16th Workshop on Generalized Nets and Data Mining
10 February 2018, Sofia, Bulgaria, 68–74, ISSN 1313-6860

On the Communication between the National Centres of Transfusion Hematology: A Generalized Net Approach

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Abstract: The generalized nets are a tool for modeling parallel processes. In the present paper a GN model of the process of communication between National Centers of Transfusion Hematology is discussed. As an example five countries from the Balkan peninsula are considered.
Keywords: Blood donors, Transfusion hematology, Generalized nets.
AMS Classification: 68Q85.

1 Introduction

Part of patients' treatments consists of the use of blood and blood components. In order to fulfill this activity in the highest of standards, it is required to gather and process information about the blood donors, their examinations, the obtained blood components and their application to the patients in the clinical facilities.

In accordance with Directive 2002/98/EC, setting standards of quality and safety for the collection, testing, processing, storage and distribution of human blood and blood components, and further directives 2004/33/EC on technical requirements, 2005/61/EC on traceability and reporting of serious adverse events and reactions and 2005/62/2005 dealing with quality systems [1] of

paramount importance is: (i) the possibility for access to current information regarding the donors at all times, which ensures the safety of the blood donation and of the donated blood; (ii) guaranteeing standardization and traceability of the procedures for the diagnosis, processing, storage and dispatch of blood and blood components; (iii) information for the availability of blood and blood components and their location at all times; (iv) creation of registries of blood donors and blood components; and last but not least (v) the automation of transfusion supervision activities.

On the territory of almost all countries there are built automated information systems centres and departments of transfusion hematology, which make it possible to work with the data of blood collection, diagnostics, processing, storage and dispatch of blood and blood components in real time from anywhere in the country.

In the present paper an idea for the creation of common information system between National Centers of Transfusion Hematology (NCTH). As an example, a case involving several neighboring countries on the Balkan peninsula – Bulgaria, Greece, Macedonia (the former Yugoslav Republic of Macedonia - FYROM), Romania and Serbia is considered.

At the present moment in Bulgaria (see [2]) there is one of the best on the Balkan peninsula National automated information system (NAIS). Using a database all five centres of transfusion hematology (CTH) and 23 departments of transfusion hematology (DTH) at the Multiprofile Hospital for Active Treatment (MHAT) have real-time connection for the examinations of each blood donor candidate. In addition all CTHs have databases from the processed donor blood, as well as the direction of the dispatched components.

In Greece (see [3]) there is no centralized donor system. There are in total 97 departments in which blood maybe donated, including hospital. The donated blood is diagnosed and processed in 4 CTH and in the Hellenic National Blood Transfusion Center.

In Macedonia (see [2]) the existing 22 centres are united in a blood transfusion system which encompasses the entire country. It consists of National institute of transfusion medicine, 3 regional centres and 18 hospital units. It is independent from organizational and financial point of view, but completely integrated in the country's healthcare system.

The Romanian blood transfusion system (see [2]) is organized in 41 districts, as well as the municipality of Bucharest – with its own administrative unit. Every district has a blood transfusion centre, an institution which collects, tests, processes and stores blood/blood components and distributes them to authorized hospitals.

The blood system in Serbia (see [4]) is decentralized and is currently organized in three levels: 3 Blood -transfusion institutes: 1 national and 2 regional, within university centres; 44 Blood transfusion centres within various health care facilities (hospitals, health care centres, clinical centre); 70 Blood transfusion departments/laboratories within hospitals, clinics and institutes.

The previously mentioned National centres ensure the collection, processing and the delivery of blood on the territory of the respective country. But with the occurrence of emergency situations (including many injured), special circumstances (epidemics, mass vaccinations), or rare blood group antigens, an unforeseen need for blood may arise. The fast depletion of the existing blood reserves may lead to lack of blood for other patients, who are in need of such, for instance, emergency transfusion (obstetrics, surgery, trauma) or regular transfusion (thalassemia, haemophilia). The developed countries with well structured healthcare systems and hemotranfusion services, based on voluntary blood donations, are usually capable to meet the demand for blood/blood components. The developing countries are commonly struggling with chronic insufficiency of blood. In such cases, there is a need for a unified structure of Transfusion

hematology, ensuring the connection between the national blood transfusion centres of each country to provide blood components to a patient in need and especially between neighboring countries. There is currently no such structure to connect the aforementioned five countries of the Balkan Peninsula.

In the present paper we use a simpler form of a Generalized Net (GN; see [5, 6, 7] and the Appendix), that in [5, 6] is called a reduced GN.

2 Generalized Net Model of a Common Information System among NCTHs

The current GN model aims to illustrate how collaboration could be carried out between neighboring countries to provide blood components to a patient in need.

When there is a request for blood component for a particular patient with specific antigenic formula, which is currently unavailable in the CTH inside the country, it can be forwarded to the closest neighboring country in the Balkans.

The model provides the means to choose the shortest route for the delivery of the considered blood component, as well as which CTH it will be taken from.

The GN-model, describing the communication between NCTHs of five countries on the Balkan peninsula, is presented in Fig. 1.

