ROADS: RFID Office Application for Document tracking over SIP

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***Abstract*— Radio Frequency Identification (RFID) technology is recently intensively investigated as an effective solution for the next generation communication services in business processes. In this paper we propose an RFID-based location tracking system for distributed offices based on Session Initiation Protocol (SIP). The proposed system is compatible with EPCglobal standard, but extension with SIP at application layer allows interoperability between various devices and platforms, which is not generally supported by the EPCglobal standard. In comparison with existing solutions the proposed system distributes RFID tag presence information to users through IMS (IP Multimedia Subsystem) presence enabler service. This enables real time monitoring of the observed office assets and their current presence status.**

***Keywords*— RFID technology over NGN, distributed offices, localization services, presence server**

I. Introduction

RFID (Radio Frequency Identification) technology is used for identification and tracking of objects which are in range of RFID antenna. RFID system consists of RFID reader, RFID Tags and RFID antennas. RFID reader connected to computer through Serial or Ethernet port has antennas attached which read tags in range. Tags are information carriers and they send memory content once they report to the reader.

There are 3 types of RFID tags [1]:

- Passive – have no power supply. They are designed to absorb power from incoming signal in order to power CMOS and transmit data to reader. It means that antenna needs to be designed both to receive and transmit data.
- Active – have its own power supply, which is used to transmit data back to the reader. Powering such a tag means greater signal power that is transmitted.
- Semiactive – have its own power supply which is used only to power microchips and data storage, but not to transmit data. Power transmission is similar to passive RFID tags.

There are many advantages and disadvantages of each tag type. Most important factor for a tag implementation is its price and range [2]. Passive tags are lower range and cheaper than active tags with higher range. Tags used in architecture proposal are passive UHF EPCglobal class 1, generation 2 tags with range of 5 meters and price of 0.19$ each [3].

EPCglobal system is a non-profit organization entrusted by industry to establish and support the EPCglobal Network as the global standard for real-time automatic identification of information in the supply chain of any company, anywhere in the world. Using EPCglobal architecture as a reference standard for business organization [4], we describe our approach in realizing the system, with emphasis on compatibility with EPCglobal and the concepts of Next Generation Networking. Localization ideas already developed [5-9] can be used for better tag position estimation. EPCglobal proposes usage of the ONS (Object Name Service) system for tag location lookup in business environment. To be compatible with existing solutions, ONS part is extended with SNS [10] – SRMS Name Service (distributed database which maintains mapping between EPCs and SIP URIs), as an approach to fully convert EPCglobal to SIP network. In [10], every component of EPCglobal standard is converted to its surrogates, in order to be compatible with SIP network. Also, [10] explicate benefits of SIP signalization. Other proposal [16], use IP infrastructure to retrieve EPC numbers exact location and validate it through SIP services. Another approach [17] presents their own system architecture based on SIP networking, independent of EPC architecture. Inspired by the lack of platform independency and Real-Time access services we propose compatible EPCglobal system architecture with SIP protocol as an application layer protocol, including standard benefits of Presence Server and IMS (IP Multimedia Subsystem).

Once RFID tag is found we use the Presence Server as a service which can monitor real time tag location changes. Benefits over existing architectures are: i) Tag location retrieval – SNS lookup allows retrieval of reader IP address location. With our SIP extension, system will identify antenna ID, reading tag or group of tags we are looking for. ii) SIP as a step towards NGN allows different client technologies to access the system iii) Presence service with its states – It is possible to recognize whether tag is moving through the office or, according to statistics, is out of range of antennas but will be back in the room soon, etc.

Implementation of SIP protocol advantages in business environment would cut costs, improve agility, provide superior customer service and make customer interactions stronger [12].

Realizing SIP architecture in business world and applying those benefits to RFID technologies would be of great importance for communications and business interaction in future services and requirements for competitiveness in future markets. Proposal presented in this article is step towards developing system for future market.

