D4.3.2 APPLICATION/ SOFTWARE DEVELOPMENT

(Application/Software Development)

«Healthcare Monitoring System Development»

Reporting period: 20/09/2018 – 05/12/2018

WP 4 Joint Monitoring System

project

IMPROVING HEALTHCARE ACCESS TROUGHA PERSONAL HEALTH MONITORING SYSTEM

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http://www.ehealthmonitoring.eu/

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Summary for the deliverable

The deliverable «Healthcare Monitoring System Development» is part of the project APPLICATION/ SOFTWARE DEVELOPMENT within the frame of WP 4 Joint Monitoring System of the project IMPROVING HEALTHCARE ACCESS TROUGH A PERSONAL HEALTH MONITORING SYSTEM, according to our contract (14/09/2018 – Ref. No: 44955) and is being implemented within the framework of the Programme INTERREG V-A Greece – Boulgaria 2014-2020.

The particular deliverable aims to highlight the activities performed within the period 20/09/2018 - 05/12/2018 concerning the design, development and pilot operation of the Integrated Health Monitoring System.

The deliverable describes the system as a whole and focuses on issues that affect its subsystems horizontally. Special reference is made to the platform subsystem that is installed and operates on cloud computing infrastructure and supports the specific applications of the system as described in the following chapters:
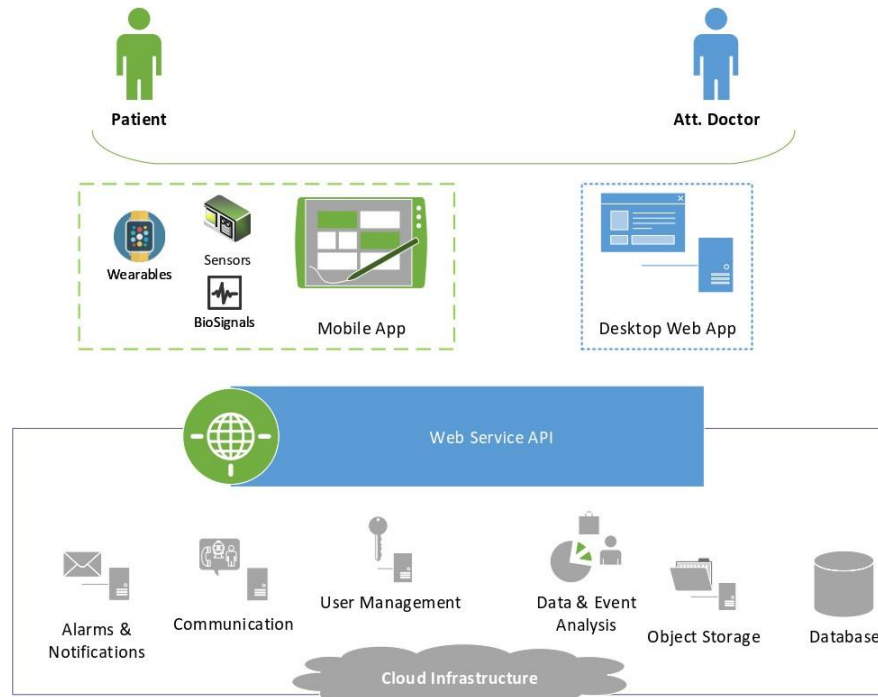
- Web App
- Mobile App (Android)

1   Introduction

The Integrated Health Monitoring System, which will be designed within the frame of the **"EHEALTH Monitoring"** project**,** consists of four main sub-systems that realize the required functionalities, as well as a cloud back-end platform, which supports all other subsystems. These subsystems have been designed and developed utilizing a rich set of state-of-the-art technologies and tools, in order to secure optimal levels of robustness, security and extendibility and the finest user-experience.

The system follows a service-oriented architectural design, exploiting the advancements and flexibility of cloud offerings, and implements modern UIs for all types of users. Cloud Computing allows for ubiquitous access to shared resources and common infrastructure, offering services on-demand, serving the constantly changing needs of the health-centric digital services. To that end, is being developed an integrated system for patient monitoring at home, utilizing Cloud Computing concepts and tools for data managements and analysis. The proposed solution focuses on the system decision support functionality, which is utilized within the smartphone app for initial assessment, as well as in the Cloud.

