A Service Oriented Approach to Clinical Information System Development

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Abstract — **In order to address the deficiencies in care, healthcare organizations are increasingly turning towards implementation of clinical information systems. This paper presents a service oriented approach to development of clinical information system which could be used in everyday clinical practice. Among other benefits, with service oriented architecture (SOA) approach in development, users are enabled to use the applications over the Internet. Two applications have been developed, Windows desktop and Android mobile application. This paper presents architecture of the system and design of application modules. Clinical system functionality is described thoroughly. Technology involved in the development is included in the paper as well. Finally, the paper covers clinical system consummation from mobile devices which is tending to be the future in healthcare systems. (Abstract)**

Key words - Clinical Information System, SOA, Development, WPF, WCF

I. INTRODUCTION

A Service Oriented Approach to create and evolve information communication technology solutions is a phenomenon that is transforming the way many organizations in the private and public sectors operate. This paper presents an approach for development of clinical information system.

Today, physicians accept the change implied by, and associated with, the need to adopt the use of computers in medical practice. This is an important question, considering the dynamic changes in the health care system. There are a lot of benefits that would accrue to the system, generally, and to the patients, specifically, if these fully operational information systems would be implemented.

Electronic health records in these healthcare information systems allow easy access to computerized records reducing costs caused by data storage, and with a system keeping all records in the same place, hospitals and clinics could become better organized. Healthcare information systems also allow different medical professionals, such as doctors, nurses and specialists, responsible for a patient's care to access the same records. This could help them avoid miscommunications and prevent mistakes.

The results of poor document management can lead to a significant loss of time. Communication problems occur even between employees in the same office because they do not have easy access to the documents that they need. For that reason, this information system uses Document Management System (DMS) [1] for easier archiving, access and distribution of scanned documents. It concerns sets of all sorts of business documents such as procedures, reports, documents received from patients, documents sent to patients and datasheets.

Reminder function integrated in the application allows users to set notifications for them, preventing them to forget important dates, meetings, etc.

By using service oriented architecture (SOA) [2][3][4] approach in development, users are enabled to use the applications over the Internet. The World Wide Web offers a potential solution, with its multifunction servers, multiplatform clients, and use of standard protocols for displaying information. This approach may be adaptable for use in developing institution-independent standards for data and application sharing.

The use of service oriented architecture can improve the delivery of important information and make the sharing of data across a community of care practical in cost, security, and risk of deployment. The organization that has a large portfolio of systems will more readily see the benefits of SOA. SOA environment enables system assets to be accessed across the organization, providing opportunities for sharing system capabilities that are currently isolated. For example, SOA can help meet unfulfilled processing requirements without purchasing additional systems and can provide opportunities to standardize processing and data management [3].

One of the key tenets within SOA lies in the ability to adapt the architecture over time, adding new services, replacing existing services, and reconfiguring infrastructure, all with minimal impacts to service consumers.

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SOA allows web service to be invoked by any potential client of the service. The ability to mix and match the execution environments separating the service interface from the execution technology, allows IT departments to choose the best execution environment for each job [4][5]. This allows the data from the healthcare system to be accessed from a distant computer or mobile device.

The rest of this paper is organized as follows: related work in the field is presented in Section II. System functionality is described in section III. Section IV contains development process, technologies and system architecture description, while section V holds our conclusions and future work directions.

II. RELATED WORK

Healthcare information systems play an important role in improving healthcare quality. A lot of papers in the field analyze different approaches for clinical information system development and implementation.

In the paper "Developing and Deploying Medical Information Systems for Serbian Public Healthcare – Challenges, Lessons Learned and Guidelines" [6] authors emphasize that the purpose of the paper is to specify development and deployment guidelines that can be applied for information systems developed in different countries facing similar problems. They promote medical information systems based on SOA, referring to the fact that they provide faster response than web – based solutions even when the internet connection is slow and the telecommunication infrastructure is poor. Taking their work into account, authors of the study presented, have developed the system according to SOA, as well.

As providing healthcare increasingly changes from isolated treatment episodes towards a continuous medical process involving multiple healthcare professionals and institutions, there is an obvious need for an information system to support processes and span the whole healthcare network. A suitable architecture for such an information system must take into account that it has to work as an integral part of a complex socio-technical system with changing conditions and requirements [5]. In the study "Towards a flexible, process-oriented IT architecture for an integrated healthcare network" authors have surveyed the core requirements of healthcare professionals and analyzed the literature for known problems and information needs. They consolidated the results to define use cases for an integrated information system as communication patterns, from which general implications on the required properties of a healthcare network information system could be derived. Key issues were flexibility, adaptability, robustness, integration of existing systems and standards, semantic compatibility, security and process orientation. Based on these results they designed architecture capable of addressing the requirements mostly on the basis of well-established standards and concepts. Target group for the presented system are small and medium clinics where processes in everyday work are not well established, so authors of that study decided to keep service oriented architecture.

