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ORIGINAL ARTICLE

INTELLIGENT MEDICAL SYSTEM FOR PARAMEDICS

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Abstract: In this paper the authors describe prehospital medical rescue, its subsystem for managing rescue efforts and subsystem for execution of rescue efforts. They present an outline of operation of an emergency medical service and as a quality solution provide a trifactorial utility function by Andrzej Janicki. The authors prepared and explained two models of prehospital medical rescue. The first one called ARM is based on agent technology, whereas the second one is prepared in terms of Petri net theory. Utility function was used to analyze the usefulness of rescue agencies with the purpose of identifying the needs for changes in the analyzed scenario within the State Emergency Medical Service (SEMS). In order to solve the problem of supporting the decisions of the Dispatcher at the Rescue Notification Centre (RNC), a proprietary rescue agency algorithm developed by P. Filipkowski was used. The developed rescue agency algorithm to support the RNC Dispatcher in the decision making process was implemented in a modelling and simulation environment based on Scilab language. Introduction of decisions characterized by higher utility values would reduce the operation cost of rescue agencies and thus the entire SEMS by increasing the quality of service provided by rescuer agents and specialist rescuer agents as well as their participation in the decision-making process initiated by the ECC dispatcher.

Keywords: agent rescue model, emergency rescue system, state emergency rescue service

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INTRODUCTION

The urgent problem to ensure the safety of life and health of the society is solved by intelligent medical systems[1] supporting the "intelligent agents" used in prehospital medical rescue as quasi-dispatchers and paramedics.

Besides the highest standby readiness, well trained and equipped rescuers and broadband Internet connections, organization of emergency medical services requires appropriate number of ambulances and appropriate deployment locations. This allows to achieve the primary goal of the system – to shorten the EMS teams' response times as measured from the call being received to the arrival to the individual at emergency health hazard[2]. Dispatched teams have to be deployed in a fashion that ensures arrival times consistent with the life and health safety criteria defined in the Polish Act on State Emergency Medical Services [7].

PREHOSPITAL[3] MEDICAL RESCUE

Death from multiorgan injury may be either immediate, early or delayed. Emergency medicine knowingly and deliberately intervenes within the early period, taking advantage of the so-called "golden hour" [4]. In order to increase the likelihood of survival of the injured individual, a "survival chain" is established to ensure that the rescuers reach the injured within 8 or 15 minutes[4] following the call and deliver them to the hospital emergency room (ER) within 30 minutes. Thus, a high standard of procedures and organization capabilities must be ensured for the State Emergency Medical Services (SEMS).

Rescue systems consist of two distinct subsystems (cf. Fig. 1.) [8][5].

a) a subsystem for managing rescue efforts;

b) a subsystem for execution of rescue efforts.

The management subsystem performs information-exchange and decision-making system tasks by receiving information on events, determining the rescue activities required and managing the efforts of the executive subsystem.

The executive subsystem consists of primary (P) and specialist (S) emergency rescue teams equipped with instrumentation and resources allowing to efficiently prevent adverse consequences of any acts of God that threaten the safety of population and the environment.

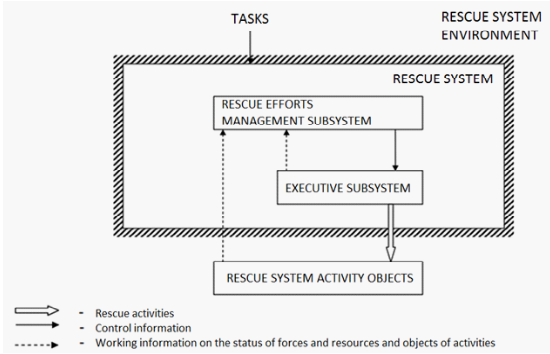

Fig. 1. A model of the emergency rescue system.
Source: [8], p. 1.

THE QUALITY OF THE DECISION-MAKING SOLUTION

The efficacy of an emergency medical service system depends on the quality of execution of tasks assigned to individual subsystems at distinct stages of the rescue cycle. Each subsystem, including every component that constitutes an essential and integral part of the entire system, makes a specific contribution to the overall system efficacy. Thus, the efficacy of the rescue management subsystem will be assessed by the impact of its characteristics (i.e. activities) on the resulting efficacy of the entire system.

Measures that characterize the quality of information exchange and decision-making processes within the management subsystem at individual stages of the rescue cycle, thus determining the efficacy of the entire cycle include:

- time required to perform information-collecting and decision-making operations;
- the quality of these operations.

A review of the literature on the subject[6] confirms the obvious need to shorten the time required for individual information exchange/decision-making operations at individual stages of the rescue cycle as well as to increase the quality of these operations [8]. In current primary rescue management systems, the main executors of information exchange/decision-making operations are humans.

[1] Intelligent medical system is defined as an IT system supporting intelligent agents in prehospital emergency medical services.

[2] Emergency health hazard to an individual is an event requiring immediate intervention of the state system responsible for the health and safety of residents.

[3] The term „prehospital" is introduced by analogy to the existing term „premedical procedures".

[4] Effective arrival times are up to 8 min in urban areas and up to 15 min outside urban areas.

[5] [8], p. 1.

[6] [8], p. 3.

