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A Solution for Mobile Computing in a Cloud Environment for Ambient Assisted Living *

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Abstract — **The objectives of this paper is to describe the software architecture and corresponding components for collecting the data from the pilot sites within the NOAH (NOt Alone at Home) AAL European Project, the developing of software services for these locations, and the improvement of the developed software components for these locations, accordingly to the co-creation sessions. The NOAH platform is implemented as a solution for mobile computing in a cloud environment. NOAH system mostly addresses user's needs related to safety, adherence to daily living prescriptions (therapies, physical activity, etc.), motivation and self-esteem, participation in social life. Exploiting accumulated knowledge about user's activity and needs, NOAH provides the user with context-sensitive support.**

I. Introduction

The NOAH AAL – Ambient Assisted Living – European Project addresses almost-fit elderly people, not suffering from major medical conditions or severe disabilities, dealing with (or being at risk of) age-related issues, including frailty, mild mental health ailments and cognitive decline [1]. It mostly focuses on elderly living alone, who represent a growing fraction of the elderly population and are likely to get the most benefit from the proposed technique [2], [3], [4].

In the system development, more needed software components and services were identified, based on client-server architecture.

For the storage of the data provided by the sensors installed in the pilot sites a MySQL database was used. For the developing phase was used a local instance of the MySQL Database Management System, and for the testing and exploitation the database was migrated in the IBM cloud [5], using Compose for MySQL [6].

The server application provides a REST API and has the role of taking, by the Internet of Things IoT platform, data from the sensors, to generate alerts and to offer the functions necessary by the client applications. These functions are based on a function structure that implies a HTTP request, a content that analyze the request and a HTTP answer [7], [8].

The client side is composed of two Android applications, one for each category of users: *NOAHCare application* used by the caregivers and *NOAH application* that is used by the end-users - the persons who receive care, the elder people.

The information stored in the cloud is accessed by the user-interfaces, through dedicated services [9].

The *NOAHCare application* was developed with the aim of helping the persons who offer care, to monitor the elder people in observation. There were implemented functionalities which allow to view the state of the sensors installed in the houses of the monitored persons, monitoring of the changes in the their behavior, alerts receiving and notifications referring to the sensors state, statistics on diverse periods, Internet traffic, as well as personal data modifications of the registered user.

The *NOAH application* was developed for notifying the end-users, elder people, about a series of alerts (for example a forgotten open door). There were implemented also facilities which offers to the users the possibility of transmitting to the system information referring to their present state, as well as establishing of two contact persons who can be called from the application any time is needed.

II. General Overview

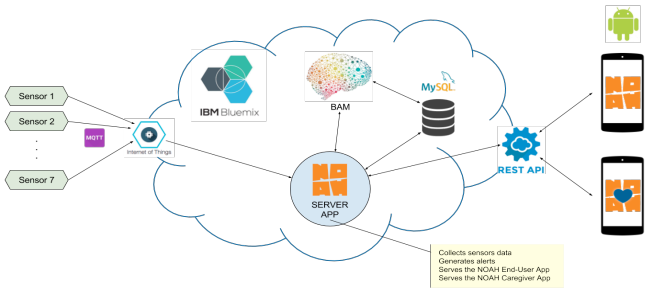

Figure 1 – NOAH System Architecture Overview

The entire system overview is represented in Fig. 1.

The project's server side is developed and hosted on IBM Bluemix, IBM's cloud platform [10]. This implies a continuously running cloud foundry application that uses two services, IoT Platform and Compose for MySQL, inheriting the corresponding security [11].

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The IoT Platform communicates [12] with the registered devices and has the role to collect data from the sensors and transmit them to the server application, while Compose for MySQL provides the storage for the retrieved data and for all the other details that the application requires to run.

The Behavioural Analysis Module (BAM) processes the sensors data to detect behavior patterns [13] that can indicate the well-being state of the monitored person and sends the results to the server application.

The project's client side is represented by two applications, one for the caregivers and one for the end-users. These are developed, native, in Android and represent mobile applications that can be used on a wide variety of devices.

