the final section contains our conclusion and future directions.

II. IMPORTANT ASPECT OF MACEDONIAN HEALTHCARE INFORMATION SYSTEM

By its nature, healthcare organizational structure is distributed since it presents a geographical spread of entrees at different levels of complexity: from general hospitals down to individual GPs. The major and most urgent [1-2] need of HCIS is therefore the definition of standards enabling the interwork of different and heterogeneous applications, enabling them to behave together as an integrated system towards the environment, even if they were developed at different times, by different vendors and with different technologies. In such a scenario, various structures operating are characterized by a high degree of heterogeneity and diversity from organizational, logistical and clinical perspectives.

Macedonian's HCIS are complex and critical enterprise systems linking together geographically distributed hospitals, clinics, physician offices and other business units with distinct business functions and mutual dependencies. In the past, these systems were built on the basis of proprietary solutions, acquired in piecemeal fashion and tightly coupled through ad hoc means. This resulted in stovepipe systems that have many duplicated functions and are monolithic, no extensible and non-interoperable. The method of a migration from these stovepipe systems to the next generation of open HCIS's that are interoperable, extensible and maintainable is a pressing problem for the healthcare industry.

Macedonian HCIS [3] is complex and critical complex system that is supposed to link together geographically distributed information systems of the Fund, IPH, Centers for Public Health, hospitals, clinics, offices of physicians, private hospitals and other business units with different

business functions and interdependence.

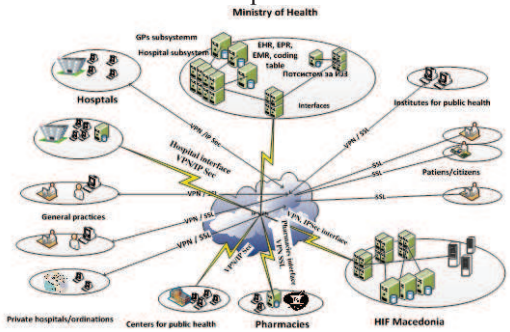

Figure 1. Macedonian Healthcare Information System

Figure 1 clearly shows the functional structure of Macedonian HCIS. The central location is stored data code, code tables, health professionals, electronic health record (EHR), electronic patient records (EPR), record of the patient medical record (EMR) and lists of drugs. This system is necessary to be developed. It is necessary to provide appropriate interfaces to use various software for working and record of reviews, referrals, prescription drugs, access to the EHR, EPR.

III. ENTERPRISE SERVICE BUS AND SERVICE ORIENTED ARCHITECTURE

An enterprise service bus (ESB) is one of the main technologies that enable implementation of service-oriented architecture (SOA). SOA is an architectural style whose goal is to achieve loose coupling among interacting services. It has become an extremely popular paradigm. An ESB is an open standard, message based, distributed integration infrastructure that provides routing, invocation and mediation services to facilitate the interactions of disparate distributed applications and services in a secure and reliable manner.

ESBs are usually realized through service containers distributed across a networked environment. These containers host integration services like routers, transformers, application adapters or MOM bridges and provide them with a broad range of communication facilities. Applications are connected to the bus using application adapters or one of the supported messaging mechanisms. In order to support SOA the ESB service containers have to include all important web service technologies. The components of the ESB as well as the mechanisms for connecting resources must be based on open standards to ensure interoperability and protection of investment.

The ESB must coordinate the interactions of the various resources and provide transactional support. A general goal is to provide messaging and integration without writing code. Therefore generic components are provided which can be configured to realize a desired scenario.

Interoperability [8], denotes the ability of information systems and business processes they support, to exchange data and share information and knowledge. The aim of the system interoperability is to increase the efficiency of the public sector, improving the quality of services available to them citizens and businesses. In the interoperability is introduced relatively new concept which is called SOA. The basic principle, on which SOA is based, is the idea of IT systems, software, devices and services to be integrated and be able to communicate each other, although they were never specifically designed for it.