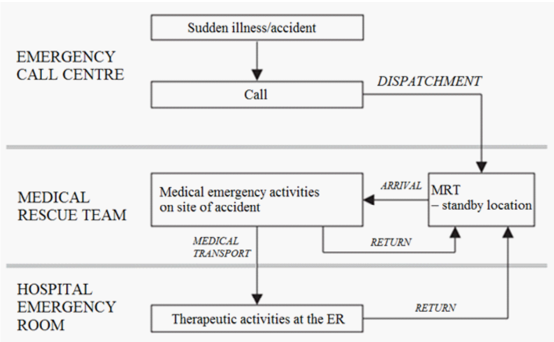

Fig. 2. An outline of operation of an emergency medical service.

Source: [7].

Taking into consideration the finite and limited capabilities of humans with regard to the collection and processing of information, desirable results may only be achieved by means of computer-assisted operations.

The emergency medical service system in Poland operates pursuant to the act of 8 September 2006 on the State Emergency Medical Service and a number of ordinances implementing the provisions of the aforementioned act. The act defines two distinct types of units operating as parts of the system: hospital emergency rooms (ERs) and medical rescue teams (MRTs). These units are connected in a functional manner [3A].

Following notification of a sudden illness or accident being received at the Emergency Call Centre (ECC), the medical response team competent in terms of location (nearest in terms of arrival time) and call reason (primary, i.e. a team of paramedics, or specialist, i.e. a team of paramedics and a physician) is dispatched. The MRT takes up the rescue efforts at the site and, if needed, continues the medical rescue activities while transporting the injured individual to the nearest hospital ER or other hospital unit appropriate for the type of disorder. Helicopter teams of the Polish Medical Air Rescue operating as part of the Helicopter Emergency Medical Services (HEMS) are also considered medical resource teams, albeit functioning on different principles.

The last stage of the emergency medical service involves therapeutic actions taken up within the hospital medical rescue facilities, i.e. emergency departments. These departments provide medical care to all patients in health- or life-threatening conditions, both delivered by medical rescue teams and reporting on their own, regardless of their residence and financial or social status [7].

Virtually every human activity is a "game" involving a process of exchanging particular "values" to other game-specific values.

Each decision regarding human actions depends on such factors as entrepreneurial activities and protective/defensive (safeguarding) activities. These two types of decision maker's motivation are reflected in a bifactorial utility function proposed by R. Kulikowski. With regards to systems of primary importance for the public, such as financial, military, police and broadly understood security and rescue systems, the model has been modified by A. Janicki. Assessment of the quality of solutions to a particular problem using R. Kulikowski's function model and experimental mathematics methodology leads to the following trifactorial utility function according to A. Janicki [6]:

$$U(x)=[X^{\beta}\,Y^{1-\beta}]^{\alpha}\,V^{1-\alpha}; \quad \alpha\in[0,1] \;\; \beta\in[0,1]$$

where x is the decision variable, X is the factor associated with expected benefits (within any assets) of making the decision in question; Y is the factor associated with the risk of losing assets invested in execution of action in question, and V is the so-called survival coefficient comprehensively reflecting all decisive processes occurring in the natural environment. As exponent α increases, the importance of the respective part of the utility function related to that particular action for the decision maker is also increased. On the other hand, the importance of the measure associated with the survival coefficient is decreased. Factor α reflects the decision maker's focus on action ($\alpha>0.5$) or reflection ($\alpha<0.5$), while β is the factor determining the entrepreneurship of the agency (understood as agency's capability to arrive at creative and balanced solutions).

The decision makers, i.e. the dispatcher agent and the ER physician agent, as well as every agent in a crisis situation, are under continuous stress. They have to survive within an environment of acts of God and undertake actions increasing the likelihood of success for particular rescue efforts.

Antonovsky related the strategies for coping with stress, i.e. surviving in a hostile environment, with the sense of coherence. Efficient survival depends on the knowledge of the surrounding environment and capability to adapt to that environment, i.e. to act in a manner bringing up stable benefits. Thus understood sense of internal coherence is a resultant of three particular interactions illustrated by the following vectors:

- vector U – Understanding the environment;
- vector F – Assessment of feasibility;
- vector S – Sensibleness of action,

defined in a predefined Cartesian space encompassing the set of actions as part of the SMER.

The survival coefficient V is expressed by the product of vectors and constitutes a measure for the ability to survive under the pressure of stressors.

MODELS OF PREHOSPITAL MEDICAL RESCUE

Model 1

The agent technology can be seen as a computer program that uses artificial intelligence methods to learn and automate certain processes.

ML Minsky from Massachusetts Institute of Technology formulated the concept of "how the mind works and how intelligence arises in the actions" [9]. According to the author, intelligent minds are built up of agents defined as parts performing simple processes. Particular combinations of agents are responsible for emergence of intelligent behaviours. An agent called Builder initializes and manages a group of operations of other agents. The agency as seen from the outside consists of the Builder who does whatever is necessary to achieve its goal of finding solution to the problem. From the point of view of the classification of agents, M.L. Minsky undoubtedly extends the object-oriented view of the agent as well as explains the principles of operation of agents – the Builder as well as the whole agency.

The idea of agency can be described by figure below.

The main principle is that Builder entity is able to handle as many random events as permitted by agency resources.

From the point of view of prehospital medical rescue, agent technology can be described for example like below.

The model above is a case diagram in agent technology. Three agencies may be distinguished in this model: the Injured, the Rescue and the ER agency. Each agency has a Builder entity and resources available for use.