Article is structured as follows: in Section II the proposed system is described which will be used in distributed system analysis. Section III gives application of the system using SIP protocol as a precursor of the Next Generation networking. In Section IV we conclude our paper.

II. The Proposed System

The considered system uses middleware which will offload a great part of information to the host computer and save communication bandwidth for redundant data as it is supposed in "The EPCglobal Architecture Framework" standard. Two major EPCglobal components are:

- EPC information service (EPCIS) – data collection mechanism, using proposed middleware for smart data collection.
- Object name service (ONS) – used for Tag location retrieval, for EPCglobal subscriber.

EPCIS include [9] RFID Reader, filtering and collection algorithms, capturing application, data repository and accessing application, while ONS uses DNS service for the EPC item lookup. Proposed standard is depicted in fig.1.

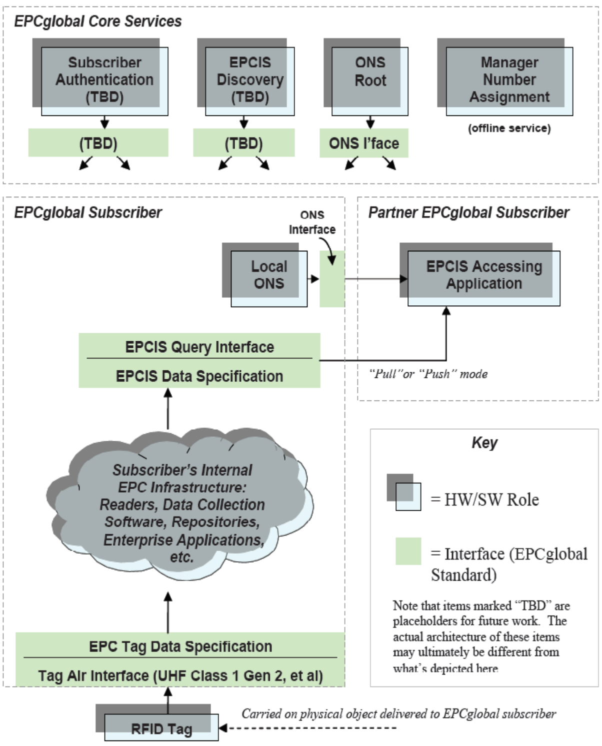

Fig. 1 EPCglobal architecture [9]

Fig. 2 illustrates the proposed system. RFID antennas monitor tags located on the shelves. Each document file has passive RFID tag attached. Using multiple port RFID reader and appropriate software it is possible to distinct which antenna reads which tag, and depicted system is the basis for passive RFID indoor localization. An antenna receives tag information and sends it to the reader. Once tag information is received, software should properly parse tag location information from logs generated on computer reader is attached to, and distribute information about location changes to the central server, described in next section. In order to provide high modularity and availability of the proposed system, our proposal is based on SIP networking [18] and Presence Server.