We have five transitions *B*, *G*, *M*, *R* and *S*, representing the corresponding countries of the Balkan Peninsula – Bulgaria (*B*), Greece (*G*), Macedonia (*M*), Romania (*R*) and Serbia (*S*). Each transition represents the transfusion system of the corresponding country.

In each transition, of the respective country, permanently stays a token with initial and current characteristics (following the requirements from [8])

"information for current state of available blood components and
current needed blood components in country *X*",

as follows, in place b_5 – β – token in place g_3 – γ – token in place m_4 – μ – token, in place r_3 – ρ – token and in place s_4 – σ - token, where $X \in \{B, G, M, R, S\}$.

When blood components are needed in the respective country the tokens $\beta, \gamma, \mu, \rho, \sigma$, split into four tokens – the original token $\omega \in \{\beta, \gamma, \mu, \rho, \sigma\}$ and its copies ω_1, ω_2, ω_3, ω_4 which have characteristics

"Request for needed blood components from country X to the other four countries".

When such token from *X* transition enters the fifth place of each one (*Y)* remaining transitions, it directly unites with corresponding token of the transition *Y*.

Let $P(X,Y)$ denote the predicate

$P(X,Y)$ = "The NCTH of country *X* asks for concrete blood components from NCTH of country *Y*" or "There is answer from NCTH of country *X* to received request for concrete blood components from NCTH of country *Y*",

where variables *X* and *Y* have obtained the corresponding values *B*, *G*, *M*, *R* and *S*, and obviously $X \neq Y$.

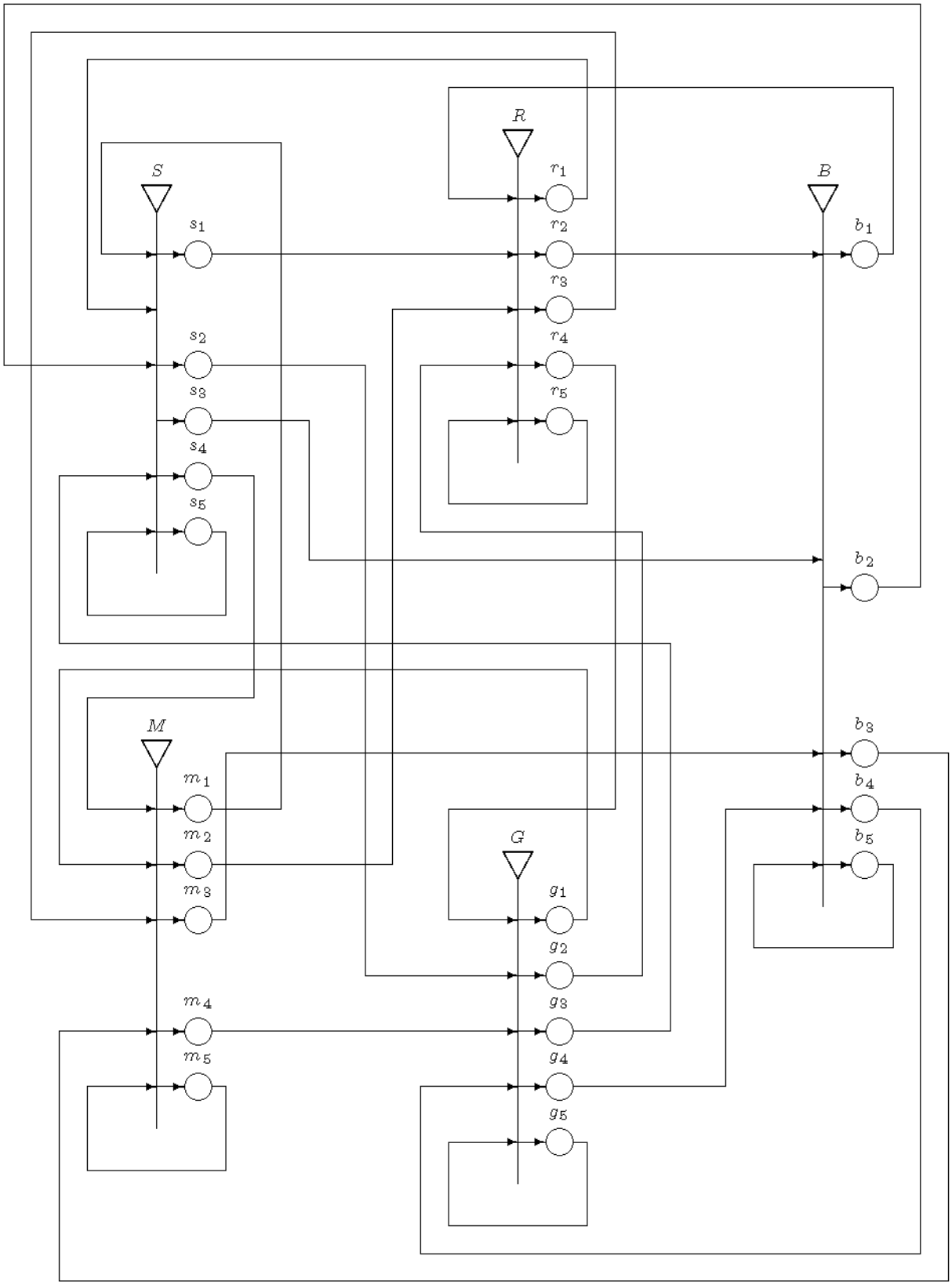

Figure 1 Generalized net model of the communication between NCTHs of five countries on the Balkan peninsula

