

Smart Home Medication Reminder System

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Abstract — The reality is that many of us will need assistance in our later years. In some cases, people need nothing more than occasional visits from a home nurse, some light housekeeping, meals on wheels, and visitors willing to talk and notify about pills. While there is a movement to make aging at home possible for more people, it is not always an option. Dementia and other illnesses can require around the clock medical care and monitoring, things often more easily given in a professional facility than at home. On the other end, increasing number of smart systems opens area where medical treatment can be utilized to completely new level. In this paper we show a working solution how a smart home can be utilized to help people with medication related reminders. Proposed flow starts when a new medication prescription is taken from the doctor. eHealth system generates QR code which is then delivered as part of prescription, holding set of information, such as medications treatment, duration, next visit and similar. This set of information is used by the expert system which handles all the notifications generated by prescription. In used system, three types of notifications are used, smart phone notifications, home voice and video notifications.

Keywords—openHAB; medication; reminder; smart

I. INTRODUCTION

Recent research studies on the Internet of Things and smart things domain shows how different elements of human daily activities become increasingly dependent on each other. Smart things are changing human life in the way that nowadays without their applications life is becoming cumbersome. With the unstoppable advance of technology, most research projects in field of smart homes have been designed to help human and increase their quality of everyday living experience. A home, which is smart, is the technology result used to make all electronic equipment around the home act "intelligent" or more smart. Smart home has advanced automatic rules for lighting, temperature control, notifications, and many other functions. There are many smart home solution, but of interest in this paper is Open Home Automation Bus (openHAB). OpenHAB is a software for integrating different home automation systems and technologies into one single solution that allows reusable automation rules. Rules are based on well known If This Then That (IFTTT) service where user can create chains of simple conditional statements what is extremely usable in OpenHAB where system comprises of many controllable smart devices.

Except modern homes, health care organizations are introducing e-Health as an essential part of most health care reforms. It is one of the fastest growing markets in the domain

of information and communication technologies, with a current estimated compound annual growth rate of 6% in the Europe. E-Health implementations have been in sharp focus for the last 5-10 years and some significant achievements have been accomplished in that period. [1] However, e-Health projects have not been easy to carry out, due to interoperability of the implemented solutions and different key indicators. Overall, manufacturers in the medical domain are seeking to transform their products into real time services, which then on the basis of new or amended business models can be integrated and aggregated according individual requirements and preference. So far these plans and visions have not been sufficiently supported by existing network technologies [2].

In this paper is shown proof of concept how an e-Health system can be linked to openHAB smart home system. To make it easier to follow we split the system in following elements:

- eHealth system
- medicines database
- reminder rules expert system
- smart home system

e-Health system represents electronic health system, usually controlled by Ministry of Health linked with pharmacy offices. Every visit to doctor is stored in the system together with potential prescription describing patient medical treatment. In most cases medical treatment is described as medication type, duration, how often or even next visit to doctor. Medication is approved by government and is stated in list of approved medications exposed to pharmacy offices. All of mentioned data is very valuable for system described in this paper and is utilized by smart home system by the reminder expert system (RES). Smart home system is end element and is crucial for delivering notifications to end user. In following chapter all elements are described and linked together in an eco-system.

II. STATE OF THE ART

Although the system described in this paper is fully based on openHAB solution there are other commercial products available. Here we show brief information of few such products:

- Nokia Smart Home
- Philips Lifeline
- Amazon Echo

Nokia Smart Home (NSH) is based on NSH Gateway device which is the central hub that controls all the devices and sensors, enables if/then scenarios, and triggers appropriate actions. These smart home gateways support both simple and more complex scenarios to ensure all conditions can be monitored in the right circumstances. While service providers can deliver best in class smart home platforms, you may want to cooperate with selected partners to maximize the success of smart home services, especially one as critical, and sensitive, as aging in place. By partnering with a healthcare provider or insurer, you can boost credibility, thought leadership and also enable the introduction of value add services like 24/7 monitoring.

Philips Lifeline medical alert system provides fast, reliable access to the help any time with the press of a button, and rest easy knowing if a fall should occur, the AutoAlert feature can still place the call for help if the fall is detected. AutoAlert fall detection will automatically place a call for help if it detects a fall and you can't push the help button yourself, even if you are disoriented, immobilized or unconscious. This solution is also based "as-a-service" type of product. The Lifeline service can be used in any emergency. From a fire, medical emergency, or if user is simply locked out of house.

Third product is the Amazon Echo, a voice-activated technology innovation that has amazing potential for helping seniors with dementia. This product can improve quality of life for older adults with Alzheimer's or dementia as well as for seniors with mobility limitations and other health conditions. Older adults with mobility issues or health conditions like Parkinson's can also benefit from an Echo. It gives them more control over their environment and more independence.