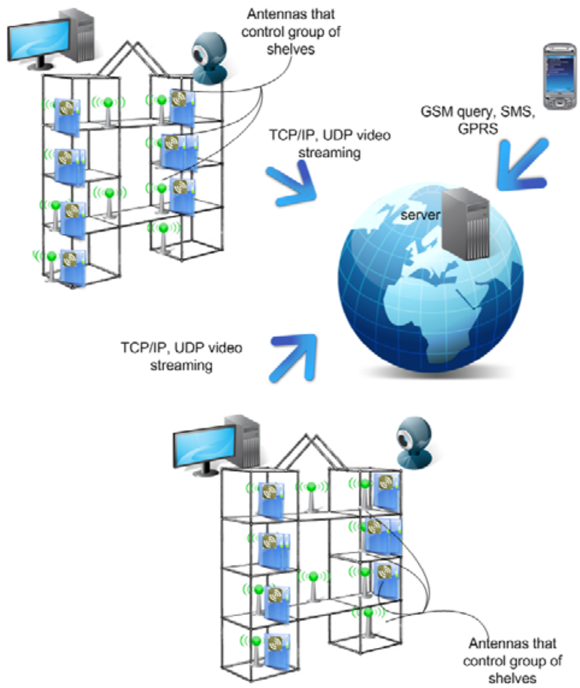

Fig. 2 The Proposed system

The system in Fig. 2 is compatible with EPCglobal network, but modifications using SIP as application layer protocol is added. SIP is chosen because the main idea is to deploy application service which can be accessed by various devices and independent platforms. Described platform independent system can handle requests of variety client devices such as smart phone, PDA, PC, mobile phone, etc. Standard SIP server includes SIP container with SIP Enablers which allow registered users to subscribe on IMS (IP Multimedia Subsystem) services. IMS is architectural protocol for delivering internet protocol multimedia services [11]. Generally, IMS connects telecommunication services with computer science, which unites PSTN (public switched telephone network) and PSDN (public switch data network) creating a single multi-service network within its architecture [9]. It uses IPv6 protocol, independent of access technology, while SIP protocol is used for signalization and convergence of different client devices. IMS has been designed for service and control of quality and integration of different services. This guarantees quality of service which is defined *apriori* by users. Layered IMS architecture allows generic common functionalities with different services to reduce unnecessary usage of the same network functionalities, which contributes to the cost reduction. Described system is scalable, allowing integration with all "next generation applications and services". Enablers are basis for all-IP services and they can handle all types of incoming requests.

Let capturing application filter tag information and send it to the SIP server. To be able to communicate, SIP clients and servers use SIP stack (SIPUA – SIP User Agent) responsible for handling SIP messages.

The IETF has produced many specifications related to Presence and Instant Messaging with the Session Initiation Protocol (SIP) [18]. Collectively, these specifications are known as SIMPLE - SIP for Instant Messaging and Presence Leveraging Extensions [19]. These specifications cover topics ranging from protocols for subscription and publication, and presence document formats, to protocols for managing privacy preferences. In our case, extended PUBLISH and SUBSCRIBE messages are used to achieve additional information about Tag, described in Section III.

Primary task of SIMPLE protocol is the transport of Instant messages in SIP, compliant to the requirements in RFC 2779 (instant messaging/presence protocol), CPIM (Common Profile for Instant Messaging - allowing interoperation of a wide range of IM and Presence systems) [20] and in BCP 41 (congestion control principles) [21].

Once defined, XML message is sent to the Presence Server over SIMPLE protocol as a publish message, publishing all tag location changes. It means that all subscribers on the IMS, whose SIP session is opened, can see the list of active tags in the distributed offices. SIMPLE includes XML tag for additional RFID tag information such as location (RFID antenna ID), time and eventually RFID tag location changes. Server agent handles requests such as information update storage or database information retrieval. SIP server container receives RFID tag information from the Presence Server, structured in XML message as a notification about presence of tags we are looking for. SIP server database updates Presence Information when office file location is changed.

Office file location and presence should be formatted according to the demands of SIMPLE protocol. RFID reader software creates logs from tag readings in XML format. XML message depicted on fig. 3 consists of tag ID received from tag memory container, time when tag is logged and captured tag antenna ID. Once received XML tag log message could be easily parsed and encapsulated in SIMPLE protocol message.

RFID capturing application generates XML log from tag readings:

```
<?xml version="1.0" encoding="utf-8"?>
<LogInfo>
        <ReadTagLog>
        <ReadMethod>Continuous Read</ReadMethod>
        <ReportFrequency>Report
        Immediately</ReportFrequency>
        <Comment>no comments</Comment>
                <Tag>
                        <DateTime>06.27.2008
                        10:39:32:906</DateTime>
                        <TagId>350000001000002000000003</T
                        agId>
                        <Count>1</Count>
                        <Reader>172.21.1.1</Reader>
                        <Antenna>1</Antenna>
                </Tag>
                <Tag>
                        <DateTime>06.27.2008
                        10:39:32:906</DateTime>
                        <TagId>350000001000002000000005</T
                        agId>
                        <Count>1</Count>
                        <Reader>172.21.1.1</Reader>
                        <Antenna>2</Antenna>
                </Tag>
        </ReadTagLog>
</LogInfo>
```

Fig. 3 Capturing log

III. Application over NGN

A Next Generation Network is a set of servers that allows User Agents to establish session and be charged for it, within which they can convey Media streams [12]. When user agents once establish the session, they can exchange media streams freely, outside of the control of Next Generation Network Service Provider (NGNSP).