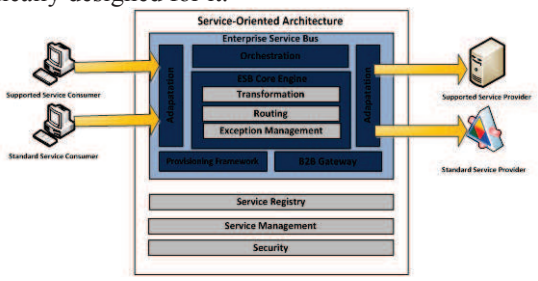

Figure 2: SOA and ESB

The most important aspect of SOA [8] is that it separates the service's implementation from its interface. Service consumers view a s ervice simply as a communication endpoint supporting a particular request format or contract. How service executes service requested by consumers is irrelevant; the only mandatory requirement is that the service sends the response back to the consumer in the agreed format, specified in contract. In order to design large scale SOA, we need to follow the following implementation standards: SOA can support variety of design patterns including: Asynchronous Messaging Patterns, Conversation Patterns, Orchestration Patterns, Process/Workflow Patterns, Endpoint Patterns, and Security Patterns etc. Messaging is the backbone of SOA. SOA views each application as a service provider and enables dynamic introspection of services via a common service directory, Universal Description Discovery and Integration of Web services (UDDI)."

SOA is implemented using web services, where applications are constructed as sets for repeated use, offer mutual cooperative services where each service is responsible for one or more specific user-defined and limited tasks, as well as business processes or information services.

The end points of service which are available in SOA, using web services, are constructed from the following standards:

- XML: eXtensible Markup Language, which enables data interoperability between systems, regardless of manufacturer;
- SOAP: Simple Object Access Protocol, which provides the syntax for accessing services;
- WSDL: Web Services Description Language, which effectively meets the needs of Web services and regulates the input parameters to provide the required output parameters.

IV. PROPOSED ARCHITECTURE

Functional purpose of the system of interoperability in healthcare should be built based on SOA. SOA of the system should provide a central system to support the interoperability of the logical aspect, while his physical structure is distributed.

For implementation of SOA, in our model, we will use web services. The idea of using web services is the ability to create functional blocks that shall be accessed via standard Internet protocols. Each SOA block can play one or more possible roles of the following three roles:

- Service provider
- Service broker
- Service requester

Service provider creates a web service and publishes its interface and access information in the registry of services. Each provider needs to make decisions about which interfaces to publish, to decide the balance between security and easy accessibility, charging for use of services or, if free, how to give a d ifferent value. The provider also needs to decide on the category in which to publish the service

Service Broker also known as service registry, is responsible for publishing the interfaces of web services and implementation at all interested service requesters. There are several types of brokers. Public brokers are available through the Internet, while private are accessible only to a l imited number of users, such as a company intranet. It also decides on the amount and type of published information services. Universal Description Discovery and Integration (UDDI) specification defines a way of publishing and finding information on web services.

Service requester (or web service client) to locate entries in the broker registry using various search operations and then binds to the service provider in order to invoke some of its Web services.

SOA is mostly built using standard web services (e.g, use of Simple Object Access Protocol - SOAP and Extensible Markup Language-XML), which have great popularity and is accepted in the IT industry. These standards provide greater interoperability and adequate protection "locked" software, specific to manufacturers.

Web services are self-tangible components that provide their services through specific Internet protocols. Communication over Internet Protocol means openness and availability of those services. Each user can access the registered web services from any computer connected through the Internet network. The only thing needed to know is how to find the service you require, ie you need to know how to detect it. This discovery of web services can be performed using a UDDI registry.

The discovery of web services is the process of finding an adequate web service for a given activity. Publication of web services includes at least creates a software artifact and its making available to potential users. For particular software application can use a specific web service, the service provider normally complete the page in web service with a description of its interface, using a special file - Web Services Description Language (WSDL).

Service provider can explicitly register service within a specific register of web services, such as UDDI registries or published additional documents with feature detection such as Web Services Inspection Language (WSIL) documents. Users of services need to search the service manual or automated. The implementation of the UDDI registry and WSDL tools should allow simple programming tools or web-based user interfaces (GUI) to assist in finding web services.

UDDI registry accepts information which describes the process of interest, including web services it provides, but also allows interested parties to make searches and downloads of information. It is necessary to emphasize that the UDDI registry does not keep components from web services or as program code, or as modules. When we talk about publishing web services in registry, we think that UDDI registry only create entry just for web service access point and its link to the WSDL documents.

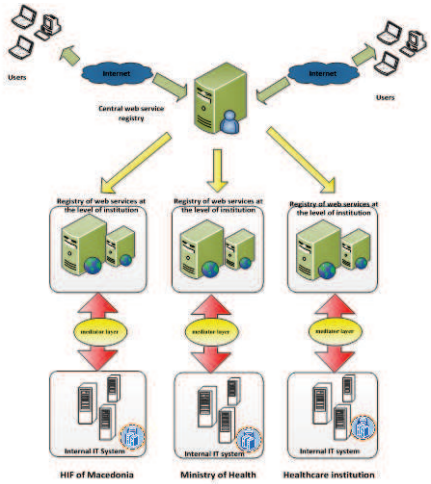

Figure 3: Architecture of the service registers of HSI

Functional purpose of UDDI registry is a representation of data and metadata for web services. Such a register represents a register intended for use within the public network or within the internal network of a particular organization, and thus provides a standard mechanism to classify, categorize and manage web services.