In the paper "Module for configuration of user privileges in medical information system" [7] different levels of access to functionalities of medical information system are defined for its users, depending on specialization, authority, responsibility, etc. There is great number of users of medical information system that can be classified into several categories. Therefore it is necessary to define exactly which privileges have each user. A software module that allows defining different levels of access to functionalities of information system for its users is discussed in the paper. This module should allow comfortable and above all efficient work. System presented in this paper also defines different user privileges for the purpose of data protection and proper management.

One of the important aspects of clinical information systems is data exchange between users and clinic departments. Paper "A cross–functional service oriented architecture to support real time information exchange in emergency medical response" [8] explores this feature in development of the systems. It represents the importance of real–time exchange of data between different systems using SOA. Presented system uses SOA to provide real-time data exchange throughout the medical institution.

In the paper "Using XAML in Representation of Dental Charts in Electronic Health Record" [9] authors emphasize its purpose to point out the benefits of using XAML (XML-based markup language) [10], that offers better optimization of code execution, extended code reusability and a fresh new visual appearance. Presented study considers XAML usage to create user interface in WPF as well as to extend the code reusability.

III. FUNCTIONALITY

According to functionality from user's point of view, developed solution consists of Windows desktop and Android application.

Windows desktop application is an ERP system designed for medical personnel in order to facilitate the maintaining of records about patients, visits, accounts and other resources. It is multilingual with following application features:

- Portable, easy starting, installation-free,
- Ability to assign different privileges to users,
- Keeping a detailed history of medical examination (patient's electronic medical record) and other records for each patient,
- Efficient patient's examination scheduling,
- Storing examination's details like: images of medical examination, receipts, and doctor's reviews,
- Reminders for user events of interest,
- Simple patient and medical reports searching,
- Invoice issuing,
- Printing reports (medical examination, pricelist, additional reports),
- Card reader usage for patient identification and instant access to patient data.

Android application is sort of a data assistant with the following application features:

- Phonebook with patient data, allowing direct phone calls and email sending to patients,
- Phonebook with medical personnel data, allowing direct phone calls and email sending to personnel,
- Reminder that reminds the user about memorized daily obligations,
- Reminder component for notifications about scheduled patient examination, containing date and time, doctor and patient name.

Screenshots of the main application windows, window for issuing receipts and windows with patient details are displayed on the images 1, 2 and 3 respectively.

Figure 1. Main Windows application window

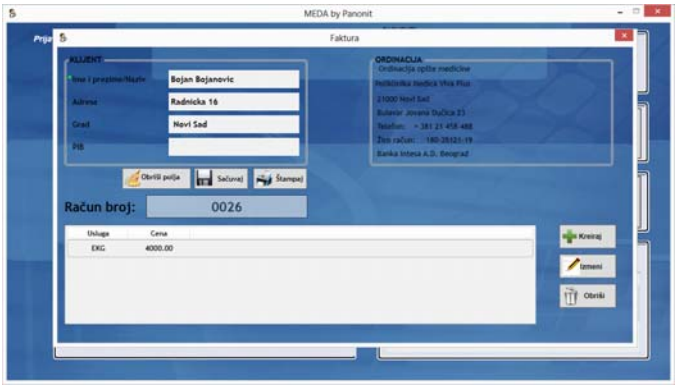

Figure 2. Invoice issuing window

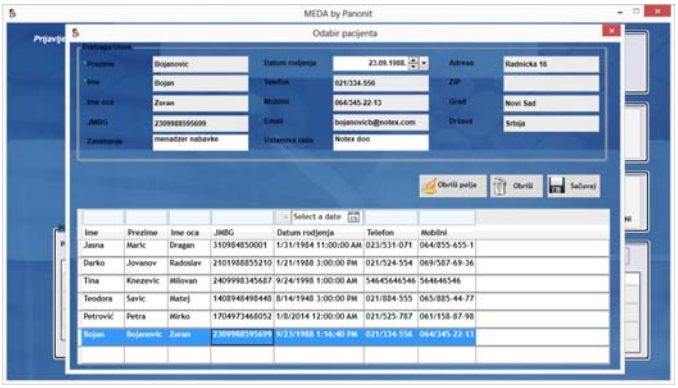

Figure 3. Details about patients

IV. DEVELOPMENT

For the development of the clinical information system, following technologies were used: Windows Presentation Foundation (WPF) [11], Windows Communication Foundation (WCF) [12], and Android SDK [13]. Windows application has been developed using Microsoft Visual Studio 2010 [14], while the Android application has been developed using Android SDK in Eclipse Juno development environment [15] running on Linux Ubuntu 12.10 operating system.

Windows application relies on the .NET framework [16], a software framework developed by Microsoft, version 4. Programs written for .NET Framework execute in a software environment (as contrasted to hardware environment), known as the Common Language Runtime (CLR) [17], an application virtual machine that provides services such as security, memory management, and exception handling. The class library and the CLR together constitute .NET Framework.

Application is written in C# - object-oriented programming language, which was developed by Microsoft within its .NET initiative.