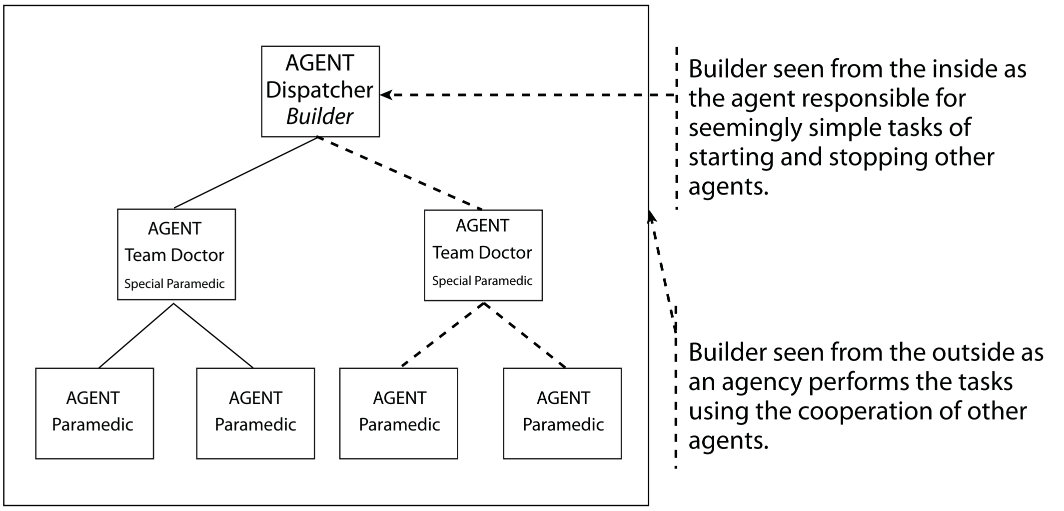

Fig. 3. Location of agent in the agency system.
Source: [3].

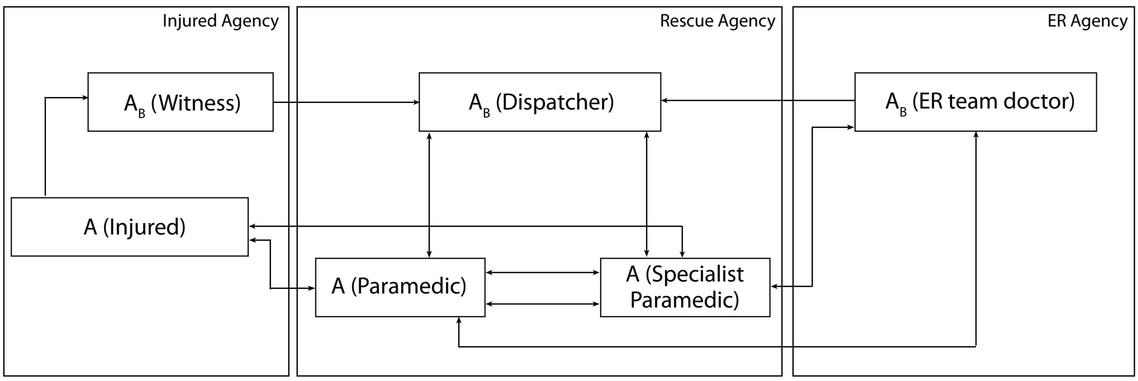

Fig. 4. Example of ARM system realization.
Source: [3].

Example realization of an Agent Rescue Model (ARM) was carried out on the basis of reports from Pope John Paul II Independent Public West Specialist Hospital in Grodzisk Mazowiecki [3].

Model 2

We want to analyze ARM and build another model which can be more flexible to use or improve and better understand its performance. Then so, we need to transform the sequence diagram into a collaboration diagram (communication diagram). The collaboration diagram puts emphasis on the communication aspect of the modelled system. It allows to visualize communication between individual objects of interaction which is important for modelling behaviour of such system.

Firstly lets analyze use case scenario of this system. The use case scenario will be generalized to the level of differences in accident types.

The ARM system is initiated at the moment of transfer of symptoms from the Injured to a casual Witness (action SendSymptoms()).

The Witness communicates with Dispatcher and describes the accident.

The Dispatcher confirms data (return message ConfirmData()), and checks the reliability of action. Next, Dispatcher sends Paramedics to the location of the accident (action DispositionDepartureOfBasicTeam()). Then, Injured transfers information about his symptoms to the arriving Paramedics (action SentSymptoms()).

Paramedic interviews the Injured, defines the problem, looks for a solution and attempts to solve the problem (actions ExaminationOfProblem(), Ascertainment Problem() and ExecutionOf()). At this point, the Paramedic decides to finish the rescue operation or to call for ER Team Doctor. When the rescue operation is completed, the system is closed.