Figure 4 present the proposed logical architecture of the subsystem to support health system of interoperability (HIS). This architecture uses model of levels and consists of the following levels:

- Users level
- Level of way access
- Level of processes
- Level of Service
- Level of service providers

Users level provides access through the use of appropriate presentation logic to the HSI for all types of functional and system users. From an organizational point of these types of users belong to: employees in PHI in Macedonia, all health workers in PHO, all registered companies (business users) in the Republic of Macedonia, every insured citizen in Macedonia, all government and state institutions and agencies in Macedonia. These users, according to security policies, have different ways of accessing the health system interoperability. The method of access is defined in the level of way access. It can be through public and open access network (e-mail, publicly accessible web portal of the HSI), a private intranet network (web pages, email and integration with information systems that exist in the institutions). Level of access, in accordance with defined policies on types of users determines how the access of any user.

By the way of access, it depend the set of available processes in the domain of HSI, to which the user has access. Services used are defined in the level of services. They are available for integration into the processes used by users in accordance with security policies and access points that have the right to used.

All services, that arising from appropriate service providers represented by the information systems of institutions: public hospitals, private health institutions, organizations and agencies involved in the HSI. Allowed to service providers to be other systems to support in inter-institutional management.

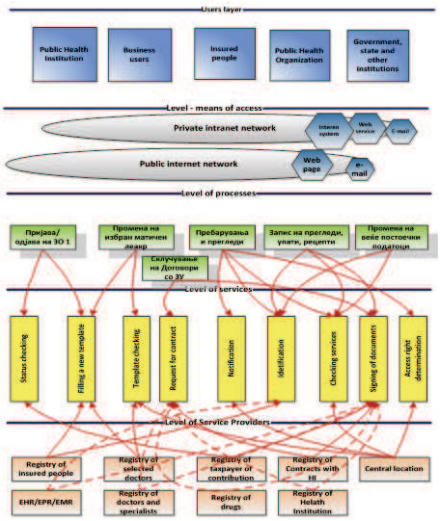

Figure 4: Logical system architecture to support interoperability

Service providers, through the system to support workflow processes, define new web services that make available to all users with provided rights of access to the appropriate registers of services. Thus provides a flexible architecture that enable constantly expanding and updating the set of services that are available to users of the HSI. The proposed architecture of the HSI is centralized by logical aspects.

The general architecture of the HSI is shown in Figure 5. Because of the complexity of the health system, that is implemented as a layered model of architecture. The lowest level is a distributed system of heterogeneous databases without common management system databases and as such they are not of direct interest of the HSI.

Exceptions to this conclusion, is the database which will record the use of services provided by the HSI. Access to individual databases, in general, are doing with the application logic modules belonging to the internal information systems of institutions involved in healthcare interoperability. Such applications should provide interfaces to the level of logic integration.

Level of integration logic is crucial for the realization of the HSI. This level should provide creation of services through the mediation tools for monitoring processes (workflow) that will be connected to existing modules of internal information systems and their transformation into web services. Integration's level, should be published these web services in appropriate registries of web services depending on access privileges.

This level manages the access privileges, exchange and adjusts the messages from different sources, in case of need for their adoption in comparable format. Finally, this level takes care for management services offered by the HSI in the form of transactions, if necessary. In one sentence, this level provides the functionality of services in the HSI.

These services should be available to various categories of users. For the purposes of protection of the HSI, beyond this level should be installed firewall, after which monitors the level of presentation logic.

This level will be realized in the form of portal that offers: list of web services through access to service register, integration of web services by electronic mail or directly as remote procedural call (RPC) for applications in a standardized format (XML), as well as plain HTML text for a specific set of services or users.

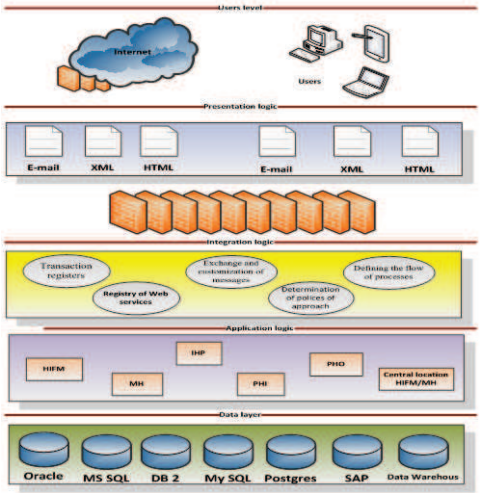

Figure 5: System architecture to support HIS

External users of the system are separated by an additional firewall, which achieves maximum protection against unwanted intrusions into the system.

