Intelligent network Services Based ECG Signal Monitoring

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Abstract

The technology and the nature of the Telecom environment are changing rapidly. Network Operators and service Subscribers have to differentiate themselves from the competitors to keep their market shares and to attack new market segments. One way of differentiating and of increasing revenues is to host IN (Intelligent Network) services that target market segments that usually were not in the operators' focus. In the current paper, such a service is presented, service that is related to the medical tele-monitoring. The paper is presenting a part of the technical aspects and market perspectives specific to such a service.

Keywords: Intelligent Networks, services, tele-monitoring, charging, Java, Distributed Object Technologies.

1. Introduction

New Intelligent Networks (IN) services should be tailored to fulfill new market demands, thus extending the existing IN functionality towards support of SIP-based networks that provide the following functionality (seamlessly to both SS7 and IP Multimedia System domains): Freephone Service, Universal Access Number Service, Premium Rate Service, Televoting Service [1].

2.

Intelligent Networks support service solutions in SS7 fixed and mobile networks as well as in these newly launched SIP networks, with a broad range of value-added service features such as user interaction, flexible routing, flexible screening, flexible pre-rating and others. IN platforms and the installed IN services can serve multiple network types simultaneously. A typical example can be the VPN of a company that can consist of mobile phones, fixed telephones as well as VoIP (SIP-based) devices. Thus, seamless services for subscribers with mobile, fixed or SIP-based terminals can be provided. This feature is very interesting for Communication Service Providers (CSP) deciding to expand their business using the opportunities of the IMS domain to offer their customers new access-agnostic services. Usually, IN strengthens the customer loyalty by offering customized services targeted at the individual. By offering comprehensive world-class feature sets for all user groups, IN ensures maximized usage stimulation, subscriber attraction and efficient roll-out, resulting in increased network traffic and average revenue per user. Customer-specific modifications of the service will be considered with a time-to-market approach. Increase in the efficiency of the company's internal and external communications or higher call completion attract high-ARPU (Average Revenue per User) customers. Therefore, CSPs are enabled to expand their customer base and to increase their revenues. IN provides carrier-grade availability as well as highest scalability, capacity and performance.

Next Generation Intelligent Networks (ngIN) represent a well-defined evolution path from current IN platforms. Integrated interfaces enable provisioning of value-added services in SS7 and SIP networks. One system can be used for both domains without compromising customer care, Backup & Restore and OA&M systems [2]. There are several physiological signals such as EEG, ECG, EMG, EOG etc., In [13] the EEG data was predicted for accident prevention in vehicles.

Service Management is of significant importance for the CSPs and covers all management tasks related to intelligent services and to the corresponding service data. Efficient data entry, easy to use services and role specific interfaces enable easy and fast service administration, e.g. implementing customer specific service management applications, import and export of mass data, etc.

User interaction and subscriber self-administration via comfortable Web interfaces, Unstructured Supplementary Service Data (USSD) or Dual-tone multi-frequency (DTMF) interfaces also reduce service management costs. Fig.1.1 gives an overview about the general layers used by IN platforms for the realization of IN services.
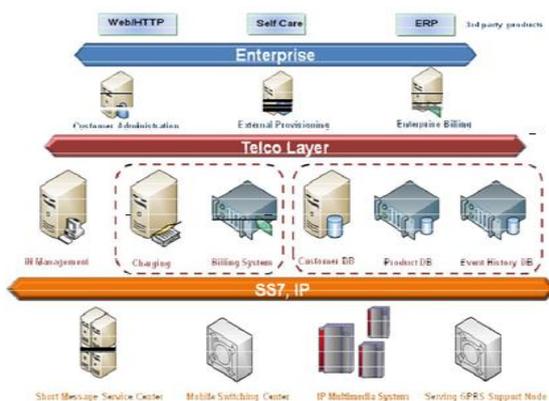
Fig.1.1: Overview of Intelligent Networks layers.