The communication between the application's components, client, respectively the server side, is realized using REST API, through HTTP protocol. The Android application builds an HTTP request corresponding to user's intentions and commands and sends it to the server using the Internet. The server will provide an appropriate HTTP response, the client application will parse this response and it will offer an information to the user.

A conceptual map of the entire system is represented in Fig. 2 and it offers detailed information about the system's workflow.

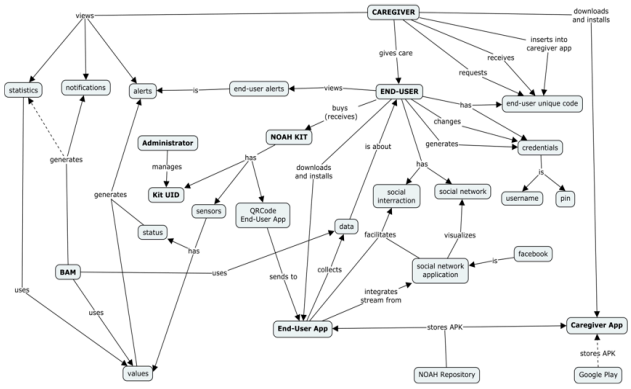

Figure 2 – NOAH System Conceptual Map

III. DATABASE

In order to store the data retrieved from sensors and all the other details that the application needs to run, a MySQL database was chosen. It is located on IBM's cloud [14] and it uses the Compose for MySQL service.

The structure of the database is represented in Fig. 3.

- Alerts table: it stores all the generated alerts;
- Auth_devices table: it is used for auto-login. When a user logins into the application a record containing his id and a generated token is inserted into the table. When he performs log-out, the record linked to him is deleted from database.
- Contacts table: every end-user can set two contact persons he can call in case of emergencies. This table stores the persons details.
- Noah_app_version table: it keeps all the developed application versions along with their download links and their types (mandatory to update or not). It is used as a log and to notify the users when an update of the application is available and to allow them to upgrade.

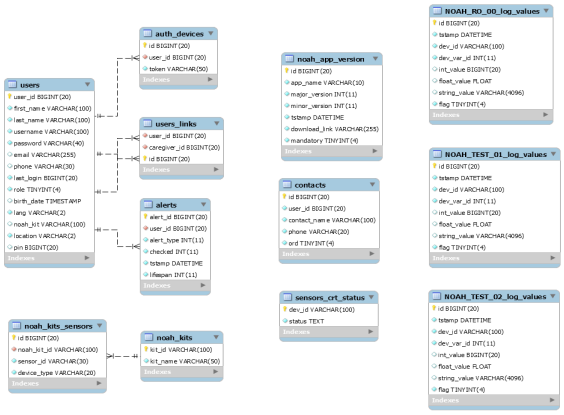

Figure 3 – NOAH database structure

- Noah_kits table: it stores the kit sets (ID and name) that the application is using;
- Noah_kits_sensors table: it contains all the installed sensors (IDs and types) and their corresponding kit (what sensor belongs to what kit);
- {Noah_kit}_{number}_log_values table (e.g. NOAH_RO_00_log_values): it stores the data retrieved from the sensors linked to noah_kit, such as sensor IDs, what values recorded and when, battery state;
- Sensors_crt_status table: it keeps records containing the last values of all the connected sensors;
- Users table: it stores the details about the registered users, such as first name, last name, username, hashed password, e-mail, phone number, what type of user he is, the language he set to use the application, his location. If it's an end-user it has associated a pin code which is used in the process of caregiver - end-user association;
- Users_links table: it contains the associations between the caregiver and end-users, to what end-users is a caregiver linked.

IV. SERVER APPLICATION

The server application of the NOAH system represents a REST API and is built on IBM Bluemix using the developing environment Node-RED, which runs over a Node.js server and provides a customizable visual environment for programming. It uses predefined or custom nodes organized

in flows for implementing the application logic. This application is responsible with collecting data from the sensors, generating alerts, serving the caregiver and end-user application.

The application is organized in three main flows, matching the needs of different modules.

