Generalized Net Model for Telehealth Services

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***Abstract*—During last 30 years, the generalized nets are used as a tool for modelling of different processes in medicine. In the present paper, an application of the apparatus of generalized nets to assistive technology, namely to telehealth services and the advantages of using such model, is discussed.**

***Keywords*—Generalized net; Modelling; Telehealth**

I. Introduction

Ambient Assisted Living, telecare and telehealth are assistive technology concepts, technological developments and an innovative organization of work, which aim is to secure the possibility for old and/or chronically ill people or people with disabilities as long as possible, an independent life at home. In addition there was in recent years a number of national and international policy initiatives and projects to develop the necessary technologies in pilot projects to test or to support the implementation. In Germany it is the BMBF/VDE Initiative Ambient Assisted Living, which significantly contributed to the connection of all relevant social groups. In Great Britain, the Department of Health has developed the Whole demonstrator program to promote large-scale telecare and to carry out the world largest randomized study. In Australia were created an Independent Living Centers as the LifeTech center in Brisbane, in addition to the large areas of assistive technologies, specifically telecare and telehealth. Relevant services were developed and tested [6].

The most effective assistive technology mentioned in research in Australia and United Kingdom is when older people are provided with early intervention, careful assessment, the correct prescription and home-based follow-up training in how to use assistive technologies. The most effective assistive technologies, identified in research [4], [5] are aids, devices and equipment to improve quality of life, environmental adaptations to the home and telecare/telehealth and smart technologies. Although only brief information is given of assistive technology policies and developments in other countries, there is work under way to expand the provision of assistive technologies to older people in a number of countries, including the United States, Japan, China, Spain and many Scandinavian countries.

Main goal of the EU Project MATSIQEL Models for Aging and Technological Solutions for Improving and Enhancing the Quality of Life (2011-2013, IRSES People Marie Curie Action) is the research on new technologies, used for concepts as Ambient Assisting Living,Telecare or Telehealth and their contribution for improving the quality of life of older people worldwide. The research field is interdisciplinary. The partners in the project are from different countries and different research areas - Northumbria University in UK (the project coordinator), University of Applied Sciences in Frankfurt, the Griffith University in Brisbane Australia, die Universidad National Autonoma de Mexico, University Kapstadt in South Africa.

The Bulgarian partner is the Institute of Biophysics and Biomedical Engineering at the Bulgarian Academy of Sciences. New knowledge for development of new devices should be developed on the base of Generalized Net approach. Here we shall show the application of the apparatus of Generalized Nets (GNs, see [1], [2], [3]) to assistive technology, namely to telehealth services and the advantages of using such model.

II. Connection of the life-sensors to a mobile network

Let us take a look into life sensors (shortly - sensors).

The first type are the sensors which are attached to the patient's body. These sensors are looking for biomedical parameters e.g. ECG signal, SPO2 (Saturation of Peripheral Oxygen). Other sensors which are stationary are placed in the rooms to monitor for CO(carbon monoxide) concentration. The third type of life sensors are the sensors which are similar

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to the first type but work in stand by mode and are activated by patient - when event has occurred e.g. extra beats, the patient pushes event button and the sensors collect the signal. The first and second life sensor types are patient-independent and can work autonomously.

In this paragraph we shall emphasize the GSM communication because this network allows more flexibility and the patient is free to go wherever he wants. These sensors can make communication to specialized medical center via GSM network. Nowadays, the existing GSM network has enough speed and possibility for data translation via e.g. network type 3G and 4G too. The current technology is rapidly advancing and, thus, this will allow in the near future seamless integration of geographically distant devices. Another advantage lies in issuing simple and easy to use special AT commands (attention commands) to manipulate the network and make it easy for using.

Any type of sensor can send short SMS or Data e.g. part of ECG signal to specialized medical center where the automatic system can determine the message priority in accordance to the urgent level. If the message's priority cannot be determined by the automated system this message will be relayed to human operator. The SMS or Data can have patient ID (identification) and code message and some additional information.

For carrying out the connection between GSM networks in life a sensor must have GSM module. Another requirement to prevent connection break, the GSM module has to connect to at least two networks available.

The autonomous sensors can establish communication with the network by using the simple AT commands and this is enough for their work. The non-autonomous sensors work in stand by mode and monitor patient's reactions. If a reaction has occurred, the sensor makes communication with the network and sends data to the message center. For example, this type of data can be ECG signal for further analysis.

