Research profile of the Faculty of Management Science and Informatics, University of Žilina (FMSI UNIZA)

The FMSI UNIZA is a technical faculty with a focus on information and communication technologies and wide range of their application in interdisciplinary oriented research projects. Our research strengths are focused in eight strategic profile lines:

- Decision support systems for extensive service systems (e.g. transport systems)
- Modelling and simulation for biomedical applications
- Computer engineering – automation – IoT
- High performance computing
- Low energy computing
- Database management systems
- Reliability Analysis
- Innovative Management
- Economics and Business

We would like to introduce to you our very successful research teams oriented to the following research topics:

- Agent-based simulation of transportation terminals
- Development of microfluidic devices for detection of circulating cancer cells
- Systems for railway corridors dispatching and basic railway transport planning
- Fuzzy logic with memristive circuits
- Mobile robots and their integration into the IoT world
- Fair optimal and reliable emergency system design
- Reliability analysis of complex multi-state systems
- Complex database management system
- Cost models in transportation companies
- Effective using of production inputs with a priority focus on human capital
- Multilateral relations and responsibility of economic entities
- Analytical modelling and machine learning in management science
- Innovation management – the process strategy and performance
- Diagnosis of specifics and determination in strategic management of sporting organization
- Stochastic modelling of decision-making processes in motiving human potential
- Marketing management in cooperative environment – proposal of strategic cooperation management implementation model

Agent-based simulation of transportation terminals

Head investigator Norbert Adamko

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Computer simulation is a research method offering a wide range of opportunities to explore systems. It can be applied in various spheres of human life (industry, transportation, crisis management, health service and others) where it helps to save money, optimize the system, improve its effectiveness and protect human lives. Using experiments with a computer model of the existing system, we are able to analyse its features and predict its behaviour in various conditions.

Long-term experience of staff at the Faculty of Management Science and Informatics in modelling and simulation presents a solid foundation for research and development of simulation architectures as well as for implementation of complex simulation tools. Our scientific and research activity is mostly concentrated to the agent-based simulation architecture. Our developed architecture ABAsim (Agent Based Architecture of simulation models) provides tools for creating flexible simulation models of complex service systems such as transportation and logistics systems. A lot of models, successfully applied in business environment as well, is based on this architecture.

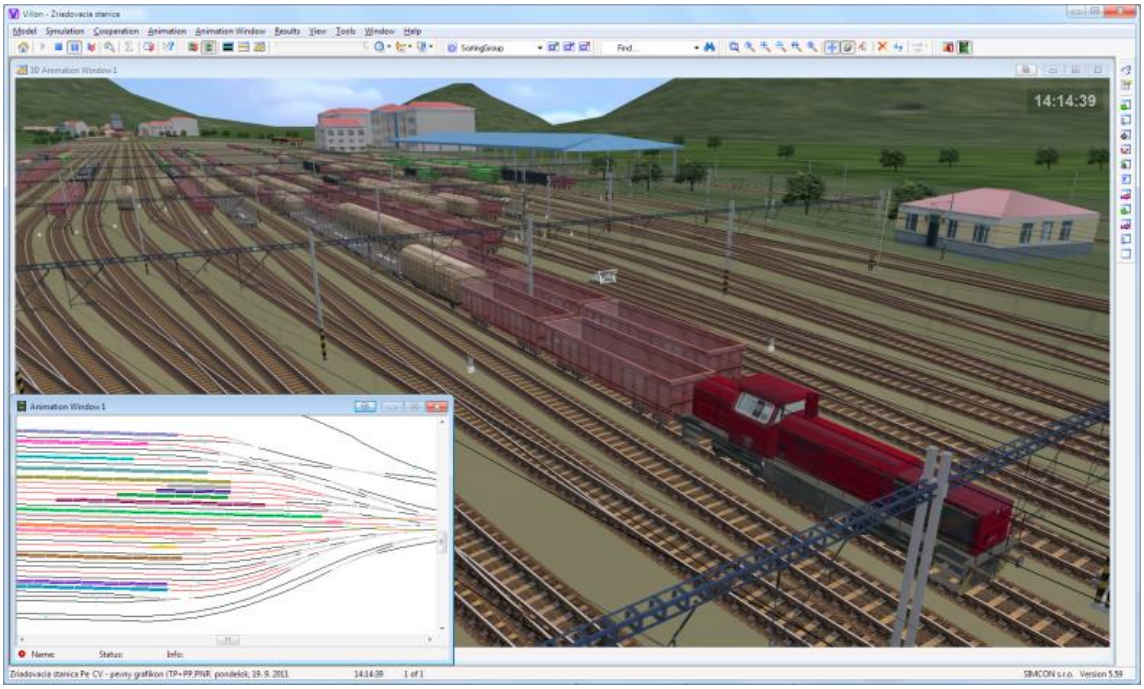

Figure 1: Simulation of marshalling yard operation in Villon simulation tool

An example of successful simulation models developed based-on the architecture ABAsim is the Villon simulation tool – a generic detailed microscopic simulation model of a transportation terminal (e.g. railway station, industrial sidings, container terminal, depot, production facility etc.). The simulation tool has been practically used to solve a large number of designing and optimization

problems of transport logistics terminals in many European and Asian countries (Germany, Austria, Switzerland, China, etc.). Villon helps in designing the infrastructure and verifying terminal operation, in changing transport organization, increasing the production in production facilities or in assessing the interaction of rail and road transport in terminals.