In this case operation is continued, Paramedic calls the Doctor and consults with him need of calling for Specialist Paramedic (action CallForSpecialistParamedic ()). The Doctor makes the decision of calling Specialist Paramedic, then sends the request to Dispatcher (action SignalingTheNeedOfSpecialistSupport()). Dispatcher sends the request for Specialist Paramedic (action DispositionDepartureOfSpecialistTeam()). Next, the Specialist Paramedic arrives at the location of accident and communicates with Paramedic (action ArrivalOfSpecialistParamedic ()). The, the Specialist Paramedic diagnoses the symptoms of the Injured and performs adequate rescue operations (actions RecurrenceOfSymptoms() and ExecutionOfRescueOperation ()). This complex action can be repeated several times. Then, the Specialist Paramedic sends information to the ER Team Doctor with a suggestion of transporting the Injured to the hospital. Doctor reposts confirmation (actions MessageAbout-

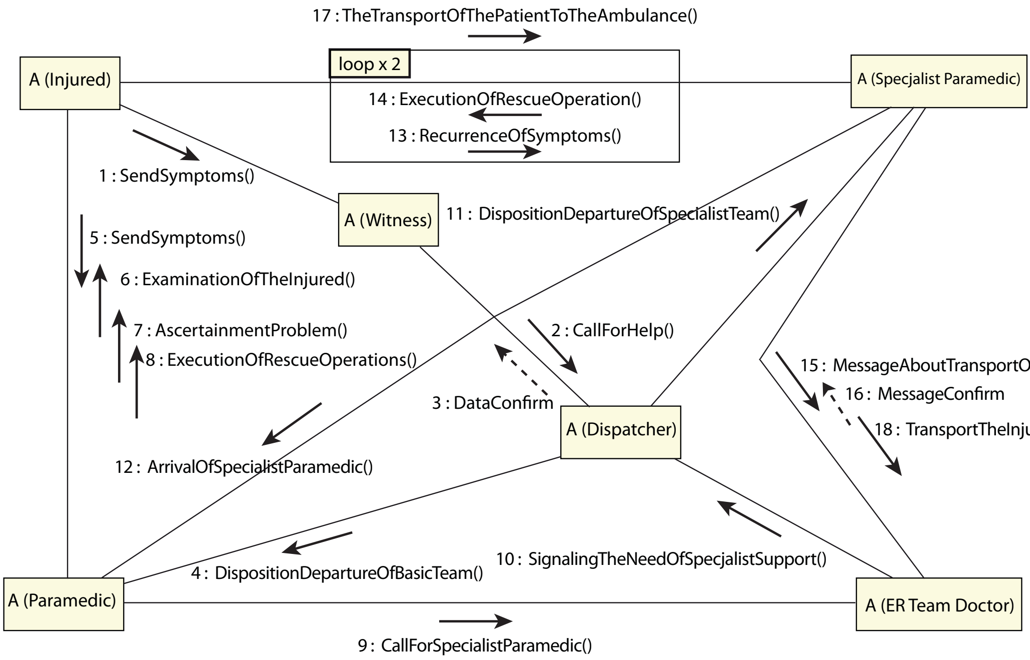

Fig. 5. Collaboration diagram of the agent rescue model.
Source: data on file.

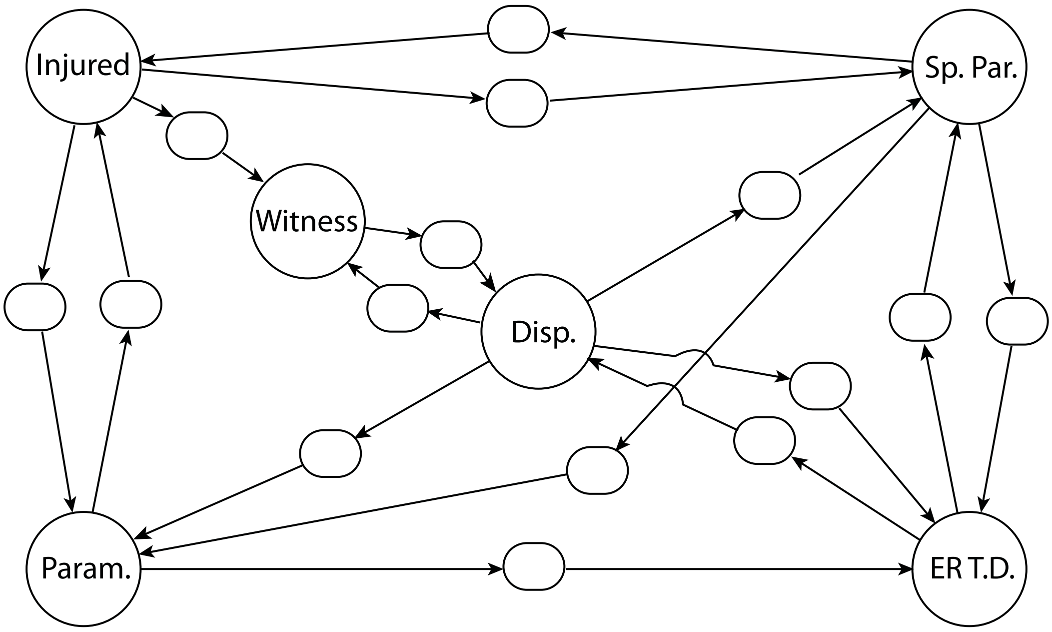

Fig. 6. Simple PN ARM.
Source: data on file.

TransportOfInjured() and MessageConfirm()). The Injured is moved to AMBULANCE and transported to the hospital and ER Team Doctor.

With this collaboration diagram at hand, Fig. 5. by which we better understand communication aspect between agents of system, we can develop the Agent Rescue Model in terms of the Petri nets theory, described in [10,11], Reisig's book. In literature there is many examples of providing a formal semantics interpretation of medical system, like Clinical guidelines which is playing important role to modelling evidence based medicine [1].

New model will be named Petri Net Agent Rescue Model, in short cut PN ARM. Firstly lets create model similar to collaboration diagram.