The messages and data analysis in the specialized center by special software or human operator is described in the next paragraph.

III. Generalized Net Model

Initially, tokens $\pi_1, \pi_2, ..., \pi_n$ stay in place l_3 with initial characteristics:

"patient; current health status; list of the medial specialists who monitor the patient; coordinates of present staying".

These tokens represent the separate (n in number) patients, who have sensors of some types. Each of these patients has a sensor, that has one or more functions. Let these sensors are represented by the tokens $\sigma_1, \sigma_2, ..., \sigma_n$ that stay in place l_5 with initial characteristics:

"respective patient; sensors parameters".

The criterion for estimation of the correctness of the signals detected by the sensors is represented by the token α staying permanently in place l_6 with initial characteristic

"criterion for the correctness of the signal".

The criterion for estimation of the degree of emergence of the medical doctor's reaction for the current patient status is represented by the token β staying permanently in place l_6 with initial characteristic

"criterion for the correctness of the signal".

Tokens $\delta_1, \delta_2, ..., \delta_m$ stay in place l_{13} with initial characteristic for the j-th token ($1 \leq j \leq m$):

"name of the j-th medical doctor; specialty".

The forms of the transitions are the following (see Fig. 1).

$$Z_1 = \langle \{l_3, l_{15}\}, \{l_1, l_2, l_3\}, \begin{array}{c|ccc} & l_1 & l_2 & l_3 \\ \hline l_3 & W_{3,1} & W_{3,2} & true \\ l_{15} & false & false & true \end{array} \rangle,$$

where
$W_{3,1}$ = "there is a change of the current patient status",
$W_{3,2}$ = "the current patient must be investigated by a medical doctor".

When truth-value of predicate $W_{3,1} = true$, the token π_i, representing the i-th patient (here and below $1 \leq i \leq n$) splits into two tokens - the original token π_i that continues to stay in place l_3 with the above mentioned characteristic, and token π_i' that enters place l_1 without a characteristic.

When truth-value of predicate $W_{3,2} = true$,the token π_i splits to two tokens - the original token π_i that continues to stay in place l_3, and token π_i'' that enters place l_2 without a characteristic.

$$Z_2 = \langle \{l_1, l_5, l_7, l_9\}, \{l_4, l_5\}, \begin{array}{c|cc} & l_4 & l_5 \\ \hline l_1 & false & true \\ l_5 & W_{5,4} & W_{5,5} \\ l_7 & false & true \\ l_9 & false & true \end{array} \rangle,$$

where
$W_{5,4}$ = "the sensor detected the patient's body signals",
$W_{5,5} = \neg W_{5,4}$,
where $\neg P$ is the negation of predicate P.

When truth-value of predicate $W_{5,4} = true$, the token σ_i enters place l_4 with characteristic

"signal of the sensors about the current patient".

When the token σ enters place l_5, it does not obtain a new characteristic.

$$Z_3 = \langle \{l_4, l_6\}, \{l_6, l_7, l_8\}, \begin{array}{c|ccc} & l_6 & l_7 & l_8 \\ \hline l_4 & false & W_{4,7} & W_{4,8} \\ l_6 & true & false & false \end{array} \rangle,$$

where
$W_{4,7}$ = "the criterion shows that the signal of the sensor is incorrect",
$W_{4,8}$ = "the criterion shows that the signal of the sensor is correct and it must be evaluated whether the medical doctor reaction is necessary".