Understanding such tremendous opportunities offered by such service characteristics is the key of a successful business case. In this paper, such a service and solution will be presented, service that is acting in the tele-monitoring domain with direct appliances in medicine. Tele-observations of cardiac patients were and are a hot topic [9], different solutions being applied during the time [10]. The current solution description is a constellation of functionalities that cover users, physicians and operators or market areas. From the user's point of view, one has to use a portable ECG device which is a non-invasive, handheld heart monitor used to record ECG tracing anywhere and anytime. The parameters are measured and transmitted in different ways depending on the device technology [9] for example when the user places both thumbs on the electrodes, a wireless connection with the server is launched, for analysis and management of data. From the physicians' point of view, they receive transmitted data in a common place, for example a database from where they can extract necessary data for patient health evaluation. They can be also alerted by SMS or even by MMS containing information from the users that are under certain observation and targeted for close monitoring. From the operator's point of view, the solution that an IN service can offer, covers all communication areas, from patient to doctor, having the possibility to administrate even the submitted information. In this way, operators can present to their customers - which can be health institutions like hospitals - an integrated solution for tele-monitoring.

2. Technical Information

In this paper section, the technical solution will be presented from all 3 perspectives: the user's, the doctor's and the mobile operator's, being in fact one integrated way out. In Fig. 2.1, a general overview of the solution is presented, emphasizing the main interfaces used.
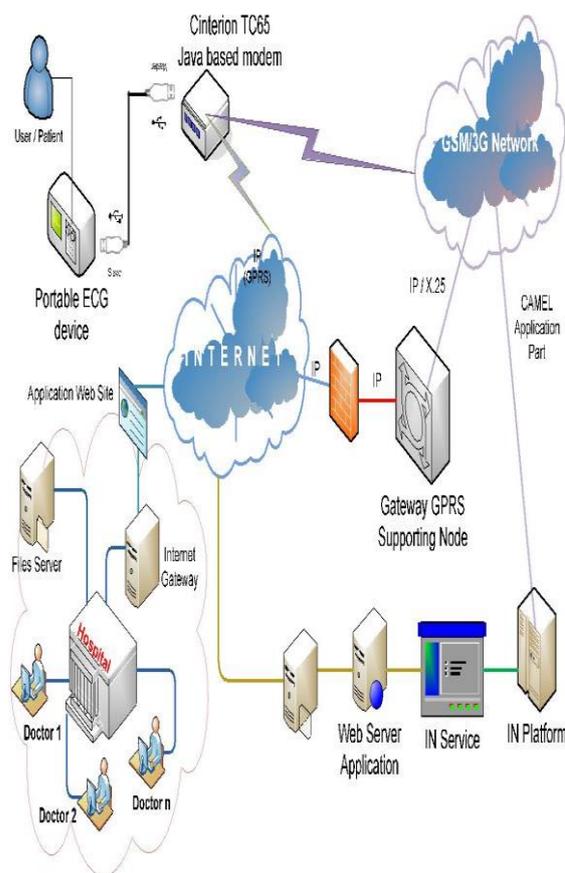

Fig 2.1: General Architecture of Solution

2.1. Monitoring Solution

There are several ECG devices on the market which are cost effecttive in terms of affordability (from regular customer point of view) and offer standard communication interfaces like Universal Serial Bus (USB) or Bluetooth. For the solution presented in this paper,such a portable ECG device which offered an USB port for connection is used. Using this connection, data stored in the device (e.g.ECG waveforms) can be downloaded, usually on local PCs. Taking this into consideration, a Cinterion GSM/GPRS modem is used to access stored diagrams via USB port. Such a modem is chosen because, besides the GPRS [8], USB and TCP/IP connectivity, it has a build in Java Virtual Machine, having the possibility to develop and deploy fast solutions using Java Micro Edition.