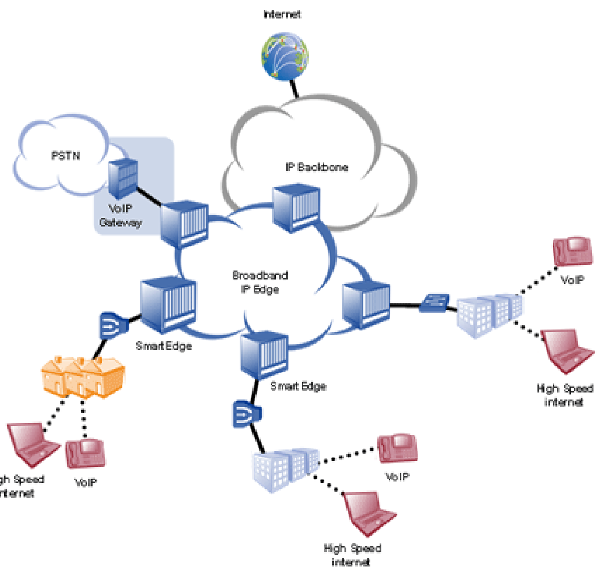

Fig. 4 Traffic unification in NGN

Fig. 4 highlights next generation networking with its idea that all kinds of network traffics are unified in single network entity.

Distributed offices can communicate through SIP server, and share tag information location and its content. Offices (simplified warehouses of information) can be distributed across the globe, and their communication can be established over next generation networking (NGN), i.e. through SIP (Session Initiation Protocol) as a step towards NGN. SIP advantages allow unified message system between all Peer-to-Peer participants [11]. SIP is application level protocol which implements RTP protocol on transport layer, and video streaming from offices can be distributed to variety of devices which implement SIP environment.

Benefits of SIP protocol are [10]:

- Easy implementation
- Easy inter-working with web
- Inter-working with other systems
- IP multimedia subsystem in 3G

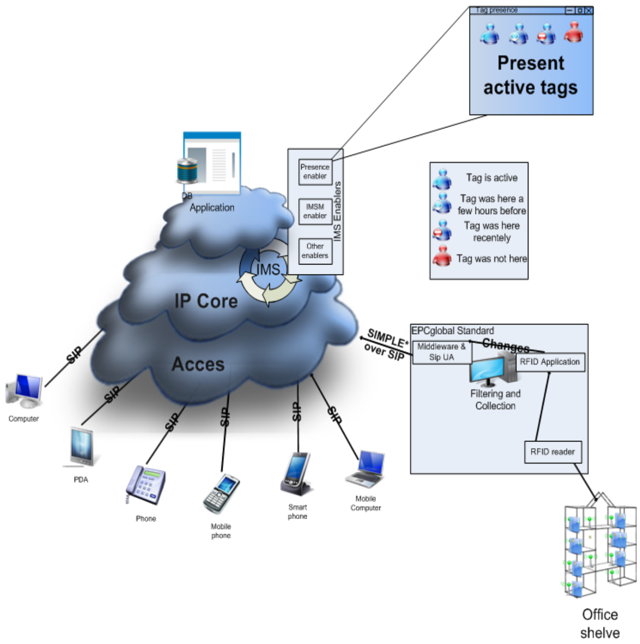

Fig. 5 Interconnection between EPCglobal and IMS

The proposed system depicted on Fig. 5, extended with SIP, allows real time office files presence access to the clients subscribed to the system. IP Core and application level layers share IMS system. IMS is proposed by 3GPP (3rd Generation Partnership Project) [13], and at first was developed as a need for next generation mobile systems. Today, IMS is extended with its enablers, as a basis for next generation networks. This article proposed usage of the Presence Enabler, responsible for presence status of each tag. It is important that all devices connected to IMS have SIP user agent installed so they can communicate with the IMS.