There is a six labelled main places in this net and fifteen non-labelled transition.

After analyses of system, we modify such model to improve its performance.

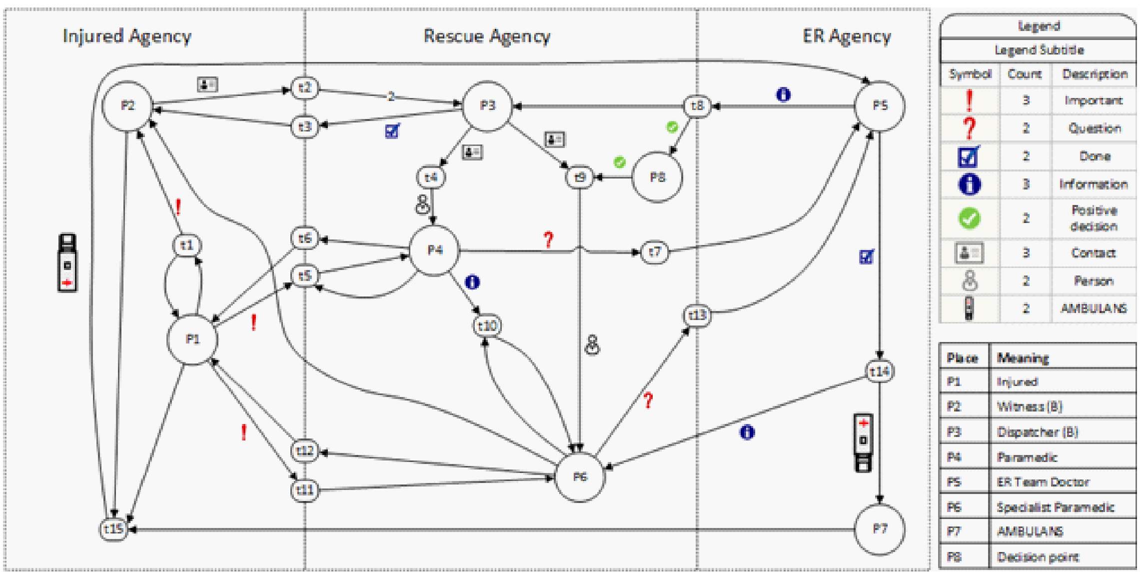

Fig. 7. Final Agent Rescue Model in a Petri net diagram.
Source: data on file.

Tab. 1. Specification for passives of ARM PN.

Symbol	Label	Meaning of coins (Description)
P1	Injured	Injured is ready to cooperate. (Coin here means that)
P2	Witness	Witness is ready to act (Witness can act by: - inform Dispatcher about accident)
P3	Dispatcher	Dispatcher has task to do. (Tasks of Dispatcher are: - send Paramedic, - send Specialist Paramedic, - receive emergency call.)
P4	Paramedic	Paramedic is ready to act in emergency pool
P5	ER Team Doctor	There is activity in ER Team Doctor (In this place Activity can be: - ready to call for Specialist Paramedic or Ambulance, - Ambulance with Injured and support team, - information about need of transport of Injured to hospital)
P6	Specialist Paramedic	Specialist Paramedic is ready to act in place of accident
P7	Ambulans	Ambulans is in a place of accident
P8	ER T.D. Permin request	It means that the Doctor permit to call Specialist Paramedic to emergency pool

Source: data on file.

Tab. 2. Specification for actives of ARM PN.

Symbol	Label	Precondition	Postcondition
t1	Send symptoms	There is Injured.	There is Injured and Witness is ready to call for help.
t2	Call for help	Witness is ready to call for help.	Dispatcher is ready to confirm data and call for Paramedic
t3	Data confirm	Dispatcher is ready to confirm data	Witness has information that data is confirmed
t4	Disposition departure of basic team	Dispatcher has received message call for help	Paramedic is ready to act in place of emergency
t5	Send Symptoms	There is Injured ready for interact and there is a Paramedic ready to act	Injured is waiting for rescue operation and Paramedic is ready to act
t6	Package of rescue operation	Injured is waiting for rescue operation and Paramedic is ready for act	Paramedic ended package of rescue operation (Package of rescue operation include: - Examination of the Injured, - Ascertainment problem.)
t7	Call for Specialist Paramedic	Paramedic ended package of rescue operation	ER Team doctor is ready to decide to call for Specialist Paramedic
t8	Signaling the need of Specialist Support	ER Team doctor is ready to make decision and call for Specialist Support to Dispatcher	Positive decision for support call and Dispatcher is ready to send support to emergency pool.
t9	Disposition departure of Specialist Paramedic	Dispatcher is ready to call for Spec. Paramedic and positive decision of ER T.D. for this call	Specialist Paramedic is ready to act in emergency pool
t10	Arrival of Specialist Paramedic	Specialist Paramedic is ready to act in emergency pool and Paramedic is also there.	Paramedic has go away and Spec. Paramedic is acting in emergency pool
t11	Recurrence of symptoms	Injured is ready to cooperation and Specialist Paramedic is waiting for symptoms	Specialist Paramedic is has information about what operation execute and Injured is waiting
t12	Execution of rescue operation	Spec. Paramedic has information about symptoms and Injured is waiting	Spec. Paramedic executed rescue operation and Injured is ready to cooperation
t13	Message about transport of Injured	Spec. Paramedic is ready to call for transport of Injured	ER T.D. has information about transport call
t14	Sending ambulance	ER T.D. is ready to send ambulance to emergency pool	Ambulance is in emergency pool and Spec. Par. Is ready to transport Injured to ambulance
t15	The transport of the patient to hospital	Spec. Par. is ready to save Injured. Injured, Spec. Par., Ambulance are in emergency pool	Injured, Spec. Par. and Ambulance are in hospital and ER Team Doctor. END OF RESCUE OPERATION.