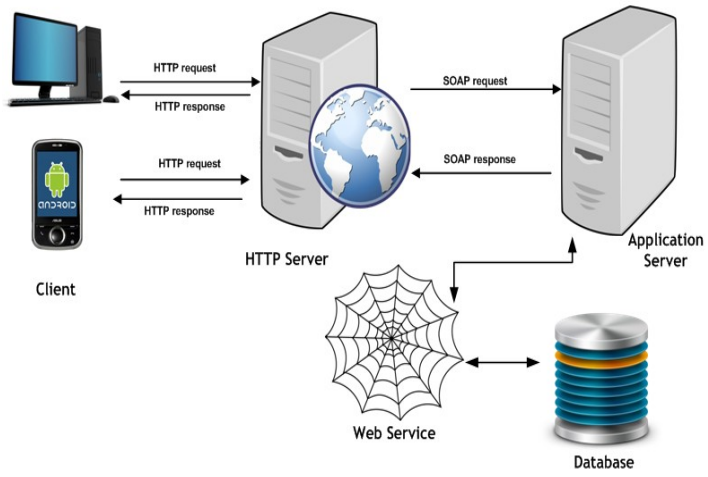

Figure 4. Service Oriented Architecture

For data management it uses Microsoft SQL Server [18]. It is a relational database management system, whose primary function is to store and retrieve data as requested by other

software applications on the same computer or running on another computer across a network (including the Internet).

For developing its user interface, i.e. its client side, the application uses WPF - UI framework that creates rich, interactive client applications. WPF uses Extensible Application Markup Language (XAML) to provide a declarative model for application programming.

Generic client/host communication between two parties is achieved using WCF. WCF allows configuration of service properties such as transport (http/pipes/tcp/Tibco EMS), security models (any of the W3C standards), compression, encoding, timeouts, etc., without changing any code. It can be configured so that it can have a service in C# and a client in Java (or any other language or the other way around), as long as they both talk using the same mechanisms. In the presented study, this approach is used within the Android application. WCF service methods are consumed from Java code. Architecture of the system is displayed on the Figure 4.

SOA-based applications are distributed multi-tier applications that have presentation, business logic, and persistence layers. Developed Windows application is based on Service Oriented Architecture, i.e. services that implement business functionality, and such services can be consumed by clients in different applications or business processes [19]. They are implementation independent - the service interface is separated from its implementation. Interoperable machine - to - machine interaction over a network is achieved through a set of XML - based standards, like SOAP, WSDL, and UDDI. These standards provide a common approach for defining, publishing, and using web services [20].

Android application uses SOAP (Simple Object Access Protocol) as messaging protocol to request response from the web service. This protocol has been accepted as the default message protocol in SOA [21]. SOAP messages are created by wrapping XML messages within a standard XML - based envelope structure. This envelope can be transported through network transports like SMTP and HTTP. Android's built in XML and HTTP support enables SOAP request messages to be constructed manually and dispatched through the HTTP Client API. The SOAP response is then manually parsed and converted into Java objects [21].

V. CONCLUSIONS AND FUTURE WORK

Healthcare in the 21st century requires secure and effective information technology systems to meet two of its most significant challenges: improving the quality of care while also controlling the costs of care. The intelligent and efficient management of information is therefore vital to the ongoing success of healthcare organizations in providing their essential services.

Presented study describes clinical information system developed intended to be used for business automation of small and medium clinics. After analyzing different approaches, SOA has been chosen as appropriate for development. System consists of sever component and Windows desktop and Android operating system based clients. Appropriate technology has been chosen for development to fulfill everyday practice requirements.

This clinical information system allows healthcare facilities to manage data collection and store information in a proficient and intuitive manner. This enables employees in all areas of the organization to benefit from better access to vital information. Electronic health records allow easy access to computerized records reducing costs caused by data storage and they can be quickly transferred from one department to another, customizable and scalable.

It also allows different medical personnel responsible for a patient's care access the same records. This could improve better communication and prevent mistakes. Also, restrictions can be made depending on the user of the system, keeping the data safe from unauthorized access.

Future work includes building the application in platform independent technology. These technologies make it possible to create executables that will run unchanged on multiple platforms. This is important in a networked environment because networks usually interconnect many different kinds of computers and devices. From a developer's perspective it can reduce the cost and time required to develop and deploy applications on multiple platforms.

Another goal could be to integrate a web component into the application. Despite it is slower and has bigger bandwidth consumption than developed application, the benefit of a web component is that it works on multiple platforms and different Internet browsers like Internet Explorer, Mozilla Firefox, etc. It is usually compatible with most of the computer operating systems. Immaterial of the browser or the operating system, there is no difference in the way these components work. Support and maintenance are easier.

Nowadays, state of the art software tools in medicine provide such utilities which can contribute to decision making process in medical practice. Thus, integration of information systems with decision support systems [22] in medicine is one of the future efforts of researchers in the field.

Finally, the most important improvement of the system presented would be integration with the system developed for the MR and CT images assessment as well as metal artifact reduction from CT images using complementary MR images [23].

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