- *User Management Flow* – contains the required functions for managing users in both caregiver and end-user applications. This flow implements the proper functions for a caregiver user to register, login, auto-login, assign elders in their care and change personal information if needed. For the end-user the functionalities that are implemented are the login, logout and the managing of two contact persons.
- *Data Process Flow* – contains the required functions for processing data, either collected sensors data or generated data. In this section there are implemented functions providing notifications, alerts and sensors statuses to the caregiver user. From this flow, the end-user receives alerts. There is also a method providing the mobile application version, in order to help the users using the last available version.
- *Data Collect Flow* – contains the required functions for collecting the information from the connected devices (sensors) at the pilot locations and storing it into a MySQL database in different forms. In other words, there are methods that listen to Internet of Things service to receive the information sent by the sensors. This data is parsed, organized and stored. Furthermore, this section has a mechanism to generate alerts according to sensors status and provide them to the user only when needed. The last status of each sensor is updated, in order to keep all the sensors linked to the system in case of malfunctions of any kind.

V. CLIENT APPLICATIONS

The NOAH client-side is represented by two Android applications, one for each type of user:

- *NOAHCare application,* used by the caregiving users to monitor their assigned end-users;
- *NOAH application,* used by the elderly people.

A. NOAHCare application

The NOAHCare application was developed to be used by the caregivers in order to keep under observation the elderly persons they take care of. They can view the state of the sensors connected in the end-user home, if there are some changes in the end-user behavior, they receive alerts and notifications about sensors and, also, they can view statistics on different time periods regarding stored data.

The application's running process is shown in Fig. 4.

When a caregiver starts the application, the Internet connection access of the device is checked. If there is no Internet access, the user will be prompted to connect to a network that has Internet connection or to turn mobile data on. Otherwise, if the device has Internet access, the application will check if the user is authorized by checking his device into the database. If the device is registered into the database, the caregiver will be redirected to the home page. Else, he will be redirected to the authentication form. Here, the caregiver has the possibility to login into his account or to create a new one.

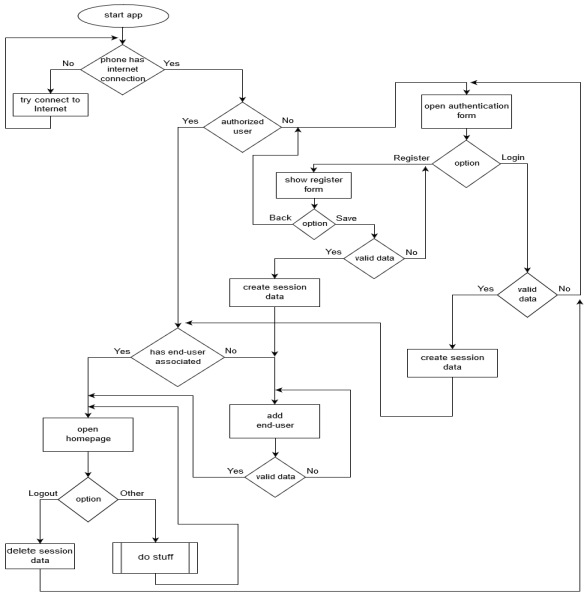

Figure 4 – NOAHCare application's workflow diagram

By choosing the "Register" option, he will be redirected to the register form. When he submits valid data, an account will be created, a session token will be added to the database and the user is redirected to associate an end-user.

If the user has an account, he will enter his credentials in order to login. When submitting valid data, a session token will be added to the database and if the user has at least one end-user associated, he will be redirected to home page (or, if there are more end-users associated, to select for which one he wants to see data). Otherwise, he will be redirected to associate an end-user.

For a caregiver to associate an end-user is necessary for him to input the pin code linked with the end-user he wants to add.

From the home page, the caregiver can see details about the selected end-user, such as sensors status, if there are behavioral changes, alerts and notifications about sensors and statistics on different time periods regarding stored data represented as charts. Also, there is an account management facility, where the caregiver can set up his name, his phone, his e-mail, the application's language to be displayed and his location, a page that offers information regarding how much Internet data the application used and the end-users management.