There are many other similar products, but most of them are based as services, giving no easy way for wider audience to deal with and utilize some ideas coming from it.

III. SMART MEDICATION SYSTEM

Overview of proposed system is shown in Fig.1. Main logic of the proposed system starts after prescription is created by the doctor. Once created prescription is, as electronic form, created in e-Health system with unique identification. Identification is entry point for pharmacy offices for issuing medicines to patients or medical care responsible persons. Proposed system starts at this point, by creating Quick Response (QR) code which is then given to the patient [3]. QR code is scanned by the patient, and then activated by the medical reminder expert system.

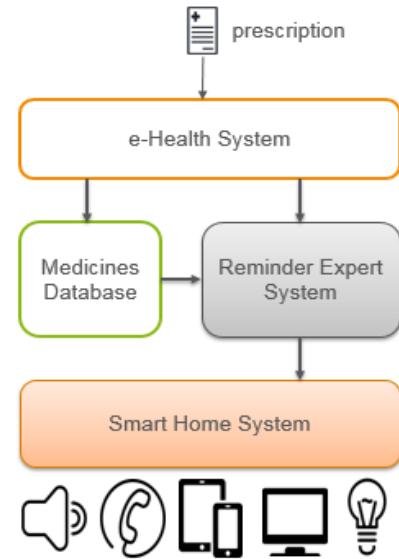


Fig. 1. Medication reminder system block diagram

A. QR code generation

Aforementioned QR code can be generated in two places, e-Health system automatically by creating prescription or once pharmacy issues the medicament to the patient. First approach requires changes in existing e-Health system implementation and therefore additional expenses for government agencies. We describe the other approach, where QR code is generated by the pharmacy office while issuing medicament. Pharmacists are qualified to issue the medicament and recommend medical treatment according to the prescription.

Before QR code is generated, certain set of data is automatically provided by the pharmacy interface to e-Health system and then be encoded as QR code:

- Prescription unique id – unique identification number for prescription request. Used to get information about medical treatment.
- Prescription issuer – unique identification of doctor who created prescription.
- Pharmacy office id – unique id of pharmacy issued medicaments.
- Patient information – patient information such as name, address and national identification number (NIN)

Required data is stored in JavaScript Object Notation (JSON) type of the structured configuration. Example of JSON configuration:

```
{
    "prescription_id": "123dd4567",
    "issuer_id": "12113408",
    "pharmacy_id": "qwe123456",
```

```

"patient": {
    "name": "Hrvoje Horvat",
    "address": "ZNG 120, Split, 21000",
    "nin": "12345789654"
}
}

```

Created set of information is then encoded as QR code with special identification icon, uniquely showing the content of code itself. Exact example is shown in Fig. 2.



Fig. 2. QR code example

QR code can be scanned only by the owner of prescription stated in encoded JSON configuration. Although anyone with access to the QR code can read the JSON information, no data describing treatment cannot be seen until user has granted access to the reminder expert system. Each user willing to use reminder system has to apply for account which has to be approved by agency that control e-Health system.

Having this step done, user grants reminder expert system (RES) access to prescription data. This implies that RES will read information about medication treatment such as:

- Medication identification – name and serial number of prescribed tablets.
- How medications are taken – i.e. how often, time plan, how long
- For how long medications are issued

B. Reminder Expert System (RES)

Reminder expert system (RES) represents most of the logic how medical reminders are distributed to the patient. Although the proposed solution is tightly related to smart home as end point for making patients aware of medical notifications, not only smart home is possible endpoint:

- Smart Phone messaging application – medical reminders can be distributed by RES to any endpoint device or application. For purpose of this paper, Telegram mobile application is used to show how RES can also be utilized on modern phones.
- SMS/MMS client
- phone call – automated system can be configured to make call reminders about medical treatment.

RES is the most advanced aspect of proposed solution and therefore must be very robust and provide high availability at all times. RES core is based on Java OSGI architecture giving simple way to extend system at runtime without stopping it. Each RES feature (QR interpreter, Database Reader, User Authentication) is developed as completely standalone Java library. In proposed system same engine, openHAB, is used for RES and smart home system. RES architecture is shown on Fig.3.