The general steps to transmit the ECG diagrams remotely are:

1. Initialize the serial transfer between monitoring device and the modem

2. Retrieve ECG diagrams from monitoring device, in binary files format, to the modem memory
3. Initialize modem GPRS transfer
4. Send data to the IN service

The serial transfer of the 1st step is a well know serial initialization, the USB connection being reduced to a standard serial communication. Retrieving of data is done using the following Java code:

```
byte[] buffer = new byte[1024];
int lenbuffer = 0;
while ((data = in.read()) > -1) // Read the response...
buffer[lenbuffer++] = (byte) data;
```

There are different possibilities to perform GPRS initialization, using different AT commands [3] sequences from Java code. In

the next capture, one option is presented using the SJNET command, which allows creating a profile containing all the parameters needed for automated network access through a dialup connection.

```
ATCommand atc = new ATCommand(false);

String textAT =
atc.send("AT+CREG?\r");//check if already is
a registration

String response="";
if (textAT.indexOf("1,1")< 0) // if not a new profile is done
{
atc.send("AT+CREG=1");
doPause(1);
atc.send("AT^SJNET=\"gprs\",\"internet.vodafone.ro\",
\"internet.vodafone.ro\",\"vodafone\",\"193.230.161.3\",0\r");
doPause(1);

response=atc.send("ATD*99***1#\r");// establish communication
if (response.indexOf("CONNECT") >= 0) {… }}
```

The last major step after retrieving ECGs data and establishing the GPRS connection is the sending of data to the IN service located on the mobile operator side. In this case, the HTTP POST procedure was adopted for sending the ECG data to the service, together with the additional user information, like International Mobile Subscriber Identity (IMSI) used for the GPRS connection. The next capture is extracted from the sending method deployed on the modem:

```
HttpConnection hcon = null;
DataOutputStream datastr = null;
// open http connection with web server
hcon = (HttpConnection)Connector.open("http://x.x.x.x:8080/
EcgServerCollector/Collector", Connector.READ_WRITE);
// setting the request method
hcon.setRequestMethod(HttpConnection.POST);

 // obtain output stream for sending query
datastr = hcon.openDataOutputStream();

byte[] ECGDataByte = ECGDataString.getBytes(); for (int i =
0; i < ECGDataByte.length; i++) {
// sending query with retrieved ECG data for web server
 datastr.writeByte(ECGDataByte [i]);
}
```

2.2. I,Service Interface and Functionalities from Doctors' perspective

Besides collecting ECGs information from users, the IN service is also dealing with the filtering of received and stored information in order to offer different possibilities to interact with the physicians needs. In this section is presented how such interface is implemented.

The interface is developed as a client-side Java technology-based program using Java Network Launch Protocol (JNLP) and Java Web Start mechanism for program delivery through Web server [5].

Doctors can access a webpage from where they can follow a simple link and the application is downloaded / updated right away.

After the username and password are introduced by the doctor and checked by the application, based on these credentials, the application interface is customized according to the rights based on the roles that the user has in the application. In fig. 3 is presented the interface for a "power user", for example a chief doctor from a hospital. Besides his lists of patients and their ECGs, he can administrate the doctors from his team, offering different types of credentials.
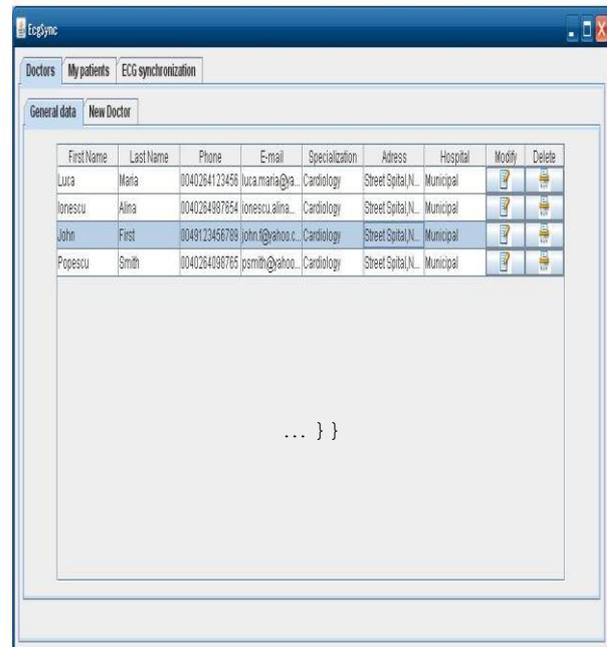