After office shelves content is read by an RFID reader, local computer with RFID application installed, generates log about tag presence. Those logs (XML files) are being parsed and changes of RFID tag locations are sent to the Middleware, being responsible for the communication with IMS. SIMPLE protocol infrastructure is used for SIP extendible messaging in IMS. Extensible means that tag presence message is not part of the standard because tags should have its own IP address. We used it as a part of extensible standard message being sent to IMS, with additional information about antennaID which captured tag. On server side, received message is parsed by the Application which uses Presence enabler for appropriate client query representation. Three important messages are being sent in the communication between SIP server and clients (PUBLISH, SUBSCRIBE, NOTIFY). During the time when SIP was developed as a need for protocol when IP telephony was introduced, extensions were necessary. Then SIMPLE was introduced for Instant Messaging over SIP [19].

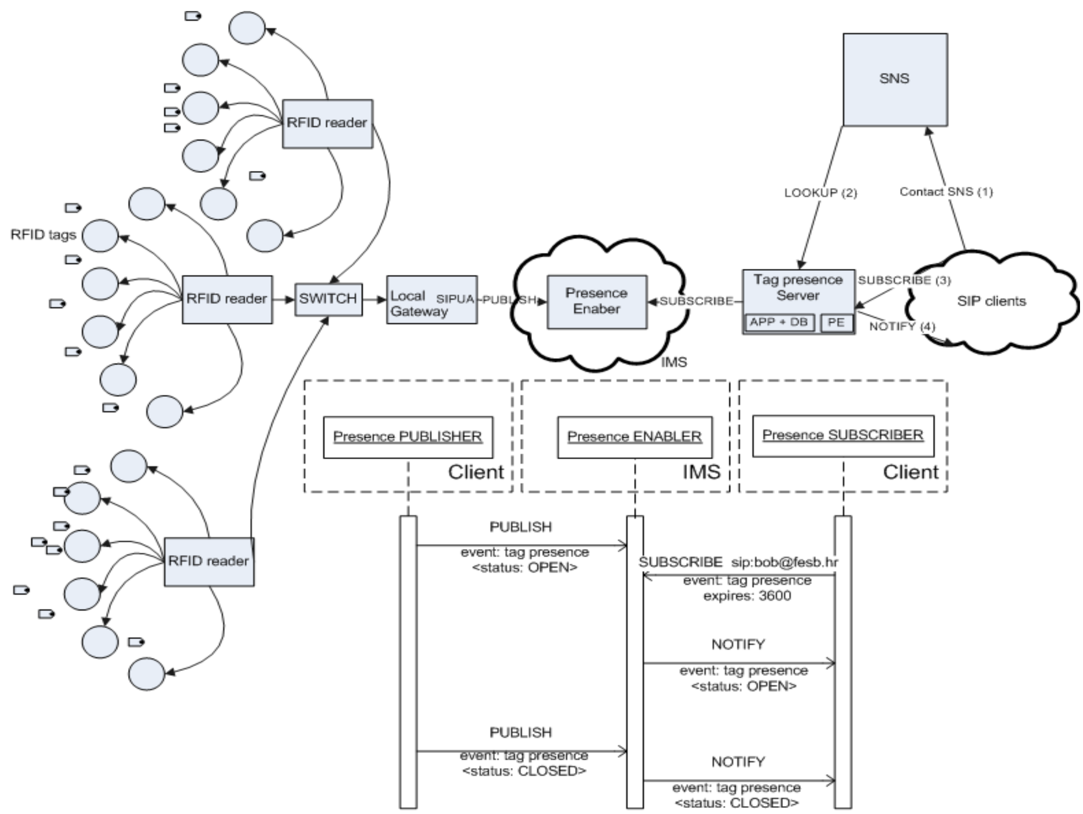

Fig. 6 Communication architecture with sequence diagram

Fig. 6 depicts the proposed system for communication architecture framework, where SIPUA (SIP User Agent) publish all changes happened in observed office. Presence Enabler handles PUBLISH messages. Tag presence Server subscribes to all changes from Local Gateway. In order to find location of the tag SIP, clients contacts SNS which will find Server tag is subscribed on. Once SIP session is established (opened) it is possible to get direct video streaming from the office by exploiting current session. To validate proposal, we have run Tag Presence Server PUBLISH message run on simulator, depicted on fig. 7.


```
PUBLISH sip:alice@fesb.hr SIP/2.0
Max-Forwards: 70
Event: presence
CSeq: 11293 PUBLISH
Expires: 7200
Content-Length: 510
User-Agent: ICP30PGMAID
To: <sip:alice@fesb.hr>
From: <sip:alice@fesb.hr>;tag=119fad4-2c1c.1c38
Route: <sip:orig@127.0.0.1:5081;lr>
Call-ID: 2dd8-a41-214321ac@127.0.0.1
Content-Type: application/pidf+xml
Via: SIP/2.0/UDP 127.0.0.1:6050;branch=z9hG4bK42.49e1.1c38
<presence xmlns="urn:ietf:params:xml:ns:pidf"
entity="sip:alice@fesb.hr">
<tuple id="t1308495763">
<status>
<basic>open</basic>
</status>
<contact priority="High">sip:alice@fesb.hr</contact>
<CustomExtendedTagOFFICE>
<Tag AntennaID=1 officeNo=1 ReaderAdress="172.21.1.1">
350000001000002000000003 </Tag>
<Tag AntennaID=2 ReaderAdress="172.21.1.1">
350000001000002000000005 </Tag>
</CustomExtendedTagOFFICE>
</tuple>
</presence>
```


Fig. 7 PUBLISH message