A combination of Java and JavaScript technologies and frameworks are used for implementation and communication of the various application components and services.

ΔΗΜΟΚΡΙΤΕΙΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΡΑΚΗΣ
ΕΙΔΙΚΟΣ ΛΟΓΑΡΙΑΣΜΟΣ
ΚΟΝΔΥΛΙΩΝ ΕΡΕΥΝΑΣ

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The main functionality of the platform is recording and analysis of biosignals. Java technologies have been utilized for development and the functionality is offered via Web Services. Similarly, synchronization and central administration functionalities of the application subsystems are provided. The following features are supported:

- ✓ User account management
- ✓ Data analysis
- ✓ Data storage
- ✓ Reminders and notifications to patients and other end-users in cases of measurements out of normal range, detection of errors, measurement and medication schedule, etc.
- ✓ Videoconferencing functionality based on the WebRTC protocol, which is utilized both for the Web app and the mobile app.

As mentioned above, the proposed integrated health monitoring system consists of four main sub-systems that realize the required functionalities. These subsystems have been designed and developed utilizing a rich set of state-of-the-art technologies and tools, in order to secure optimal levels of robustness, security and extendibility and the finest user-experience. To that end, the proposed

solution follows a service-oriented architectural design, exploiting the advancements and flexibility of cloud offerings, and implements modern UIs for all types of users.

A combination of Java and JavaScript technologies and frameworks are used for implementation and communication of the various application components and services. A cross-layer technology that has a key role on the realization of the communication and videoconferencing functionality is WebRTC[1], which is used both for the desktop and mobile applications.

1.1   Web app

The web app includes the core functionality for interacting with all user types. In contrast to the mobile application, which is lightweight and simplified so as to ease the interactivity with the elderly users and patients, the web application has rich user interface for configuring the user and application parameters, and also for visualizing the biosignals and health records. WebRTC based communication is also provided through the web application.

1.2   Android app

For a simplified, flawless and ubiquitous access to the system, a mobile app for Android devices has been developed. Besides the core functionality for communicating with the backend, the mobile applications allow for the integration of Bluetooth devices, sensors and wearables. The native android application targets (API) Android 21 / Lollipop.

The application incorporates the required functionality for communicating with the cloud-based platform services and also acts as a platform gateway to the various Bluetooth devices (biosensors και wearables).

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[1] http://www.webrtc.org/

2 Methodology for the system design and development

The methodology used for design and development follows the Design-Build-Test cycle, known also as the Prototyping Model. According to this model, a prototype of the software, including only the basic features of the final version is developed first. Testing of the prototype provides feedback, which can be used to improve the system. This model is useful when it is not easy to derive requirements for the system, or the requirements may change significantly during the development process. The software development process within the prototyping methodology consists of four stages:

- ✓ Defining basic user requirements
- ✓ Development of the prototype of the system
- ✓ Testing of the prototype to redefine user requirements
- ✓ Revision and improvement of the prototype

The use of the specific methodology allows for improved design, based on the evaluation of the prototype by users and experts, resulting in the development of applications that satisfy user requirements to the fullest extent.

3   System's requirements

3.1   Functional requirements

3.1.1   User Roles

The user roles are described in the following table:

Type	Role	Description
User	Patient (χρήστης)	The main user of the system (recipient of the service)
User	Contact	A user that can communicate with Patients. Every Patient may have more than one Contacts.
User	Attending doctor	Doctors
Admin	System Administrator	Technical and administrative role. Has access to all reports/MiS.

