

Careggi Smart Hospital: a mobile app for patients, citizens and healthcare staff

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Abstract— This paper presents a mobile app called “Careggi Smart Hospital” which has been developed for the Careggi Polyclinic in Florence. The application is designed for Android smartphones and tablets and it is freely downloadable from the Google Play Store. It provides various useful tools to the hospital’s users such as personnel and structures finding, way-finding and the possibility to access personal medical records collected on regional electronic health record.

I. INTRODUCTION

Careggi Polyclinic is a hospital with 52 pavilions spread over a 74 hectares area. Its inner organization is structured in Departments, Activity Areas and Operative Units for about 6900 employees. The Departments are 20 functional macrostructures, scattered in more than one building, using different structures, technology and rooms throughout the whole hospital area.

For each Department there are functional substructures with a lower level of aggregation: 276 Activity Areas (AA) and 181 Operative Units (OU). The first ones are groups of physical spaces that share a healthcare activity. The Operative Units join together healthcare staff in relation to their medical activity. Therefore it is possible to have many Operative Units operating in different rooms associated with different Activity Areas: a single room is assigned to only one Activity Area but it can be used by more than one medical Operative Unit.

Ten years ago the hospital made an agreement with the former Department of Electronics Engineering (now Department of Information Engineering) and the Department of Architecture of the University of Florence to set up a permanent office inside the Technical Department of the hospital for the developing of new informative tools to manage the healthcare facility, help the top-management with decision-support systems and to assess and improve the inner weakness. Throughout the years the Monitoring Laboratory (this is the name of the research team) has been developing many tools: in particular it has designed and developed an informative system called SACS (an Italian acronym that

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means system for the analysis of the hospital spaces) together with a web-application called EUREKA which is a searching engine for people and structures inside the hospital.

When a user approaches the hospital, he usually finds it difficult to understand its organization and even though he is able to reach the correct pavilion, he often gets lost through the medical centers, especially if he only knows the name of the doctor and not the OU he is assigned to.

This work thus comes from the top-management idea to develop an application for smartphones which could help hospital users to simply easily reach their destination. Plus the application allows the user to view his medical records via a common smartphone, thus reducing physical accesses to the hospital. Many other information, such as the hotels and the restaurants near the Careggi’s area and news RSS feed from the main national and regional newspapers, are provided via the app.

II. METHODS

SACS is a software that drives Autocad to manage and analyze digital plans of hospital buildings coded on specific layers. It maps Departments, Operative Units, Destinations of Use, healthcare technologies and environmental comforts, grouping the information by single room and homogeneous area. System outputs can be used by top-management as a decision-support aid to assess parameters to improve the hospital structure and organization [1,2].

EUREKA is a web-based search engine developed in ASP.NET that allows users to perform free-text queries on the data stored in the SACS database, performing real-time reports.

Careggi SMART HOSPITAL is designed by Careggi together with the University Monitoring Laboratory and developed (to date for Android systems) by Dromedian Ltd. The link between the application and the medical records is achievable by the user by means of the national health card (in Italy every citizen has one) and it is powered by a link to the Tuscany Region health records.

Hospital inner resources have been used for searching people and structures as well as for the way-finding module, by taking advantage of the informative tools already developed by the above mentioned Monitoring Laboratory: EUREKA’s algorithms provides the necessary functions and information using data collected by SACS.

All the functionalities for the search module (except the way-finding procedure) are obtained by querying EUREKA, therefore a web service interface between Eureka and the mobile application has been purposely designed.

A. Algorithms

The SACS Microsoft SQL Server database includes different types of structured data, both structural and organizational. For each of the about 15.000 rooms of the hospital there is a detailed mapping of the surface, the volume, the electrical and air-treatment plants. However these structural data are not useful for our scope. What we need to access is the organizational one. For every space, SACS provides the Department and the Activity Area as well as the Operative Units that make use of it (figure 1).

