GENERALIZED NET MODEL FOR TELECOMMUNICATION PROCESSES IN TELECARE SERVICES

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Abstract: In (Andonov et al., 2012) a Generalized Net (see (Atanassov, 2003, 2007)) model of processes, related to tracking the changes in health status of adult patients has been presented. The contemporary state-of-the-art of the telecommunications and navigation technologies allow this model to be extended to the case of active and mobile patient. This enforces the inclusion of patient's current location as a new and significant variable of the model. Various opportunities are considered for the retrieval of this information, with a focus on the optimal ones, and a refined Generalized Net model is proposedt.

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1 INTRODUCTION

Let us take a look into life sensors attached to a person's body and one other type of sensors.The sensors can be divided into two main groups. The first group is the group of the stationary sensors. They are placed in the rooms to monitor for CO, CO_2 concentration, temperature and other parameters which can endanger one's life. These types of sensors are patient independent and can work autonomously. They are connected to the server with internet connection (WiFi or LAN).Their alarm events in most of the cases are True positive, can be recognized and a decision can be easily taken.

The second type of sensors are looking for biomedical parameters e.g. ECG signal, SPO2. They collect the biomedical signals, analyze them and consequently take the most expected decision. Alarm message is sent sent to the server and, if necessary, part of untypical biomedical signal or parameter value. The server can send requests to the sensor to confirm the alarm event or resend biomedical signal or parameter. In these sensors we can have the False positive event. For this reason the server has to have very smart filter for False positive removing or translate the alarm event to human operator if the case is complicated.

The second type of sensors can work with a cheap smart module for connecting to the GSM network. Because this network allows more flexibility and the patient is free to go wherever he wants. These sensors can make communication to smart phone by Bluetooth or direct cable communication. Nowadays, the existing GSM network has enough speed and possibility for data translation via e.g. network type 3G and 4G too. Also these GSM modules can have the GPS module.

This GPS module is necessary in case that the medical center has to localize the person in urgent cases such as earthquake, fires, etc. The smart module can send the GPS coordinates to the rescue center for easy localization of the person or persons.

In order to carry out the connection between GSM networks, the sensor should have a GSM module or a smart module. Another requirement to prevent connection break is that the GSM module

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has to be connected to at least two networks available or a WiFi network connection should be accessible.

2 LOCATION TECHNOLOGIES

There are three most commonly used location technologies: stand-alone (typical stand-alone technology is dead reckoning), satellite-based and terrestrial radio-based.

2.1 Satellite-based Systems

Global Navigation Satellite System (GNSS) are systems of satellites that provide autonomous geo-spatial positioning with global coverage. Only the United States NAVSTAR Global Positioning System (GPS) (Hofmann-Wellenhof) and the Russian GLONASS are fully globally operational GNSSs.

Satellite navigation systems that provide enhanced accuracy and integrity monitoring usable for civil navigation are classified as follows: the combination of existing satellite navigation systems (GPS and GLONASS), with Satellite Based Augmentation Systems (SBAS) or Ground Based Augmentation Systems (GBAS) (2010 FEDERAL RADIONAVIGATION PLAN). In the United States, the satellite based component is the Wide Area Augmentation System (WAAS), in Europe it is the European Geostationary Navigation Overlay Service (EGNOS) (Gauthier,2001; Filip, 2001), and in Japan it is the Multi-Functional Satellite Augmentation System (MSAS). Ground based augmentation is provided by systems like the Local Area Augmentation System (LAAS).

2.2 GPS Receivers

There are three types of GPS receivers which are available in today's marketplace. Each of the three types offers different levels of accuracy. To this point, the discussion in this paper has focused on Coarse Acquisition (C/A code) GPS receivers. The two remaining types of GPS receiver are Carrier Phase receivers and Dual Frequency receivers. C/A Code receivers typically provide 1-5 meter GPS position accuracy with differential corrections (Filip, №5/2001). C/A Code GPS receivers provide a sufficient degree of accuracy to make them useful in most GIS and emergency applications. A *GPS tracking unit* is a device that uses the Global Positioning System to determine the precise location of a vehicle, person, to which it is attached and to record the position of the asset at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular, radio, or satellite modem embedded in the unit. This allows the asset's location to be displayed against a map backdrop either in real time or when analyzing the track later, using GPS tracking software http://www.liveviewgps.com/. GPS personal tracking devices assist in the care of the elderly and vulnerable. Devices allow users to call for assistance and optionally allow designated carers to locate the user's position, typically within 5 to 10 meters. Their use helps promote independent living and social inclusion for the elderly. Devices often incorporate either 1-way or 2-way voice communication which is activated by pressing a button. Some devices also allow the user to call several phone numbers using pre-programmed speed dial buttons. GPS personal tracking devices are used in several countries to help in monitoring people with early stage of dementia and Alzheimer http://www.eurogps.eu/bg/world-news/tracking/99-gps-tracking-alzheimer.