3.1.2   General Requirements

The general application requirements are the following:

Application	Role	Functionalities
Web app	Patient	• Contact management • Videoconferencing with contacts • Account and personal info management • Reminders management • View PHR and add content • View recorded biosignals • Manage medications and relevant settings
	Attending doctor	• Account management • View patients • Videoconferencing with patients • Manage medications and relevant settings (for patient) • View patients' biosignals • View patients' PHRs and add content
	Contact	• Contact management

Application	Role	Functionalities
		• Videoconferencing with contacts
Mobile app (Android based)	Patient	• Videoconferencing with contacts • Reminders management • View PHR • Record, view and upload biosignal measurements
	Contact	• Contact management • Videoconferencing with contacts

3.2   Non-functional requirements

Cloud infrastructure will be used for platform hosting and support of the various sub-systems. Exploiting **Cloud offerings** allows for:

✓ **Improved resources management**: Preparing services which may later not cover user requirements can be avoided. Cloud computing reduces costs and maximize utility, since resources are provided only when needed.

✓ **Flexibility**: All systems and software remain constantly available.

✓ **Accessibility**: Cloud computing allows ubiquitous access to applications and data, with encryption security, via the Internet. When connection to the Internet is not available, bandwidth requirements can be covered even with a 3G connection.

✓ **Cooperation**: Accessibility of applications and data over the cloud facilitates cooperation between different components, since applications can have simultaneous access to data.

✓ **Disaster recovery & Business continuity**: Recent research indicates that approximately 90% of businesses do not have adequate plans for managing total or partial loss of their computer infrastructure, in order to ensure uninterrupted operation. Cloud computing allows for automation of disaster recover processes through the use of backups, as well as maintaining servers that can operate as others' images.

3.3 Criteria for Infrastructure Design & Selection of Development Tools

The main criteria for the Design of the Infrastructure are the following:

- ✓ **Functionality:** The main focus of the design process is to satisfy all functional and technical requirements (communication between components, communication with end-user devices, etc.).

- ✓ **Costs**: Operations and initial deployment cost. Open-source software bears no intial deployment cost (software licences for server web apps, database, etc.), as well as maintenance costs. Distributions are provided for free even for commercial use, while the open-source community offers continuous support through new versions (often with the capability for automated installation).

- ✓ **Application Support**: Support of applications – development tools, in terms of updates, as well as on operational level, by official guides or the user-developer community was and important consideration in the choice of development tools.

- ✓ **Scalability**: Both the architectural design and the development tools should allow the addition of new modules, as well as new functionalities, without the need for redesign or radical changes in implementation.

- ✓ **Security:** The hosting and operational environment should be secure, incorporate strict user and access-rights management, and support on the application level state-of-the-art mechanisms for user authentication and secure data transfer. The following aspects have also been considered:
  - o securing integrity and availability of information
  - o protection of stored and processed personal data, by methodically selecting and applying technical measures and organizational processes.
  - o composition of the required documents for terms of use and privacy policy

- ✓ **Electronic Health Record Specifications**
  - o Cloud technologies support and web-based access.
  - o Incident based structure and visualization.
  - o Patient authentications using their SSN.
  - o Classified access/recording, depending on each role's access rights
  - o Stored data
    - · Demographics.
    - · Medical History: diseases, medications, allergies, etc.

- Biosignals
- Other exams if available (in case of examination at home or if provided by a user)
- ICD-10 diagnosis, if available, enriched with free text.

- **Relevant Legislation**
  - Institutional and legal framework in force (directive 95/46/EK, protection of personal data Law 2472/97, protection of personal data in the telecommunications sector Law 2774/99).
  - The General Data Protection Regulation (EU) 2016/679 (GDPR).

- **Usability Requirements**
  - Convenience and user-friendliness. Common theme for all applications, unified and consistent functionality.
  - Special care for elderly user needs.