Fig 3.1: Doctors Team administration

Entering new patients in the application and the ECGs administration is done using the same type of interface, as shown in the next figure.
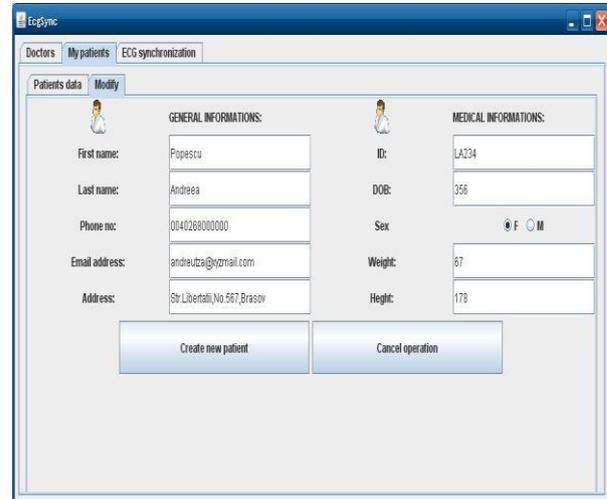

Fig 3.2: Patients administration

2.3. I, Service from mobile operators' perspective

The IN service is developed in Java Enterprise Edition and from the functionality point of view, the service is split in 2 major parts [6]. One part is related to ECGs, patients and doctors management and the second part is related to specific IN functionalities such as charging and alarming. In this section an overview of both parts is presented. In the management part of the service, the mechanisms for receiving ECGs, the specific database handlers and the Graphic User Interface generator are the major features.The receiving mechanisms are handling the ECG data from the modem and convert them to files with the specific format in order to be viewed using dedicated software for ECG displaying. Receiving and conversion of data are not tied together in order to reuse the receiving part for other applications.

The database has a specific structure and in the next capture there is an example of table used in the case of ECG data.

```
CREATE TABLE `ecg`.`ecg_burst`
(
`ecg_burst_id`        Integer unsigned    Not null
                                          auto_increment
`ecg_burst`           Blob                Not null,
`ecg_count`           Integer unsigned    Not null,
`ecg_device_id`       Varchar(20)         Not null,
`ecg_receive_time`    Timestamp           Not null default
 CURRENT_TIMESTAMP, PRIMARY KEY (`ecg_burst_id`)
)
```

Receiving of the information submitted by the modem is handled on the service side using *doPost* method from an extended Http Servlet class, where received data is parsed and introduced in the database tables. To avoid unnecessary traffic, the client PC user (doctors) will have a profile saved on the database that will contain the current list of ECG data and patient data. Because of this profile, only yet unavailable data (for client) will be transferred and thus updated. After the data transfer, the profile will be also updated. Patient specific data is synchronized with the one available on the server, as well. In this way more doctors can access the same data for the same patients.

The GUI was presented in the previous sections and it will not be detailed any more here. From various dedicated functionalities of the IN service, just a part of the charging service strategy will be presented. The charging strategy for such a service, as it was described until now, is very complex but yet flexible because a service like the one presented, offers a number of possibilities to charge the customers in different ways. From the mobile operators' perspective, both the doctors and the patients must be charged, because they are using the service and the network infrastructure; on the other hand the doctors have to charge the patients because of the time spent to analyze their ECGs. In the following part, the technical approach is presented for one charging scenario. When the doctor has a new patient who has to use a remote ECG for sending a diagram to be analyzed, the doctor has to enter the patient's coordinates in the application / service as presented in the previous sections. When he submits the form in the application backend, new items are entered in the management part of the service, but also new information is submitted to the charging part. In this way, when the patient will submit any ECG diagram he will be charged automatically for that with the amount of money established previously. In order to build network operator-specific charging applications, a synchronous dialog-oriented interface is provided by the IN platforms in the form of the Service Management Agent / Access Function (SMAF) Common Object Request Broker Architecture (CORBA) interface [7]. Based on this, there are few steps that have to be followed in order to create users in the service with the purpose to be charged later on. In the next capture, there is an example of how this can be done based on the input information from the doctor, regarding the patients.

```
// Initial credit
smafSDBeforeExecu-
tion.TheSubscriberData[0].OnPeakAccountI
D.Balanc e = 10;
//Creation of Subscriber
ICorbaSubscribertheCorbaSubscriber =
ICorbaSubscriberHelper.narrow(
myOrb.string_to_object(ICorbaSubscriber_IOR));

subscriberData=
the orbaSubscriber.newCustomer(); //A new Subscriber type
client is created.
//There are mandatory values that have to be fill in.
//Cgpa = CallingParty
```