2.3 Positioning in 3G Networks

- Mobile-based technologies: Cell-ID, time advance;
- Network-based technologies: TDOA (time difference of arrival), AOA (angle of arrival);
- Mobile-assisted technologies: A-GPS (assisted GPS), AFLT (advanced forward link trilateration), E-OTD (enhanced observed time difference), U-TDOA;

These technologies typically use base stations, satellites or devices emitting radio signals to the mobile receiver to determine the position of its user. Signals can also be emitted from the mobile device to the base. Commonly studied techniques are angle of arrival (AOA) positioning, time of arrival (TOA) positioning, and time difference of arrival (TDOA) positioning. All these methods require radio transmitters, receivers, or transceivers. To determine the location, these methods generally have the assumption that one end of the positioning system is fixed and the other end is moveable such as a mobile phone. However, the location determination capability can be either at the fixed end or at the mobile end. For performance improvement, hybridmethods (various combinations of the techniques) are possible (Overview of 2G LCS

Technnologies and Standards, London, UK, January 2001).

Other methods based based on measuring the signal strength or measuring the signal characteristic patterns and multipath characteristics of radio signals arriving at a cell site from a caller. For measuring the signal strength, it employs multiple cell sites to find the location. For measuring the signal characteristic patterns, it identifies the unique radio frequency pattern or "signature" of the call and matches it to a similar pattern stored in its central database (Shu Wang, Jungwon Min, Byung K. Yi, 2008; Y. Zhao, 2000).

TOA and TDOA are time-based measurement technologies. They can be implemented either based on the forward (down) link signal or reserved (up) link signal. In addition, the location determination capability can reside either at the network side or at the mobile phone. In order to locate several base stations or cell sites, the sensitivity of the mobile phone may need to be increased. These methods also require software modification on the mobile phone and additional location determination units and related software in the network. As discussed above, the mobile phone needs to listen to the signals of at least three base stations or cell sites. The visibility and geographical locations of these base stations will affect the availability and the accuracy of the location determination (Overview of 2G LCS Technnologies and Standards, London, UK, January 2001).

The performance of the satellite-based GPS receiver is getting better and better while the receiver size and price keep going down. To develop an assisted GPS (A-GPS) solution for the mobile phone requires software and hardware modifications of both the mobile phone and its communications network.

The A-GPS use a GPS reference network (or a wide-area DGPS network) whose receivers have clear views of the sky and can operate continuously. This reference network is also connected with the cellular infrastructure, and continuously monitors the real-time constellation status and provides precise data such as satellite visibility, ephemeris and clock correction, Doppler, and even the pseudorandom noise code phase for each satellite at a particular epoch time. At the request of the mobile phone or location-based application, the assist data derived from the GPS reference network are transmitted to the mobile phone GPS receiver (or sensor) to aid fast start-up and to increase the sensor sensitivity. Acquisition time is reduced because the Doppler versus code phase uncertainty space is much smaller than in conventional GPS due to the fact that the search space has been predicted by the reference receiver and network. This allows for rapid search speed and for a much narrower signal search bandwidth which enhances sensitivity. Once the embedded GPS receiver acquires the available satellite signals, the pseudorange measurements can be delivered to network-based position determination entity (PDE) for position calculation or used internally to compute position in the handset.

Additional assisted data, such as DGPS corrections, approximate handset location or cell base station (BS) location, and other information such as the satellite almanac, ionospheric delay, universal time coordinated (UTC) offset can be transmitted to improve the location accuracy, decrease acquisition time, and allow for handset-based position computation. Several schemes have been proposed in the standards which reduce the number of bits necessary to be exchanged between the handset and the network by using compression techniques such as transmitting only the non-redundant or the changes to parameters instead of the raw parameters themselves. Other satellite systems could be used, such as the Russian GLONASS system, but none of the standards have made provision for anything except GPS and the GPS Wide Area Augmentation System (WAAS) signals. Besides adding a GPS reference network and additional location determination units in the network, the mobile phone must embed, at a minimum, a GPS antenna and RF down converter circuits, as well as make provision for some form of digital signal processing software or dedicated hardware (Overview of 2G LCS Technnologies and Standards, London, UK, January 2001). All the radio-based technologies discussed can be affected by interference, blockage, and multipath.

3. GENERALIZED NET MODEL

In our model, we consider n patients. The i-th patient has i_k different sensors. The sensors for the i-th patient are represented by the tokens $\delta_{i,1}, \delta_{i,2}, \ldots ,\delta_{i,ik}$. The tokens $\delta_{i,1}, \delta_{i,2}, \ldots ,\delta_{i,ik}$ enter the net in place l_2 with initial characteristics:

"name of the patient; sensor's parameters"

The criterion for the correctness of the signal detected by the sensors is represented by the token α which stays permanently in place l_7 with initial characteristic:

"criterion for the corectness of the signal"