The form of the transition B of the GN-model is:

$$B = \langle \{ g_4, m_3, r_2, s_3, b_5 \}, \{ b_1, b_2, b_3, b_4, b_5 \}, r_B \rangle,$$

where

$r_B =$

	b_1	b_2	b_3	b_4	b_5
b_5	$P(B,R)$	$P(B,S)$	$P(B,M)$	$P(B,G)$	*true*
g_4	*false*	*false*	*false*	*false*	*true*
m_3	*false*	*false*	*false*	*false*	*true*
r_2	*false*	*false*	*false*	*false*	*true*
s_3	*false*	*false*	*false*	*false*	*true*

The form of the transition G of the GN-model is:

$$G = \langle \{ b_4, g_5, m_4, r_4, s_2 \}, \{ g_1, g_2, g_3, g_4, g_5 \}, r_G \rangle,$$

where

$r_G =$

	g_1	g_2	g_3	g_4	g_5
b_4	*false*	*false*	*false*	*false*	*true*
g_5	$P(G,M)$	$P(G,R)$	$P(G,S)$	$P(G,B)$	*true*
m_4	*false*	*false*	*false*	*false*	*true*
r_4	*false*	*false*	*false*	*false*	*true*
s_2	*false*	*false*	*false*	*false*	*true*

The form of the transition M of the GN-model is:

$$M = \langle \{ b_3, g_1, m_5, r_1, s_4 \}, \{ m_1, m_2, m_3, m_4, m_5 \}, r_M \rangle,$$

where

$r_M =$

	m_1	m_2	m_3	m_4	m_5
b_3	*false*	*false*	*false*	*false*	*true*
g_1	*false*	*false*	*false*	*false*	*true*
m_5	$P(M,S)$	$P(M,R)$	$P(M,B)$	$P(M,G)$	*true*
r_1	*false*	*false*	*false*	*false*	*true*
s_4	*false*	*false*	*false*	*false*	*true*

The form of the transition R of the GN-model is:

$$R = \langle \{ b_1, g_2, m_2, r_5, s_1 \}, \{ r_1, r_2, r_3, r_4, r_5 \}, r_R \rangle,$$

where

$$r_R = \begin{array}{c|ccccc} & r_1 & r_2 & r_3 & r_4 & r_5 \\ \hline b_1 & false & false & false & false & true \\ g_2 & false & false & false & false & true \\ m_2 & false & false & false & false & true \\ r_5 & P(R,S) & P(R,B) & P(R,M) & P(R,G) & true \\ s_1 & false & false & false & false & true \end{array}.$$

Finally, the form of the transition S of the GN-model is:

$$S = \langle \{ b_2, g_3, m_1, r_1, s_5 \}, \{ s_1, s_2, s_3, s_4, s_5 \}, r_S \rangle,$$

where

$$r_S = \begin{array}{c|ccccc} & s_1 & s_2 & s_3 & s_4 & s_5 \\ \hline b_2 & false & false & false & false & true \\ g_3 & false & false & false & false & true \\ m_1 & false & false & false & false & true \\ r_1 & false & false & false & false & true \\ s_5 & P(S,R) & P(S,G) & P(S,B) & P(S,M) & true \end{array}.$$

The proposed model may be used as a foundation for the development of information system encompassing the CTHs in Europe. Every national transfusion centre has a database with information with information regarding the donors, their health status and additional data, which data are protected in accordance with the regulations in the specific countries. Some of these data – however can be made public, like for instance, availability of blood which may be provided to systems in neighboring countries. The public data may be then processed using data mining tools. Places b_5, g_5, m_5, r_5, s_5 in the proposed model correspond to the work of CTHs in the individual countries. The processes which occur in them are described in detail [9]. Thus, the proposed model may be made more detailed by adding specific information pertaining to the individual countries.

3 Conclusion

The so proposed GN-model is the first simplest model, providing the interconnection between the five national CTH on the Balkans. In the future the model may be refined in different directions when there is a positive response for collaboration by a given country. Based on this the most rational course of action is to send an initial request to all countries. If a negative response is received by all, a courteous thankful reply should be sent back to all parties. If a positive response is received from more than one country, the country the blood components would be taken from may be chosen based on the transport options and patient needs.Nowadays intelligent systems can be found in areas as diverse as robotics, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances.

Acknowledgments

Work presented here is partially supported by the National Scientific Fund of Bulgaria under the Grant DN02/10 “New Instruments for Knowledge Discovery from Data, and their Modelling”.

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