Application's features

1. *Caregiver account register and login*

To register an account, the caregiver has to run the *NOAHCare application* and when the authentication form is available to press "Register" button. Next, the user needs to enter his credentials and some other details.

The login into the *NOAHCare application* is based on the caregiver's username and password he set in the register form.

This process is exemplified in Fig. 5.

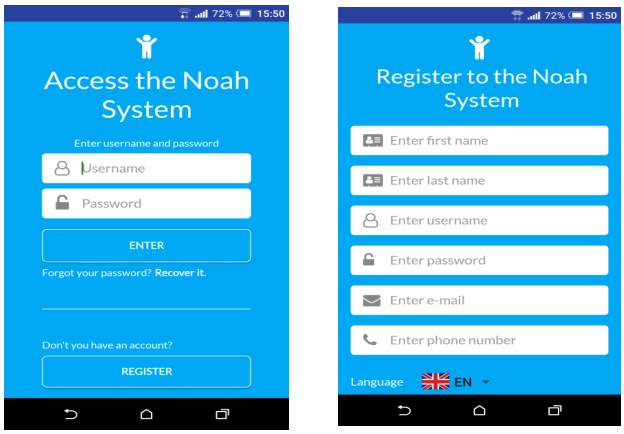

Figure 5 – Account register

2. End-users management

In order to use the application's facilities, is required the caregiver to have at least one end-user associated to his account. This can be done after the caregiver registered an account or by accessing the "End-users" option from the menu (showed in Fig. 6) and then pressing the "Add end-user" button.

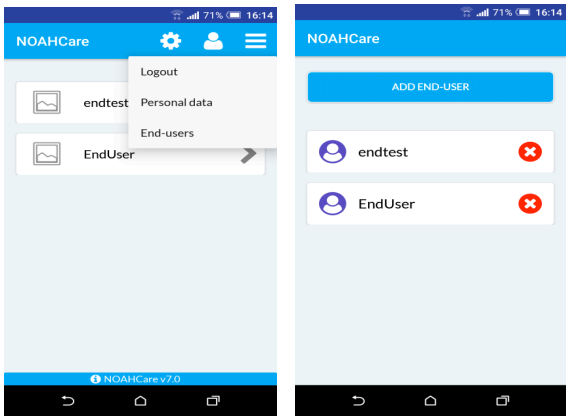

Figure 6 – End-users management

On the "Manage end-users" page, the caregiver can dissociate an end-user by pressing icon. To associate an end-user, the caregiver has to input the pin code linked to that end-user as shown in Fig. 7.

3. End-user monitoring

To serve this feature, a service is started when the user logins into the application. This service requests at every 30 seconds information about sensors, alerts and changes in behavior.

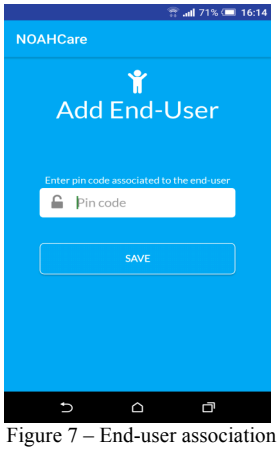

Figure 7 – End-user association

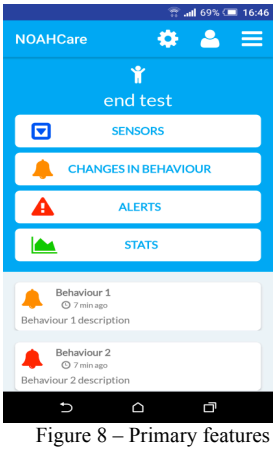

Figure 8 – Primary features

Once selected the end-user, he wants to keep under observation, as in the Fig. 8. The list below the buttons represents the changes that appear in the end-user behavior. This facility requires data from the Behavioural Analysis Module, which is not available yet.

He can view the state of the sensors connected in the selected end-user's home. Regarding the sensor status, an icon and a message are displayed (Fig. 9).