The tokens $d_{i,1}, d_{i,2}, \ldots ,d_{i,ik}$ stay permanently in

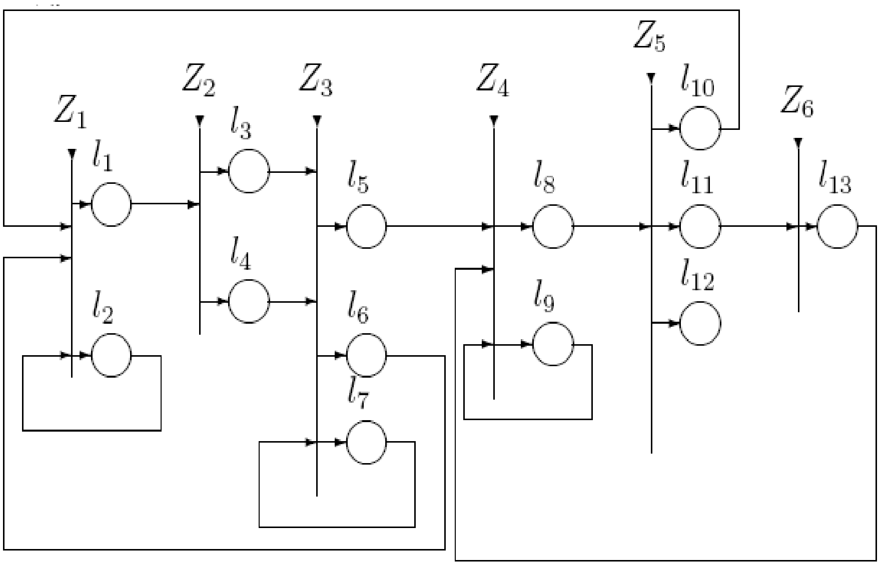

Figure 1: Generalized Net

place l_9 with initial characteristic:

"name of the patient; previously recorded sensor data and respective action taken"

We use the tokens $d_{i,j}$ to keep record of the sensor's data which can be used in future to decide whether the patient should be sent to a medical doctor.

Below is a formal description of the transitions of the net.

Z_1 =<{l_1, l_6, l_{10}},{l_1,l_2},

	l_1	l_2
l_2	$W_{2,1}$	$W_{2,2}$
l_6	false	true
l_{10}	false	true

> ,

where

$W_{2,1}$ = "the sensor detected the patient's body signals",

$W_{2,2} = \neg W_{2,1}$,

where ¬ P is the negation of the predicate P.

When the truth-value of the predicate $W_{2,1}$ =true the token $\delta_{i,j}$ enters place l_1 with characteristic:

"signal of the sensor about the current patient"

When the truth-value of the predicate $W_{2,2}$ =true the token $\delta_{i,j}$ enters place l_2 without a new characteristic.

Z_2 = <{l_1},{l_3,l_4},

	l_3	l_4
l_1	$W_{1,3}$	$W_{1,4}$

>,

where

$W_{1,3}$ = "the signal comes from a stationary sensor",

$W_{1,4} = \neg W_{1,3}$.

When the truth-value of the predicate $W_{1,3}$ =true the token $\delta_{i,j}$ enters place l_3 and does not obtain any new characteristic. When the truth-value of the predicate $W_{1,4}$ =true the token $\delta_{i,j}$ enters place l_4.

Z_3 = <{l_3, l_4, l_7},{l_5,l_6, l_7},

	l_5	l_6	l_7
l_3	true	false	false
l_4	$W_{4,5}$	$W_{4,6}$	false
l_7	false	false	true

>,

where

$W_{4,5}$ = "the criterion shows that the signal of the sensor is correct and it must be further evaluated whether a medical doctor's reaction is necessary",

$W_{4,6}$ = "the criterion shows that the current signal must be confirmed".

When the current $\delta_{i,j}$ token enters places l_5 or l_6 it does not obtain any new characteristics.

$Z_4 = <\{l_5, l_9, l_{13}\}, \{l_8, l_9\},$		l_8	l_9	
	l_5	true	false	>,
	l_9	false	true	
	l_{13}	false	true	

When the current $\delta_{i,j}$ token enters place l_8 it obtains the characteristics of the respective $d_{i,j}$ token. In place l_9 the token $d_{i,j}$ obtains as characteristic the signal parameters of the respective $\delta_{i,j}$ token and the decision that has been made. In place l_{13} the current $\delta_{i,j}$ token splits into two tokens, the original $\delta_{i,j}$ token which continues to stay in place l_{13} and a new token $d'_{i,j}$ with the same characteristics which enters place l_9. and it unites there with the respective $d_{i,j}$ token.

$Z_5 = <\{l_8\}, \{l_{10}, l_{11}, l_{12}\},$		l_{10}	l_{11}	l_{12}	
	l_3	$W_{8,10}$	$W_{8,11}$	$W_{8,12}$	>,

where

$W_{8,10}$="the history shows that the signal should be confirmed",

$W_{8,11}$= "there is no similar sensor data in the history or the history suggests that the patient should be sent to a medical doctor"

$W_{8,12}$= "the history suggests that no action should be taken",

$Z_6 = <\{l_{11}\}, \{l_{13}\},$		l_{13}	
	l_{11}	true	>,

When the current $\delta_{i,j}$ token enters place l_{13} it obtains the characteristic:

"send the patient to a medical doctor"

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