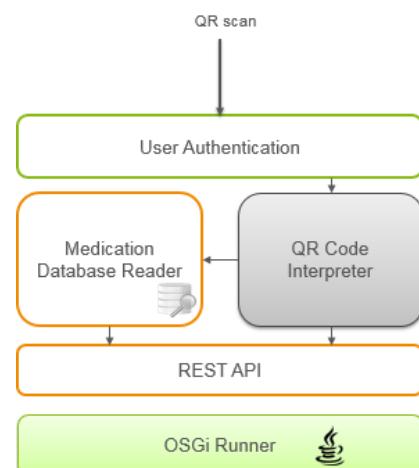


Fig. 3. RES block diagram

Typical RES flow starts by patient scanning QR code provided by pharmacy office. Scan starts connection towards RES web service, where patient needs to authenticate to allow QR code interpretation. User authentication is performed by digital certificates, or by predefined user password. Once authenticated, RES allows user data to be interpreted by QR code interpreter. This component plays important role in extracting medical treatment data from provided prescription id. Extracting medication identification, RES retrieved medicament serial number which is then used to query Medication Database. This process prepares image of medicament for easier usage, general usage rules, side effects. All data is exposed to the end user.

RES network layer serves HTTP based web service using the Representational state transfer (REST) or RESTful protocol. REST-compliant Web services allow requesting systems to access and manipulate textual representations of Web resources using a uniform and predefined set of stateless operations [4].

This kind of service is widely used for many IoT systems as usage is very simple and does not require special programs to be used. RESTful service exposes several predefined operations that can be utilized by the smart home system or another client browser. Most of the logic of RESTful service implements JavaScript Object Notation Application Programming Interface (JSON API) to deal with communication towards RES. JSON schema is a simple schema language that allows users to constrain the structure of JSON documents and provides a framework for verifying the integrity of the requests and their compliance to the API.

REST API delivers several groups of HTTP requests:

- Medicament treatment plan
- Next doctor appointment
- System logging

RES can be queried at any time to get medicament treatment data. This action is usually performed by software application which can act on received data. In particular proposal, RES data is used by openHAB smart home system. This requires openHAB Java library to be installed on the system which can communicate with RES and accordingly create notifications.

Querying RES API structured JSON reply is returned:

```
{
  "medicaments": [
    {
      "id": 163375,
      "name": "Prazine",
      "treatment": {
        "start": "12-06-2017 15:00",
        "end": "13-09-2017 06:00",
        "step": "Every 6 h"
      }
    },
    {
      "id": 167115,
      "name": "Concor",
      "treatment": {
        "start": "12-06-2017 15:00",
        "end": "13-09-2017 06:00",
        "step": "After lunch"
      }
    }
  ]
}
```

```

    }
  }
]
```

Looking above example, each prescribed medicament is defined in several details, such as name of medication, id, start, end and step between each usage. This leads to the smart system that uses this data.

C. Smart Home System

Although there is different smart home system implementation, from commercial to open source, in proposed solution openHAB system is utilized. We chose openHAB for several reasons. First, openHAB has a growing community driven approach. Second, connection to 153 different devices and protocols such as Samsung TV, Z-Wave, Asterisk and many other.

To make openHAB aware of RES, it is required to install RES library (also called binding) to a running openHAB system which then can interpret medication JSON responses. RES binding is responsible to:

- Translate RES JSON response to a set of reminders within openHAB
- Bind medication reminders to a specific openHAB rules on how smart home will act on medication reminder

OpenHAB has simple rules configuration control where each rule can be configured on a running system from the user interface. Depending on rule configuration user (patient) living in smart home can create a set of actions that can be performed by smart home devices to make medicament notification:

- Voice (Text to Speech)
- Smart Phone Messenger – Telegram messenger is used as existing messaging application providing secure and reliable delivery [5]
- TV display
- Light

Any of notification devices can be linked together to make medication process very easy to use. All of the rules are configured once, and each new medication is following created rules.

Voice notifications are very useful and are easily controlled by openHAB, providing unambiguous information at the right time. OpenHAB speaks medication name, dose and time to take it. At the same time visual notification is displayed on smart TV, showing pop-up dialog with medication information. Example of medication reminder on smart TV is shown on Fig.4.

If patient is not in the house at the time, notification is automatically forwarded to user's smart phone messaging Telegram client. This type of notification takes in consideration that patient may be away of home, notification is generated predefined time in advance so that user has time to make it.

Similar procedure happens when user leaves home, RES notification is sent to the user to take medications for later use.

IV. CONCLUSION

Nowadays when each and every component gets its network connectivity it is important to get into the speed with the rest of the community. On the other end, increasing number of smart systems opens area where medical treatment can be utilized to completely new level. In this paper is shown a working example how a smart home system can be part of patient medical treatment. Although described solution is based on smart home as end point, the same solution with smart phone notifications can be used in hospitals when nurses have to monitor patients. RES system can be extended to send notifications to nurse showing what patient should get medications, measure temperature or similar.

Described system is to proof-of-concept solution so no extra evaluation has been made. This is yet to be started by

promoting it in medical circles, both school/academic and hospitals.

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