Source: data on file.

We can add some information about meaning of floating tokens of net and extend actual net by adding missing elements.

Secondly, as a result we received model with a sufficient number of places and transition but difficult to read.

The final result is more readable. On the right there is legend and description of places of net.

Model above (Tab. 1.) can be described in formal language as *N=(P,T,A)* where *P* is a set of places, *T* is a set of transitions, and *A* is a set of combined place and transition, or transition and place pairs, in other words is arc set. In tables below there are detailed description of passives and actives of ARM PN.

The dynamics of this model can be represented by Petri net marking. *N* above can be extended to $N'=(P,T,A,M_0)$ where the meaning of *P,T,A* is as above and M_0 is the marking. Marking provides information on the number and locations of tokens. By this end, it is possible to examine the behaviour of an ARM system. For example, unfolding of Petri nets [2] can be used to explore their live status. Otherwise we can use HIGH-LEVEL formal method description like Algebraic framework for concurrent system [12] to describe behaviour aspects of the modelled system, by with its possible to use only transition to describe behaviour of ARM system.

RESULTS

Each of the rescue agents was assigned a matrix variable allowing for the recording of its behaviour. Due to the lack of data regarding probability distribution for particular behaviours of the agents, it was assumed that the actions taken by these agents in time would be subject to uniform distribution of probability[7].

The decision makers, i.e. the dispatcher agent and the ER physician agent, as well as every agent in a crisis situation, are under continuous stress. They have to survive within an environment of acts of God and undertake actions increasing the likelihood of success for particular rescue efforts.

Utility function was used to analyze the usefulness of rescue agencies with the purpose of identifying the needs for changes in the analyzed scenario within the State Emergency Medical Service (SEMS).

The process of exchanging information is simultaneously accompanied by an adequate decision-making process. With the duration of the symptom t as the decision variable, following utility factors were identified:

- entrepreneurial activities (time until response to Witness' call) X,
- security activities (time of communication with the Dispatcher) Y,
- duration (the time required for rescue efforts and consultations with ER) V.

For an example scenario simulation and predefined balanced activity weights of $\alpha=0.5$ and $\beta=0.5$, the utility was 0,41. By increasing internal coherence ($\alpha=0.1$) and the weight for entrepreneurship of the team's activities ($\beta=0.9$) we are able to increase the usefulness of the rescue agency activities to 0.56.

In order to solve the problem of supporting the decisions of the Dispatcher at the Rescue Notification Centre (RNC), a proprietary algorithm developed by P. Filipkowski was used instead of pseudorandom calculations with uniform distribution.

The developed rescue agency algorithm to support the RNC Dispatcher in the decision making process was implemented in a modelling and simulation environment based on SciLab language, and individual simulations were calculated on computers equipped with 1 GHz RAM Intel Xeon 3210 processor and 1.36 GHz RAM Intel i7 processor.

For the purpose of presentation of the problem and its solution, as well as of for simulation of variants, predefined characteristics of a Medical Rescue Team was used as database field sets containing the most important information on the Team.

MRT entity:

IDz – Identifier
szz – MRT location latitude
dlz – MRT location longitude
tY – Time of consultations between paramedics and the dispatcher.
tV – Duration of activities at the site of event
a – Coefficient α
b – Coefficient β
S – Specialist MRT (0 – no or 1 – yes)

Injured entity:

IDp – Identifier
szp – Injured location latitude
dlp – Injured location longitude
tX1 – Time from the onset of symptoms to completion of call reception by the Dispatcher

The design of the Information System[8] developed on the basis of the above attributes allows to process input data into output data by means

[7] SciLab functions - rand(a,b,'uniform') for range [0,1] or grand(a,b,'unf',min,max) for range [min,max].

[8] The particular information system is in fact one of the modules of the transactional system presented in [5].

of predefined procedures and models. Due to the lack of actual data, database information are derived from pseudorandom generators of uniform distribution and treated as historical data. Coefficients α and β are also drawn from a uniform distribution set of 0 through 1.

The conducted simulations of the selection of Medical Rescue Teams appropriate for the condition of the compliant with the trifactorial utility function criterion did not rule out a possibility to dispatch a specialist MRT right away following the emergency call from the injured or a witness (an artifact).

Historic information on medical rescue teams and injured parties are used to derive a trifactorial utility function according to A. Janicki.

Also conducted were simulations in which the following criteria were sequentially used for selection of the Medical Rescue Team:
- pseudo-random – with uniform probability distribution;
- graph-based – including the selection of the shortest arrival time.

Inspiration for using these criteria for the selection of MRTs came from examination of the operation of Rescue Notification Centre in high stress (situation and personnel-related) conditions.

The results are presented in Fig. 8.

CONCLUSION

The obtained results confirm the necessity to use trifactorial utility function in the process of selecting medical rescue teams. When selecting MRTs according to A. Janicki's method, the utility increases along with the increase in the number of MRTs available within a particular area. An important task is to improve the quality as regards the aid in the decision-making process, as this might improve the functioning of the system by at least 50%[9].