BUILDING	FLOOR	ROOM_CODE	DEPT	OU	AA
1	DEAS	PRIMO 12_A_117b	DAI Specialità Medico-Chirurgiche	Chirurgia Toracica	Comperto Operatorio Chirurgico B
2	DEAS	PRIMO 12_A_115a	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
3	DEAS	PRIMO 12_A_115a	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
4	DEAS	PRIMO 12_A_117a	DAI Specialità Medico-Chirurgiche	Chirurgia Toracica	Comperto Operatorio Chirurgico B
5	DEAS	PRIMO 12_A_115	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
6	DEAS	PRIMO 12_A_116	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
7	DEAS	PRIMO 12_A_117	DAI Specialità Medico-Chirurgiche	Chirurgia Toracica	Comperto Operatorio Chirurgico B
8	DEAS	PRIMO 12_A_117c	DAI Specialità Medico-Chirurgiche	Chirurgia Toracica	Comperto Operatorio Chirurgico B
9	DEAS	PRIMO 12_A_121	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
10	DEAS	PRIMO 12_A_119	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
11	DEAS	PRIMO 12_A_119a	DAI Del Cuore e dei Vasi	Cardiochirurgia	Comperto Operatorio Chirurgico B
12	CLINICA NEUROLOGICA	TERRA 10b_053	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
13	CLINICA NEUROLOGICA	TERRA 10b_052	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
14	CLINICA NEUROLOGICA	TERRA 10b_069	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
15	CLINICA NEUROLOGICA	TERRA 10b_068	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
16	CLINICA NEUROLOGICA	TERRA 10b_067	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
17	CLINICA NEUROLOGICA	TERRA 10b_050c	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
18	CLINICA NEUROLOGICA	TERRA 10b_050	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
19	CLINICA NEUROLOGICA	TERRA 10b_050b	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
20	CLINICA NEUROLOGICA	TERRA 10b_050a	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
21	CLINICA NEUROLOGICA	TERRA 10b_094	DAI Diagnostica per Immagini	Neuroradiologia	Neuroradiologia-Sala Angiografica
22	VILLA MONNA TESSA	PRIMO 2E_A_142	DAI Specialità Medico-Chirurgiche	Anestesia e Ria...	Comperto Operatorio Ortopedico

Figure 1. List of buildings, floor, rooms, departments, operative units and activity areas stored in the sacs database.

When performing a search for a particular structure, the current first release of SMART HOSPITAL leads the user to the desired building and floor (no in-door navigation still). So the minimum degree of analysis is the floor of a building, and this comes easily from the SACS database. By selecting the Department and then the desired AA or OU, the related buildings and floors can be extrapolated by the database with a simple “SELECT ... WHERE” statement in SQL (figure 2).



Figure 2. Screenshots of the mobile application: the search module main page (a), the list of all the available Buildings (b) and Departments (c), the list of the Activity Areas for the Cardiology Department (d) and the details (director’s name, buildings and floors) of the selected activity Cardiology Ward B (e).

People-finding procedure is similar. SACS is linked to the hospital’s main personnel database, containing the OU or AA they are assigned to. Sometimes also the information about the actual room is available.

So by querying the database for a given person the results can be showed in two different ways: if he is associated with a room the query returns the building and floor codes, otherwise it just returns the name(s) of the building(s) and the floor(s) where his OU/AA works through. Plus the algorithm also provides a “did you mean” functionality. If the user does not type correctly the name of the person he is searching for, a word-distance analysis is performed between the typed text and a fuzzy dictionary which contains all the words in database that can be outputted as a query result (figure 3).