4 Web app

4.1 Web App Requirements

The following table lists the requirements particular to the Web app:

Web-App	Functionality	Role	Description
A1	User account management	Patient, Contact, Attending doctor	All user account info, except the Username can be edited.
A2	Personal info management	Patient, Contact, Attending doctor	All users can edit all fields. Every Patient, Contact, Attending doctor add/remove a Profile pic.
A3	PHR management	Patient	The user can view their health information which have been recorded in their PHR, which are visualized appropriately, depending on the data type. The user can search for specific records. The user can add records to the PHR.
		Attending doctor	Attending doctors can access their patients' PHRs only upon the patients' consent.
A4	Biosignal management	Patient	The patient can view recorded biosignal measurements and perform new measurements of the following vital signs: • Blood Oxygen • Blood Glucose • Blood Pressure • Spirometry • Temperature • Weight • Steps Measurements may be: • Recorded via biosensors used by the patient

Web-App	Functionality	Role	Description
			• Manually input by the patient The aforementioned biosignals should be visualized graphically.
		Attending doctor	Attending doctors can access their patients' biosignal measurements only upon the patients' consent.
A5	Contact management	Patient, Contact	Every user can send and receive requests to add other users to their contact list.
A6	Reminders management	Patient	The user can create reminders for any event, based on the following: • Reminders are classified as 'Measurement', 'Medication' and 'Message' • Reminders can have occurrence Once, Daily, Monthly, Yearly and for each one a data and time is set • The user can delete or edit reminders
A7	Videoconferencing	Patient, Contact, Attending doctor	The user can call or receive calls from anyone on their contact list at any time. Communication begins upon confirmation of the receiver. The user receives image and sound.

4.2 Usability Requirements

- Convenience and user-friendliness. Common theme for all applications, unified and consistent functionality.
- Special care for elderly user needs.
- Mechanisms for detection of errors and erroneous data input

4.3 Implementation Specifications

The following technologies were utilized for the development of the application:

✓ **Java Programming Language** for the development of the Business Logiv of the Web app and communication with the database.

✓ **Apache Tomcat Servlet Container** for the deployment and operation of the application based on Java technologies.

✓ **Apache Web Server - Load balancer** for for seamless operation of the application even in cases of high load and number of simultaneously connected users.

From the end-user's point, the only requirement is the use of a web browser that supports the WebRTC protocol, which can be any of the following:

· Google Chrome >= 65
· Mozilla Firefox >= 60
· Opera >= 54

5   Mobile App (Android)

5.1   Mobile App requirements

The following table lists the requirements particular to the mobile app:

Mobile (Patient)	Functionality	Must Have
B1	Reminders	The UMU (tablet) must be able to display reminder notifications at specific time intervals. Reminders can be set via: • The web app, by the Patient or the Attending doctor • The mobile app by the Patient. In this case, the user must be able to set the same parameters as in the Web app. Reminder notifications must be displayed on the screen (potentially with an image or animation/video) and accompanied by an audio alert, which should be repeated until the user presses a specific button. The alert stops after a preset maximum time interval.
B2A	Connection with biosensors	The device can connect to biosensors (e.g. blood pressure monitor, glucometer) in a wireless manner via Bluetooth. The connection status is displayed on the screen.
B2B	Record biosignals	Recorded measurements are stored on the cloud and displayed on the screen. The user is also able to view past measurements.
B3A	View contacts	All of the user's contacts are displayed on the device.
B3B	Videoconferencing	The user can call any other user from their contact list by pressing a (green) button. The call ends by pressing a red button. The device can receive incoming calls (video or voice only) even on standby mode.

5.2 Non-functional requirements

The **Android** platform has been chosen for the end-user unit and the development of the videoconferencing functionality, biosignal recording and other various features of the application (e.g. content display, reminders, etc.).

Android is an open-source development platform for smart mobile devices (smartphones, tablets, etc.). It supports development of applications with a graphic user interface, automated updates, videoconferencing and data transfer via available networks (WiFi or/and 3G). It is widely accepted by mobile device manufacturers and is an optimal choice for the proposed solution, as:

- ✓ client applications will be compatible with a wide range of devices (smartphones, tablets and set-top-box), without need for further development of compatibility issues
- ✓ there is significant available support for the specific development environment, which is certain to be maintained in the following years
- ✓ there is a great number of existing compatible applications
- ✓ Android applications have relatively low hardware requirements
- ✓ There is no need to acquire costly licenses.