Method PUBLISH (on the Fig 7) publishes SIP address. Max-Forwards can be easily explained as a TTL (time-to-live), in order not to enter infinite loop. Event is presence, because we use Presence Server Enabler to provide tag presence. Cseq is random number important when there is messaging in the same session. Expires tells us what is the time in seconds that SIP message will live. Content-length indicates the size of the message-body in decimal number of octets, and it is calculated after message is created. The User-Agent header contains information about the client user agent originating the request. “To” and “From” addresses must be same when we publish presence. This SIP PULISH method was simulation and Route was set as a localhost. Generally, route header is used to store route set of a transaction. Call-ID header uniquely identifies a particular invitation or all registrations of a particular client. Content type indicates the media type of the message-body sent to the recipient. Via header indicates the path taken by a request so far and can be used to prevent request looping and to ensure that replies take the same path as the request. After headers, we send XML message formatted in accordance with SIMPLE protocol. This message is extended with part used for an identification of the office files. Tag attributes are AntennaID, which identify location of RFID tag, and the other one is the IP address of the reader that antenna is attached to. Value is TagID. When tag changes position inside the room a new SIP message is formatted with new reading information about tag changes. In order to receive tag status, clients must SUBSCRIBE to presence of tags. A NOTIFY message is received by the subscriber when the status of user changes (for example when tag position is changed). SUBSCRIBE and NOTIFY messages can be found in appendix of this paper.

	Header	Filter Value	Partition	Company Prefix	Item Reference	Serial Number
SGTIN-96	8 bits	3 bits	3 bits	24 bits	20 bits	38 bits
	0011 0000 (Binary value)	3 (Decimal value)	5 (Decimal value)	0614141 (Decimal value)	100734 (Decimal value)	2 (Decimal value)

Fig. 8 SGTIN 96 format

Fig. 8 illustrates example of the Specific trade item (SGTIN) proposed by standard [14]. According to standard tag content we specify tag memory organization to be compatible with ONS, i.e. with proposed SNS [14, 15]. Using company prefix number SIP URI is resolved and SNS (hierarchically composed as DNS) finds home domain of the tag we are looking for. Afterwards, item reference and serial number is used for specifying object inside office. Item reference and serial number are used for tag identification, and those fields are organized in compliance with the needs of the system users or business process.