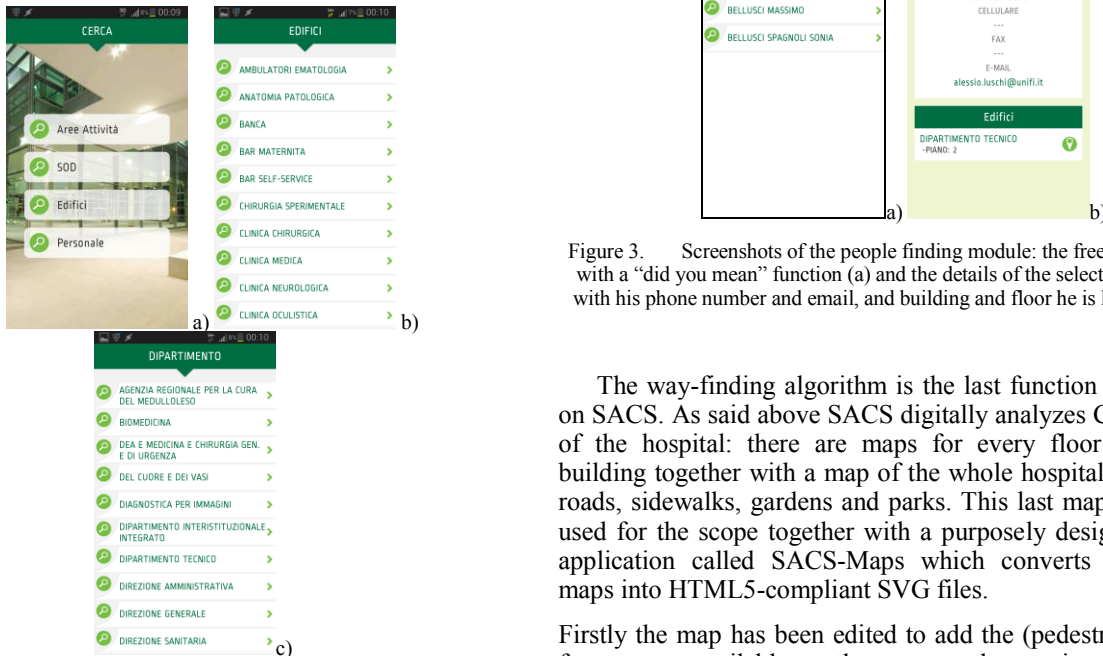


Figure 3. Screenshots of the people finding module: the free text search with a “did you mean” function (a) and the details of the selected persons with his phone number and email, and building and floor he is located (b).

The way-finding algorithm is the last function that relies on SACS. As said above SACS digitally analyzes CAD maps of the hospital: there are maps for every floor of every building together with a map of the whole hospital area with roads, sidewalks, gardens and parks. This last map has been used for the scope together with a purposely designed web-application called SACS-Maps which converts the CAD maps into HTML5-compliant SVG files.

Firstly the map has been edited to add the (pedestrian) ways for every available path among the various hospital structures. Main pavilions’ entrances have been added too. Then the mobile application stores the coordinates of every vertex of the Autocad polyline entities which outline buildings, roads and every other element on the analyzed

plan. The coordinates are opportunely scaled and at last a SVG file is outputted with 4 XML groups:

- *Buildings* node, which contains the shapes of the navigable items of the map
- *Base* node, which contains the shapes of all the non-navigable items that are however useful to give the user recognizable fixed-points for routing
- *Path* node, that groups the lines that represents the paths among the buildings
- *Doors* node, containing the entrances to the buildings, i.e. where the relative path ends.

This SVG is then analyzed via a routing algorithm which is able to find the minimum distance between 2 doors (one for the destination building and one for one of the available starting points which coincide with the main hospital's entrances) evaluating all the available paths and the result are then proposed to the user.

When the user selects a destination to navigate to, additional textual information about the accessibility of the entrance can be showed by the application: this info is especially useful for letting low-mobility people know if there is some sort of architectural barrier, in advantage (figure 4). The way-finding function is available by tapping on a building after searching for an AA, an OU, a person or obviously a building.



Figure 4. Screenshot of the routing map for a the selected building and starting point (a) and information about the accessibility of the destination building (b).