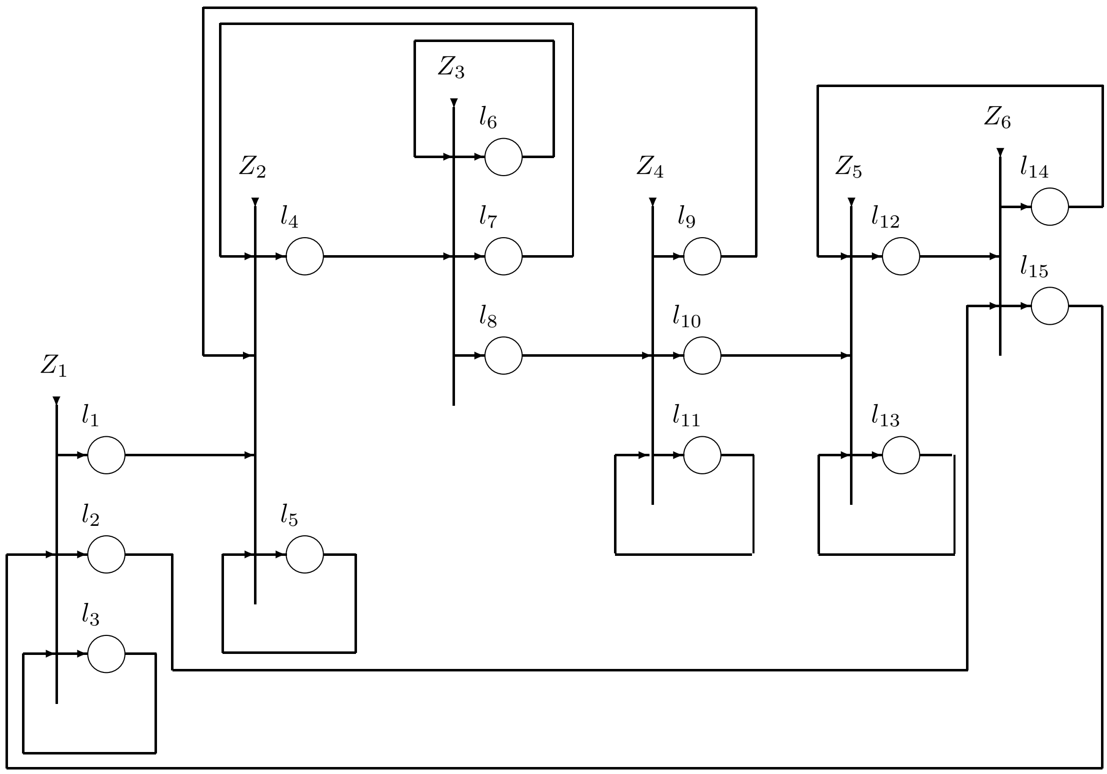

Fig. 1: GN-model

When the current token σ enters places l_7 or l_8 it does not obtain any new characteristic.

$$Z_4 = \langle \{l_8, l_{11}\}, \{l_9, l_{10}, l_{11}\}, \begin{array}{c|ccc} & l_9 & l_{10} & l_{11} \\ \hline l_8 & W_{8,9} & W_{8,10} & false \\ l_{11} & false & false & true \end{array} \rangle,$$

where
$W_{8,9}$ = "the criterion for emergency shows that the current signal must obtain a confirmation from next sensor signals",
$W_{8,10}$ = "the criterion for emergency shows that the signal of the sensor must be directed for a medical doctor reaction".

When the current σ token enters places l_9 or l_{10} it does not obtain any new characteristic.

$$Z_5 = \langle \{l_{10}, l_{13}, l_{14}\}, \{l_{12}, l_{13}\}, \begin{array}{c|cc} & l_{12} & l_{13} \\ \hline l_{10} & false & true \\ l_{13} & W_{13,12} & W_{13,13} \\ l_{14} & false & true \end{array} \rangle,$$

where
$W_{13,12}$ = "the current doctor must visit the patient",
$W_{13,13} = \neg W_{13,12}$.

When truth-value of predicate $W_{13,12} = true$, the token δ_j, representing the j-th medical doctor enters place l_{12} with characteristic

"the name of the patient, who the doctor must visit".

$$Z_6 = \langle \{l_2, l_{12}\}, \{l_{14}, l_{15}\}, \begin{array}{c|cc} & l_{14} & l_{15} \\ \hline l_2 & false & true \\ l_{12} & true & false \end{array} \rangle.$$

When token δ_j enters place l_{14}, it obtains the characteristic

"activities of the medical doctor related to the current patient".

When token π_i enters place l_{15}, it obtains the characteristic

"current patient status after medical doctor intervention".

IV. Conclusion

Telehealth is the remote or enhanced delivery of services to people in their own home by means of telecommunications and computerised systems. Telehealth ranges from basic community alarm services to more complex interventions involving fall detectors and sensors which monitor a range of physical behaviour.

The present GN-model describes the indirect (i.e., by life-sensors) communication between patients in helpless condition and medical doctors from a telehealth center. It can be used, e.g., for simulation of different situations, related to increasing the number of emergent cases to which the medical doctors must react. The GN-model could show the necessary combinations of sensors used for the different patients. On the basis of the simulations, we can determine the minimal number of the necessary doctors in the telehealth center.

In future, the way of communication between the patients (sensors) and the telehealth center also can be modelled.

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