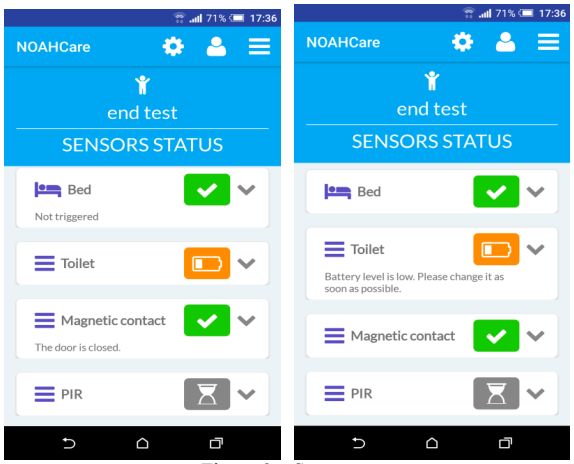

Figure 9 – Sensors status

When sensors state changes or if there are some malfunctions of any kind, alerts are generated to notify the caregiver (Fig. 10).

There is also a facility that allows the caregiver to view general statistics on different periods of time using charts, as in Fig. 11 (has to be decided what information should be represented).

B. NOAH application

The *NOAH application* was developed for the elderly people in order for them to receive a series of alerts (e.g. when a door is open). They have the possibility to send to the system a feedback about how they are feeling in a certain moment, to set two contact persons and call them when needed and to access a social media feature, feature that is not available yet.

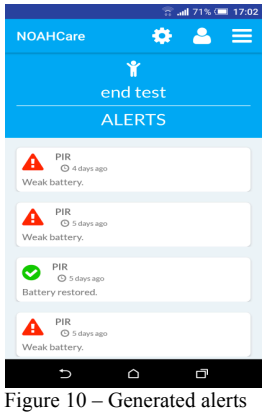

Figure 10 – Generated alerts

Figure 11 – General statistics

This application's running process is represented in Fig. 12.

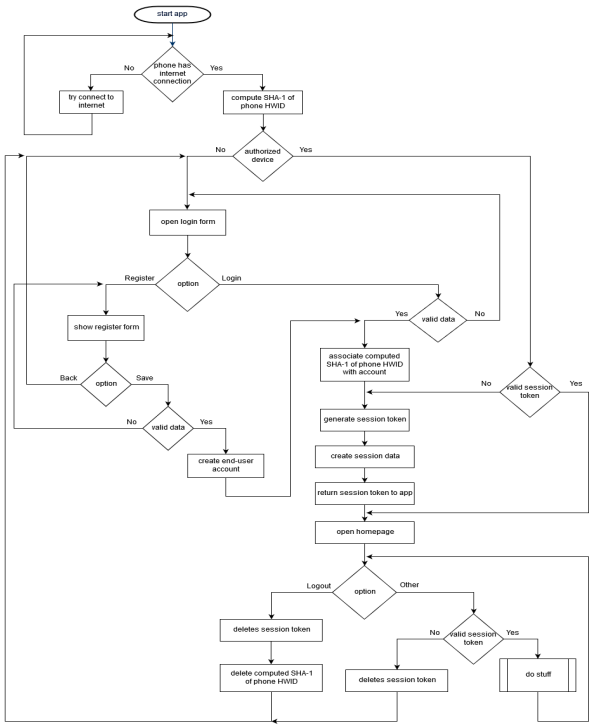

Figure 12 – NOAH application's workflow diagram

When an elder person starts the application, the Internet connection access of the device is checked. If there is no Internet access, the user will be prompted to connect to a network that has Internet connection or to turn mobile data on. Otherwise, if the device has Internet access, a hash of the device's hardware ID will be generated and the application will check if the user is authorized by checking his device into the database. If the device is registered into the database, the end-user will be redirected to the home page and the session token created if it's not valid. Else, he will be redirected to the authentication form. Here, the end-user has the possibility to login into his account with the credentials he received from a system's administrator (register facility not being required at this moment).

If the end-user has an account, he will enter his credentials in order to login. When submitting valid data, the generated hash of the device's hardware ID will be associated with his account and a session token will be added to the database. Then he will be redirected to home page.