B. Interface between Eureka and Careggi Smart Hospital

SACS database is physically located on a server machine linked to the hospital intranet network. Some of the data in SACS are sensitive, due to its nature, and need not to be accessed from outside. Thus the mobile application must not directly have access to the SACS database.

Web services are hence used to overcome the problem. An ad-hoc web service has been developed and installed on a server accessible from outside the corporate network: on the inside, it communicates with EUREKA and with its algorithms to perform the desired queries for structures or people, while on the outside it outputs XML files with the relative information via HTTP protocol. This avoids restricted data to be showed outside the intranet network.

The web service comes with 8 methods:

- *DeptList* returns a list of all the Departments (it does not expect any input string).
- *BldList* returns a list of all the hospital buildings (it does not expect any input string).
- *AAList* and *UOList* return a list of all the Activity Areas or Operative Units associated with the number of the Department provided as input.
- *AADetails* and *UODetails* return a list of the details of the selected Activity Area or Operative Unit. Details are information such as director, phone numbers, buildings and floors it is located (the input string is the code of the AA/UO outputted by *AAList* and *UOList*).
- *PeopleList* and *PeopleDetails* respectively return a list of the people compatible with the input searched text and the details of the selected person such as phone and fax number, email and space location.

Methods can be openly accessed by the mobile application via HTTP protocol and inputs can be passed both via POST and GET method.

C. Interface between Careggi Smart Hospital and HER

Careggi hospital uses Electronic Health Records (EHRs) system to store medical information about inpatient and outpatient care. With this app the top-management wants to offer a way for patients to view their health records anywhere and everywhere in mobility, download the information in their personal device, and share it with others that patient trust. App use secure technology to protect medical information from being seen without correct permission and satisfy privacy regulation.

The user authentication is achieved using the national electronic health card. The authentication certificate is onboard the card's chip. By inserting the card in one of the fixed "totems" that are spread in the hospital area (as well as in all the other hospitals and healthcare structures in Tuscany) the user is prompted for his personal identification number (PIN). At this time a QR code is printed and the app can be activated by simply focusing it with the device's internal camera. This makes it possible a multiuser approach. For example, in a family, a single device can be shared by all the components. Every user will use his own PIN to access his sensitive data.

III. RESULTS

Careggi Smart Hospital has been released on late December 2013 in its Android version. On Google Play Store in less than one month it achieved more than 350 downloads and an average rating of 4.5 (see fig. 5). Having in the same app multiuser capability to access to clinical records, information about the hospital, a search engine to find personnel and structures, and a dynamic way-finding system is a satisfactory achievement both for end user and for internal personnel.

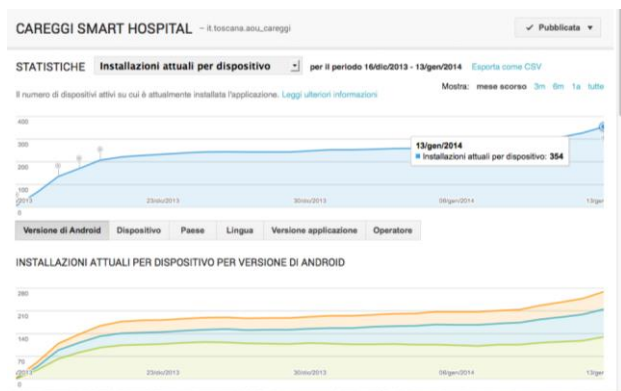


Figure 4. Statistics of the app installations from Google Play

IV. CONCLUSIONS

The app is constantly updated with new functionalities. The first important update is the possibility to offer a complete navigation tool using the localization signal of the mobile phone to trace the actual user position in real-time. SVG files need to be made for every floor of every navigable building of the hospital in order to provide an indoor navigation. An iOS version is about to be released.

The app is far from reaching its full potential. In the future it will be the starting point for many specialized clinical and non clinical applications, such as chronic care management [3,4], telemedicine application [5,6,7], patients tracking [8,9,10], technology management [11] and drugs smart administration [12,13].

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