MSISDN_String represents the modem phone number of the patient based on which the charging is done
```
subscriberData. TheSubscriberData[0] .Cgpa =
MSISDN_String;
subscriberData.TheSubscriberData[0] .Cgpa OperationMode
= is Defined.value;
```

//Each subscriber has to be part to a provider which in our case it is already created.

```
subscriberData.TheSubscriberData[0] .ProviderID = "1";
subscriberData
erData .ProviderIDOperationMode = ISDE-
FINED.VALUE;
```

Based on this and additional settings that has to be done regarding the charging rates, the patients will start to be charged when they send ECG diagrams. Depending on the charging strategy, the verification of the patients' "accounts" can be done before sending any ECG data or after submitting data, but only before the doctor's analysis of the diagram. Part of the verification procedure of the service account balance is presented in the next capture.

```
ICorbaSubscriber ics = Utili-
tyClass.getICorbaSubscriber();
Hashtable unusedSubscribers = Sub-
scrib-
ersPool.getInstance().getUnusedSubsc
ribers();
Object[] subscriberNumbers =
unusedSubscribers.keySet().toArray();
Arrays.sort(subscriberNumbers);
// Initiate Subscriber

smafSubscriber = "1-" + smafProviderID +
"-" + smafCC + smafNDC + subscriber-
Numbers[i];
// Get Subscriber by ID from the IN system
SubscriberDataData[] newSubscriberData = ics.
findSubscriberDataByCustomerId(_smafSubscriber);
//Calculate delta balance between
the initial time and the current one
long delta = smafSDBeforeExecu-
tion.TheSubscriberData[0]. OnPeakAc-
countID.Balance - newSubscrib-
erData[0].OnPeakAccountID. Balance-
((Long)unusedSubscribers.
get(subscriberNumbers[i])).longValue();
System.out.println("Balance for subscriber "
+ _smafSubscriber + ": " + newSubscrib-
erData[0].OnPeakAccountID.Balance +

''.Expected charge: " + unused-
Subscribers.get (subscriber-
Numbers[i]) +". Delta from ex-
pected "+delta");
```

Using the balance calculated as above, different types of decisions can be taken in the service logic, all these having the possibility to be customized by the mobile operator.
".
As written in the first part of the paper, these services can have the possibility to offer also alarms based on already standard messaging SMS or MMS. What can be further developed are the triggering feature and the policy for such an approach.

3. Conclusion

There were only few aspects covered, from technical- but also market- point of view, due to the complexity of the discussed topic and because of the service development difficulties. But, due to the global economical environment and the market demands, such a service can bring new ideas in terms of revenues strategy from the mobile operators' point of view. As the solution is still under test, there are no final results but some measurements were done regarding the transfer speed of the ECG data. Thus, since GPRS is used for uploading, for five user ECG files at an average of 25-30 kbit/second upload rate the time required for a 100 kb total size is about 30 seconds. This test is very dependent on the information contained in the ECG files but it is relevant to determine how long a connection is active from service perspective in order to determine the accepted number of connections in a time frame. Since performance was not treated in this paper due to current status of the service development, further efforts will concentrate on the development of demo services in order to cover this issue and to bring this solution to a mature and consolidated stage.

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