From the home page, each time the user selects an option, the session token is checked and if it's not valid he will be redirected to the login form.

Until the end-user will log out of the application (when the session token is deleted from the database and the dissociation between the device's hardware ID and the user account is realized), each time the application will be accessed he will be automatically logged in.

Application's features

1. *End-user authentication*

The login into the NOAH application is realized by entering and submitting the credentials the user received from a system's administrator. The login form is presented in Fig. 13.

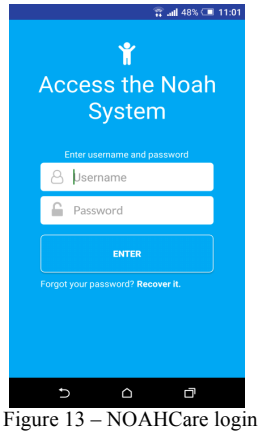

Figure 13 – NOAHCare login form

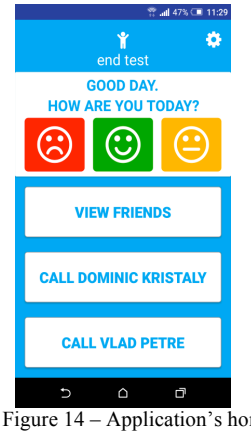

Figure 14 – Application's home page

2. *Contact persons*

Each user has the possibility to set two contact persons. He can call them when needed by pressing the button corresponding to the contact on the home page (Fig. 14).

If there are no contacts associated, no person name will be displayed and pressing the buttons will open the "Settings" page. The same result will be obtained by pressing icon. This page is illustrated in Fig. 15.

Pressing the "Add" button will open the phone's contact list and a person can be selected. If the contact has more numbers, the application offers the possibility to select which number does the user want to set for that contact.

3. *Alerts*

After the user logins into the application, a service that gets alerts is starting. The service makes a request at every 30 seconds to the server. If the server response contains alerts, they are showed to the user, one by one. One example is presented in Fig. 16.

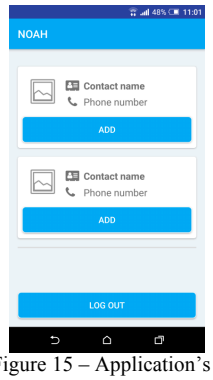

Figure 15 – Application's settings page

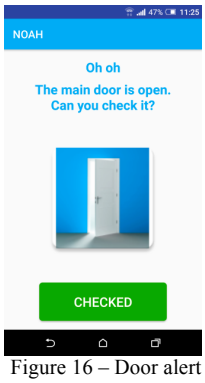

Figure 16 – Door alert

4. *Feedback*

The end-user can send information to the server about how is he feeling in that moment (Fig. 17). This feedback will be used by the BAM to detect behavior patterns.

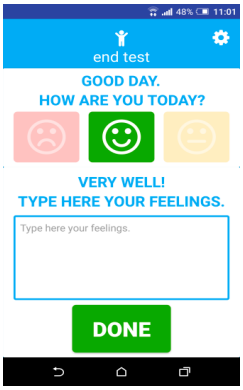

Figure 17 – Sending feedback

VI. Conclusion

The NOAH cloud services accounts for collection, gathering and processing of data coming from the heterogeneous sensor network and from user's interaction. Cloud services power apps dedicated to the end user and to the caregiving persons.

The NOAH system does not aim at implementing an "automatic" assistive tool, but instead at effectively integrating and complementing (family) caregiving practices in a two-sided approach: from the end-user point of view, effective tools will be provided, helping in planning and dealing with daily living activities in a safer and more effective fashion, also involving motivation and social engagement [15]. From the (family) caregiver perspective, increased perspicacity will be attained by means of continuous, unobtrusive behavioral monitoring and information fusion techniques [16], providing objective measurements and detecting anomalies not necessarily evident at human, discontinuous observation [17].

In summary, we expect the project to result in a complete, ready-to-use package, suitable for enabling families and home-care providers to easily install, manage and operate NOAH services out-of-the-box.

Acknowledgment

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