IV. Conclusion and Future Work

This article provides a new approach in application of passive RFID technology over existing SIP technology benefits. Presence functionality as a Presence Enabler and EPCglobal standard mutually interconnected allow clients with different technologies full access to specified tag location service. SIP and SIMPLE as its extension approach allows real time changes of the tag presence status described by Presence Server. It allows clients monitoring the system to discover if RIFD tag is in the office, moving through it or to discover if tag was in the office.

Assuming that antenna positions are known, it is easy to detect where tag we are looking for is. Tags used in experiment are Avery AD-222 tags with 96 bits of EPC memory allocation. Each tag memory container can be programmed separately, so files organizing can be done by:

- Author_Field
- Field_Year
- Application_Year
- Etc

Software should make easy finding files for person using it. Accordingly, one part of searching can be allocated to Internet searching mechanism, bound to tag information and any redundant data could be easily located. Once Internet finds document user is looking for (certainly, if it exists on the Internet), user can discover relevant data about that file. Described feature and proposed searching mechanism would be of great importance for the next phases of system development.

Security aspects will be discussed in future work, following standard SIP supported tools - TLS or IPSec, or authentication compatible method - HTTP Digest authentication.

RFID system is a cost effective way of building model described in this paper. Implementation of the proposed algorithm is simple and effective. Logically, next step in system development would be system scalability, so it is supposed to define room size dynamically using laser distance meter attached to a number of antennas. Monitored room can be supervised by a camera which can be accessed over proposed SIP protocol, exploiting current SIP session. In order to visualize room panorama photo of monitored room can be made and added to system visualization, for the person who is not familiar with the shelves content.

APPENDIX

A. Appendix: SUBSCRIBE and NOTIFY messages run on the simulator

```
SUBSCRIBE sip:bob@fesb.hr SIP/2.0
Max-Forwards: 70
Event: presence
Supported: presence
CSeq: 11325 SUBSCRIBE
Expires: 3600
Content-Length: 0
Contact: <sip:alice@127.0.0.1:6050>;ICP30PGMSID
User-Agent: ICP30PGMAID
To: <sip:bob@fesb.hr >
From: <sip:alice@fesb.hr >;tag=11a532c-2c3c.4014
Route: <sip:orig@127.0.0.1:5081;lr>
Call-ID: 44dd-2ea1-8881878@127.0.0.1
Via: SIP/2.0/UDP
127.0.0.1:6050;branch=z9hG4bK43.3b3.4014
NOTIFY sip:alice@127.0.0.1:6050 SIP/2.0
Max-Forwards: 70
Event: presence
subscription-state: active;expires=3600
CSeq: 1 NOTIFY
Expires: 3600
Content-Length: 347
Contact: <sip:127.0.0.1:6000>
Route: <sip:127.0.0.1:5082;lr;from-tag=11a532c-
2c3c.4014>
From: <sip:bob@fesb.hr >;tag=1
To: <sip:alice@fesb.hr >;tag=11a532c-2c3c.4014
Call-ID: 44dd-2ea1-8881878@127.0.0.1
Via: SIP/2.0/UDP
127.0.0.1:6000;branch=z9hG4bK3b092e62-beaf-4348-
8241-51f688797256
Content-Type: application/pidf+xml

<presence xmlns="urn:ietf:params:xml:ns:pidf"
entity="sip:bob@fesb.hr>
        <tuple id="t1308495763">
                <status>
                        <basic>open</basic>
                </status>
                <contact
        priority="High">sip:bob@fesb.hr</contact>
<timestamp>2006-05-19T14:52:44.498Z</timestamp>
        </tuple>
</presence>

            <?XML VERSION="1.0" ENCODING="UTF-8"?>
```

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