Assigning higher weighs to the factors in A. Janicki's utility function unambiguously suggests the need to:
- improve the information flow within the system between the ER physicians and primary (P) as well as specialist (S) units;
- improvement of the decision-making process as performed by the Dispatcher;
- improvement of the system for communication between the witness and the rescuers.

[9] This article makes use of the utility criterion as a basic concept defined by A. Janicki in [5] – in current conditions, this concept best fits the complexity of today's real-time information and decision support systems in situation- and personnel-related stress conditions.

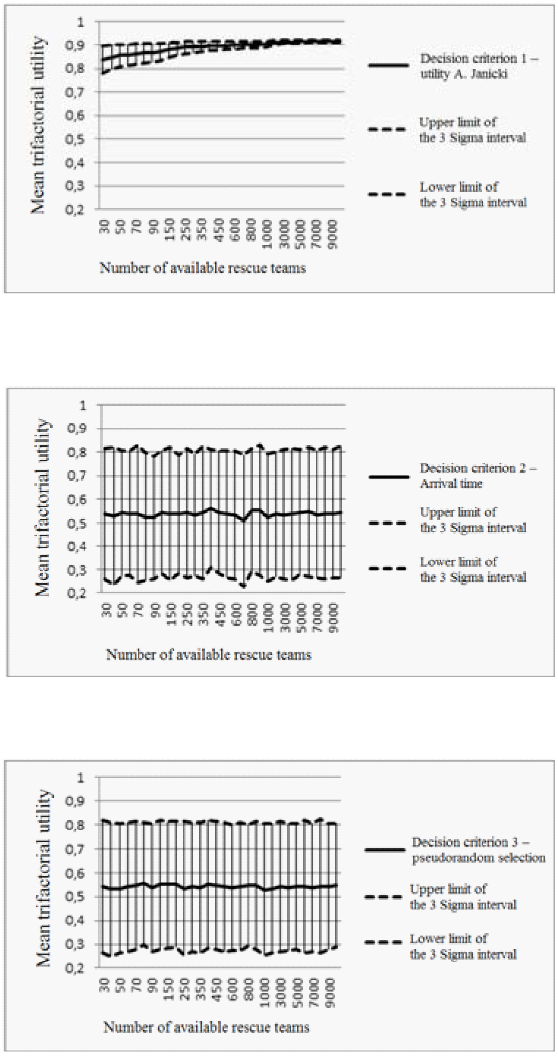

Fig. 8. Mean trifactorial utility depending on the number of reachable MRTs (rescue agents)

Source: data on file.

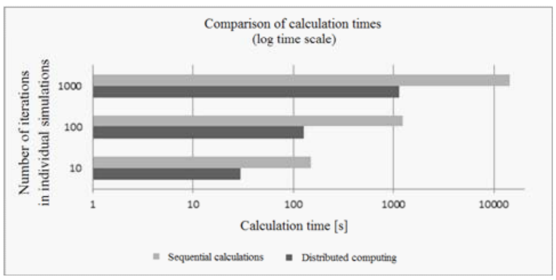

Fig. 9. Calculation times for simulations performed using an Intel i7 processor-based computer system

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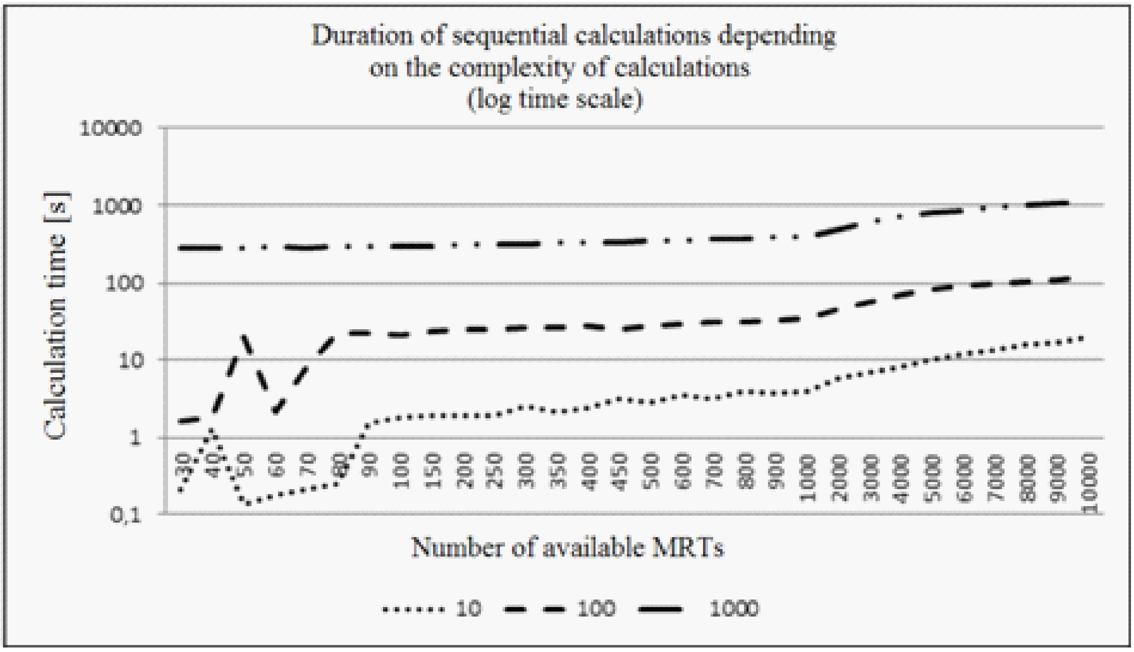

Fig. 10. Calculation times for simulations performed using an Intel i7 processor-based computer system
Source: data on file.