Figure 6 show the diagram of components for HSI and explain the positioning of the components. Each institution which participating in the process of interoperability has a local register of services and more systems for arbitration and mediation. Number of systems for arbitration and mediation depend on the number of locations where the stored data.

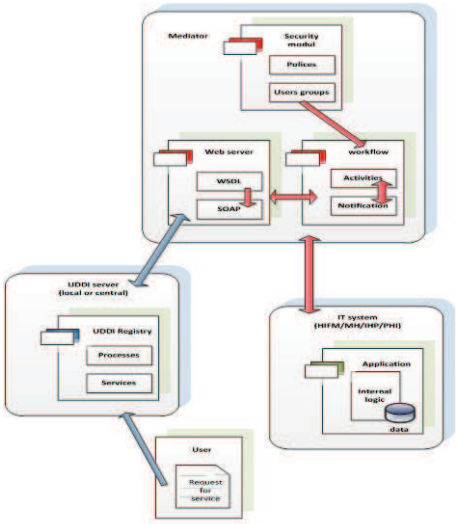

Figure 6: Providing service from service provider

Mediation system provides connectivity to the applications of individual institutions, perform authentication and regulates access control. Access control should be determined locally, if it can be regulated by local policy, but if necessary (if local policies do not allow action) should be performed as an application service for HSI, which will perform the search through central service registries. Component for supporting of the work of mediation's workflow system should establish interface with the applications of each institution involved in the process of interoperability.

In the same way (through the mediation system), information systems and applications from the individual institutions may set the requirements (or enter information) to

the HSI. Then as a client of the HSI, appropriate mediation system are appears.

If it is not possible to directly connect to the modules and applications of the different institutions involved in interoperability at the time of interpretative solution, as a minimum, should be provide access to the HSI through the portal of the HSI (in compliance with security policies).

Each institution involved in the process of interoperability should undertake to provide an interface to the HSI. This is in accordance with internal strategies for developing of information systems of institutions involved in healthcare of interoperability. All information about services that pass through any of the registry services of the HSI (local or central) are stored in a database using the HSI (only information about services, not the data itself from them). By setting the correct hierarchy and cooperation between service registries (public, private, cooperative) to achieve optimum availability of the services of the HSI in accordance with current security policies.

V. EVALUATION

Enterprise systems using SOA may experience service failures due to infrastructure breakdowns, host overloads, or software compatibility issues. It is important for SOA systems to recover from such incidents as quickly and as efficiently as possible. It is undesirable to have to stop the whole service process and recompose a new business process whenever there are only a few services at fault.

The concept of HSI provides online data exchange between different information systems and the ability to exchange the minimum necessary information without a duplication of information that is in line with European directives. The development of new web services in their design includes two separate segments which relates to their identification and specification [5].

Phase of identification is focused on determining the required services and their capabilities, at this stage services are called service candidates and their abilities, the ability of candidates. When designing the proposed concept of Web services in the health system were used recommendations and access provided by the authors [5], Michael Gebhart, Marc Baumgartner and Sebastian Abeck. Using this approach to IT architects is facilitated choice of methods in implementing the proposed web services. Attributes identified in the design of Web services in many can help IT architects in the design of the system [4]. Following the approach in analyzing the design of the model of Web services, experience and results obtained from the authors of [4-7], it can be applied to proposed services Macedonian health information system that would help a lot of designers in IT development and implementation of health IT distributed system based on SOA.

VI. CONCLUSION AND FUTURE WORK

The proposed SOA of HSI, itself is a platform for further development of components and functionality, according to the specific needs in this case. This does not mean that the operation of the platform caused by the specific application, but due to the openness of the presented solutions much easier than before can integrate specific components into the system. This can extend the application of HSI in support of management of healthcare.

HSI is to provide the necessary components, protocols and hierarchical structures that integrate data and entities in health management systems provide an integrated analysis system and provide management support.

The proposed model will still be the basis for defining the data warehouse where the use of data mining technology will allow getting various information, previews, predictions, reports that on the other hand many will use the definition of health policy and rational planning health penny and this leads to better and higher quality health care for citizens.

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