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Service-Based Medical Platform for Personal Health Monitoring

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Abstract

Previous developments of medical mobile applications usually were monolithic ones, designed for a fixed HW infrastructure. The whole application has to be developed and deployed in one piece and the entire tier has to be retested and redeployed when something is changed. Hundreds of applications for smart phones with various operating systems have been created by different providers. We are mostly the first who start to investigate advantages of service-oriented architecture in mobile medicine. This paper is a generalization of the author's publications on the possible usage of the service-oriented computing paradigm (SOC) for building a medical services platform which allows unifying the development of applications for patients, doctors and the central server by orchestrating and composing web services from a common cloud repository. Due to this approach the created applications can be adapted to the particular patient, his disease and the plan of his treatment at home.

Keywords: Wireless Sensor Networks; Health Monitoring, Advanced Engineering Systems for self-care; Personal Health Systems; Cloud services, Decision support systems; Web-services; Service-oriented Architecture (SOA); Micro services and Containers

Introduction

One-stop shop for health information may be created by building a smart healthcare ecosystem where patients' health parameters can be permanently monitored by the networked medical heterogeneous devices and solutions, and then used for decision making together with the structured EHR data, unstructured clinical notes, medical imaging data, etc. Effectively integrating and efficiently analyzing various forms of healthcare data over a period of time can answer many of the impending healthcare problems in Mobile Health Care [1].

Let's imagine that every medical sensor (or another data resource) of that ecosystem has its own URI allowing doctors and patients interact with it via the web browser, and at the same time every sensor can have the software interface – a set of web services allowing intelligent software agents to interact with it (analyze the data etc.) on behalf of doctors and patients. A plurality of portable diagnostics device in Patient's services part depends on the type of disease and may include, in particular, blood glucose meters, blood pressure monitors that measure

blood pressure and pulse or peak flowmeter. They also include devices used by patients for home treatment: inhalers, scales, heart rate monitors and insulin pumps. Some patients with complications of their diseases can purchase and use at home portable devices which allow them to take an electrocardiogram, or make ultrasound investigation.

The proposed SOA Medical Platform for supporting the patient and the physician in the treatment and monitoring *differs* from many available mobile applications of the similar appointment *in the following important features* [2]:

1) Mobile applications for the patient, physician and service management have a service-oriented architecture and can be built in on-demand forms by discovering and using reusable microservicesand containerswith HTTP or JSON interfaces, to perform a certain task.
2) The Repository of micro services (web-applications with a unified interface) is proposed for patient care (care services), for planning and carrying out of treatment (treatment services) and to ensure the functioning the entire system (services management). Some of these services (so called *Generic Enablers*) can be taken from existing Repositories (say, FIWARE), but many of value added services (so called *Specific Enablers*) had to be developed. Functionalities of Specific Enablers for patients, physicians, services management were specified taking into accountthe recommendations of medical institutions.
3) Development of mathematical models and algorithms based on Bayesian approach to data analysis, multivariate conditional distributions, regression models and stochastic volatility models for predicting the dates of potential crisis of a patient (say, asthma attacks) and warning doctor about this.
4) Depending on particular requirements the SOA Medical system can be scaled from the corporate (national) scale of patients care to the scale of supporting profile patients in a particular region.

Services Repositories

Due to such ecosystem, healthcare is migrating from episodic and fragmented illness response to a patient-centric model of care delivery. We are developing distributed repositories of services related to processes of data collection and storing from all data sources (and developing the ontology of these services), which are listed in the following Table 1.

Data and data resources
Classification of ***portable devices indicators***which turns usual smartphone into a portable medical diagnostic device or even in a laboratory setting (blood glucose meters, blood pressure monitors, peak flowmeter, heart rate meter, ECG monitor, bodily fluid colorimetric tester, liquid handling systems, activity measuring, ultrasound systems, otoscope ,eye care tools, GPS inhalers or insulin pumps, environmental screening tools, etc.) and development their ontologies for interoperable usage together with a wireless transmitter that communicates with the sensor and a mobile medical app.
Forming services for picking up outputs of portable devices used for diabetes and asthma patients (a implanted sensor for constant remote glucose levels measuring; acoustic detection technology for coughing and wheezing control and traditionalspirometry with FEV1 or FEV1/FVC ratio; Allergic and non-allergic triggersestimation).
Evaluation and digitizing data of additional resources: *Medical History* (EHR, Disruption of usual activities, Sleep disturbance, Adherence to medical treatment plan, Interval exacerbation of symptoms, Side effects of medications);*Physical Examination* (height, eyes, ears, nose, throat, lungs, heart, skin, X-ray, etc.);Context data (say, *Asthma Triggers/Allergens)*, etc.) and development their ontologies for interoperable usage.
Data aggregating services
Ontology-based services for gathering the various portable wearable devices output data.
Ontology-based services for managing the EHR data, clinical notes, claims, medical imaging data.
Ontology-based services for capturing the information of patients' behavior and environment parameters.
Copying (replication) data for improving their localization, increasing availability and reducing the risk of loss.
Using metadata (data about data) with descriptive information about the origin of the data, ways of generating (measured or calculated).
Content data management with Semantic support.
Data translation between standard and task-specific data exchange formats.