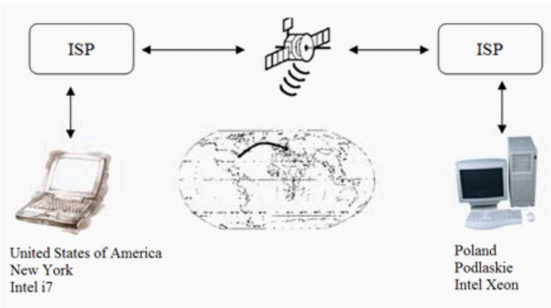

Fig. 11. Connection diagram for computers involver in simulation calculations
Source: data on file.

In future studies, the conducted simulations will be optimized by using distributed calculations used to search for potential improvements within the SERS with respect to individual agents and agencies. The objective of these studies will be to optimize the procedures of the MRTs and external ER agencies with respect to the threshold times between the injury and life-saving intervention, i.e. the ability to contain the required efforts of the intermediate agency within the "golden hour".

The key role will be played by the intelligent rescue agency and its algorithm acting as an in the relationships between the injured and the doctor as well as by the BLS awareness of the witnesses of sudden health loss cases.

From the standpoint of the decision-making process initiated by the dispatcher agent with regard to sending a medical rescue team (MRT) to the injured, it is evident that not taking into consideration the MRT characteristics requirements as defined in A. Janicki's approach, and using instead e.g. only the criterion of distance from the injured so as to minimize the arrival costs yields the decision utility value comparable to that of a decision made by the system dispatcher agent without any consideration.

Introduction of decisions characterized by higher utility values would reduce the operation cost of rescue agencies and thus the entire SEMS by increasing the quality of service provided by rescuer agents and specialist rescuer agents as well as their participation in the decision-making process initiated by the ECC dispatcher.

Such design of an intermediate agency acting as Information and Decision Support System would allow to increase the quality of services offered by the SEMS.

The agent approach to the problem facilitated the development of a practical model and simulation of a significant craniological case recorded at Pope John Paul II Independent Public West Specialist Hospital in Grodzisk Mazowiecki.

The developed model of an intermediate agency will permit identification of behaviours of the elements of the State Emergency Rescue System and simulation-based verification of different variants of call servicing scenarios as well as system-specific support of dispatcher's decisions and quantitative assessment of results. The use of system-specific solution quality assessments ensures rational improvement of complex systems such as the Emergency Rescue System.

Tab. 3. Calculation time results for different platform configurations.

		10 iterations	100 iterations	1000 iterations
Configuration 1	Duration of all sequential calculations [s] Intel Xeon	199,523	1 423,270	13 679,860
	Duration of all sequential calculations [s] Intel i7	151,112	1 234,072	14 334,380
	Duration of all sequential calculations [s] Intel Xeon + Intel i7	117,945	788,619	7 793,422
Configuration 2	Duration of all distributed computing [s] Intel Xeon	36,157	172,502	1 524,612
	Duration of all distributed computing [s] Intel i7	29,590	127,400	1 135,750
	Duration of all distributed computing [s] Intel Xeon + Intel i7	19,417	88,268	851,476

Source: data on file

Based on the recorded actions of the system elements, the utility of actions of an intelligent dispatcher agent was calculated using the trifactorial utility function by A. Janicki. Based on the case study mentioned above, premises for improvement operation of agents were formulated.

Based on the results presented in the article, further studies are under way to develop a pilot system environment[10], a modelling and simulation platform meeting the needs of today's business transactions using information society technologies.

AUTHORS' DECLARATION:

Study Design: Andrzej Janicki, Piotr Filipkowski, Michał Horodelski; **Data Collection:** Andrzej Janicki, Piotr Filipkowski, Michał Horodelski; **Statistical Analysis**: Andrzej Janicki, Piotr Filipkowski, Michał Horodelski; **Manuscript Preparation:** Andrzej Janicki, Piotr Filipkowski, Michał Horodelski; **Funds Collection:** Andrzej Janicki, Piotr Filipkowski, Michał Horodelski. The Authors declare that there is no conflict of interest.

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I. Literature

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II. Acts

1A. Rozporządzenie Ministra Zdrowia z dnia 21 grudnia 2010 r. w sprawie wojewódzkiego planu działania systemu Państwowe Ratownictwo Medyczne oraz kryteriów kalkulacji kosztów działalności zespołów ratownictwa medycznego - Dz.U. 2011 nr 3 poz. 6.

2A. Rozporządzenie Ministra Zdrowia z dnia 29 grudnia 2006 r. w sprawie szczegółowego zakresu medycznych czynności ratunkowych, które mogą być podejmowane przez ratownika medycznego - Dz.U.07.4.33.

3A. Ustawa o Państwowym Ratownictwie Medycznym z 8 września 2006 roku.

4A. Ustawa o Świadczeniu Usług Ratownictwa Medycznego z 6 grudnia 2002 roku.

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