Aggregating and storing data of patients' personalized monitoring.
Data sharing services
Cloud distributed data storage withmulti-channel-multi-service access.
Powerful associative data search and discovery (search by value, not by the location), and automatic parallel access.
Cloud ***Repository*** as a multicloud application hosted platform which contains services and applications descriptions and supports consumers and developers of applications.
Application ***Mashup creator*** with a service composition editor and an execution engine for definition and execution of service workflows by special ***'glue' high-level ontology.*** It is a distributed and fully decentralized and scalable and reliable tool for composite services
Context-aware adaptation of workflow processes
The ***individual patient pathway*** (patient-specific workflows) forming in the semantically-enhanced event-driven service-oriented architecture.
Open Access to obtained results and an obligation to ensure that all publications produced will be linked to the Open portal.
Opening services code and algorithms made to make them to be available for and to (re)use by others.
Data Warehouse facilities for supporting management of open data at large scale and transform it into knowledge
Data processing services (Analytics)
Using EHR for automatic circulation and accessibility of medical data about the patient, filling its fields and read data from EHR.
Remotemonitoringofthepatient'sstatusinany place and at any time. Estimating patients risk of becoming ill or developing a serious condition.
Preparing the Treatment Plan (roadmap) and control its fulfilling, taking into account individual feathers of patients and their personal allergy records
Support for the electronic prescription (ePrescription)
Providing Extreme Warning and Emergency Information, when a doctor (and / or ambulance staff) will be immediately informed if vital patient's parameters get close to a dangerous point.
Insights synthesis and informing patients, health professionals, health payers and insurers, and life science companies' actions.
Integrating individual patients' data across a community into a broader, meaningful view of health and healthcare in a particular region to support healthcare migrating from episodic and fragmented illness response to a ***patient-centric model of public healthcare.***
Data mining procedures for detecting hidden patterns of aggregated data in the form of significant features, correlations, and trends.
Complex event detection in distributed big data streams.

Table 1: Service repositories content.

Ontologies are used not only to gather portable personal devices data and behavioural and environmental data and to integrate data formats, software tools as a service collection, but also to analytic processing of data across the healthcare ecosystem. The last ones may include also insights and inform actions for patients, care providers, health payers and insurers, and life science companies. Events in the ecosystem with semantically-enhanced event-driven service-oriented architecture (SEMSOA) can be initiated by patients, doctors, and devices outcomes [3].

The mechanism of customer-driven medical applied software development is provided by compositing and orchestrating dynamically discovered services from developed repositories to form the individual patient pathway (patient-specific workflows) of monitoring and treatment, taking into account different existing rules, regulations and standards. In the phase before an illness develops patients are provided with medical advice early and they can safely be treated – avoiding hospital treatment. In case of an already existing illness patients are provided with the involvement of the healthcare, where they can get an effective professional treatment, based on the suitable medicine adjustment. With advancements in technology, home telemonitoring has become an effective and reliable approach that is well accepted by patients and supports patient care at home.

Let's consider the particular case of supporting health self-management of asthma patients. The main idea is to combine data on air pollution, gathered from external sources (such as local meteor-stations), wearable air quality trackers and personal physical data of particular user to track and predict moment of exacerbation of asthma. The symptoms in the attacks include wheezing, shortness of breath (dyspnoea), chest tightness and cough. Asthma is a chronic disease; however, as long as patients receive health care, execute their self-management plan, and follow their doctor's instructions, they can achieve long-term monitoring [4].

Cloud IaaS for supporting individual healthcare for asthma patients by providing the interaction of the doctor and the patient in the treatment process. It will be built as micro service system which includes:

- Micro services for physical data traction (breath monitoring, heart rate);
- Micro service for air pollution monitoring;
- Micro service for warning user before critical state coming
- Containers for integration executing micro services and integration them with local EHR services.

It is possible to build and adjust patient's treatment plan and workflow by selecting the necessary micro services for the individual patient, for the doctor and for application management which to be executed in cloud by containers and API technologies. Mobile asthma management tools target those who suffer from asthma attacks, especially children; in order to help them avoid attack-inducing allergen areas and help them better control and treat their asthma symptoms. They can help to reduce asthma attacks, which could prevent unnecessary hospital readmissions and decrease the number of hospital admissions due to preventable asthma complications.With advancements in technology, home telemonitoring has become an effective and reliable approach that is well accepted by patients and supports patient care at home. In addition there are possibilities to rearrange the system for supporting people with other diseases due to the system micro service architecture.

We propose also to establish connection between data sources, patients, doctors and healthcare organizations by developing a healthcare ecosystem in the Cloud for data sharing across the entire ecosystem, using SaaS and IaaS technologies [5]. The above-mentioned ecosystem is designed and developed to be a part of and to benefit from the European Open Science Cloud.

We invite everyone who wishes to participate in the development of SOA approach in mHealth, which allows building universal interoperable mobile tools for which due using ontologies there are no state boundaries.

Conclusion

The proposed SOA Mobile Platform allows easily developing interoperable healthcare means with a wide range of self-care services for chronic patients and which differs from existing holistic solutions in the following important features (invention) by using service systems approach. It takes into account the need to design complex architectures relating together people (patients, caregivers, and others), organizational structures and processes (Centers of Health Monitoring with a doctor on duty, etc.) and IT possibilities and service system design innovation. Such more personalized patient-focused healthcare platform is more targeted, effective and efficient and supports the self-control of health.

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