Furthermore, our research is also devoted to the development of a simulation tool for modelling movements and behaviour of pedestrians at the microscopic and macroscopic level called PedSim. Modelling pedestrian movement is used mainly in designing transportation hubs and in the field of crisis management, it contributes to a greater comfort and safety of passengers. Thanks to the employed ABAsim architecture, the pedestrian movement module is (besides the autonomous PedSim tool) also integrated in the Villon simulation tool. This provides a unique ability to create simulation models that include rail and road vehicles, manipulation equipment as well as pedestrians in a single simulation environment, allowing to model their mutual interactions in various types of transportation terminals.

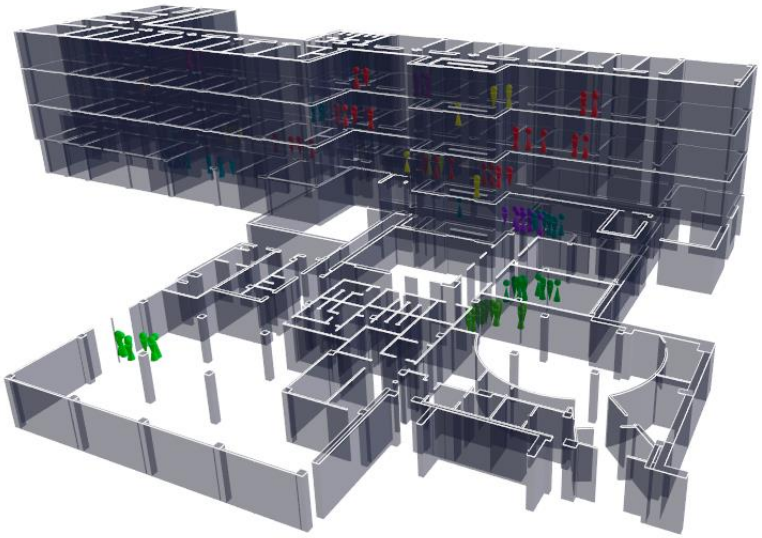

Figure 2: Simulation of pedestrian movement in PedSim simulation tool

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Development of microfluidic devices for detection of circulating cancer cells

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To design a microfluidic device with predefined purpose may be a hard task requiring a lot of knowledge and experience. Computational modelling belongs to strong and effective tools helping such process. We have developed a computational model which captures the bio-mechanical processes inside microfluidic devices including cell deformation, fluid flow, mutual cell-cell and cell-fluid interactions, cell adhesion. Using this model, we are able to model and simulate different devices such as periodic obstacle arrays, cell retention structures, different T- or Y-junctions, cell isolation channels, etc.

The model governs the fluid dynamics (Fig.1), as well as the elasticity of the cells immersed in the fluid (Fig. 2) During the simulation we have complete information about the cell membrane geometry and about the surrounding fluid. Therefore, we can compute a wide range of physical and mechanical quantities including local membrane stress, shear stress at the cell's boundary, cell velocity, its deformation index. We are able to see the cells' behavior by letting the cell pass various obstacles or retention structures (Fig. 3). With the latest developments of the model, we are able to simulate cell adhesion to functionalized surfaces, which enables modelling of devices for circulating tumor cells isolation.

Parallel implementation of the model allows us to simulate suspensions of thousands of cells which gives statistically significant information about global behavior of the suspension and thus we can model rheological properties of the suspension (Fig. 4). The model is implemented as Object-in-fluid module of open source scientific software package ESPResSo. The detailed documentation provides guidance for biologist with basic interest in modelling.

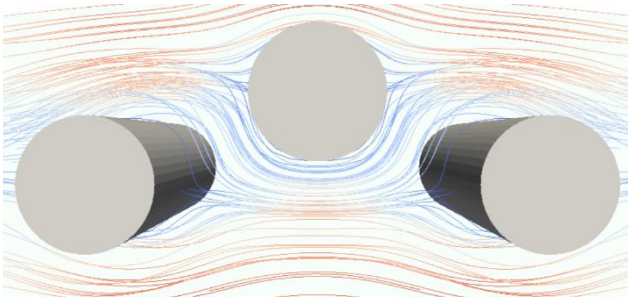

Figure 1: Lattice-Boltzmann method governs fluid dynamics

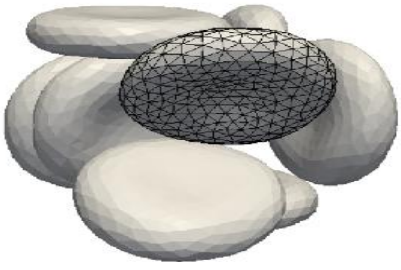

Figure 2: Immersed boundary method is based on the triangulation of the cell's membrane

With this model we have investigated the influence of cell suspension density on cell collision rates in periodic obstacle arrays (Fig. 5). Using simulations, we have discovered a hematocrit threshold, above which the cells do not enter the collision mode. Further, we have analyzed suspensions of red blood cells (Fig. 6) and rare cells in obstacle arrays and the capture rate of the rare cells.

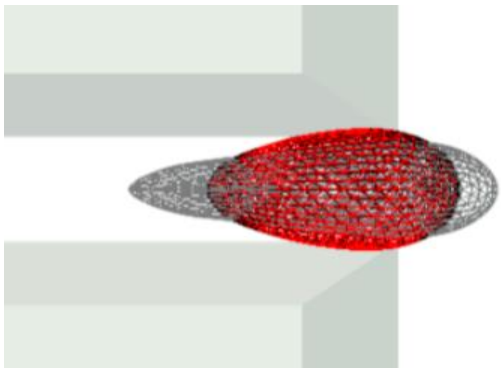

Figure 3: Deformation of elastic spherical objects with different membrane elasticity passing a narrow opening

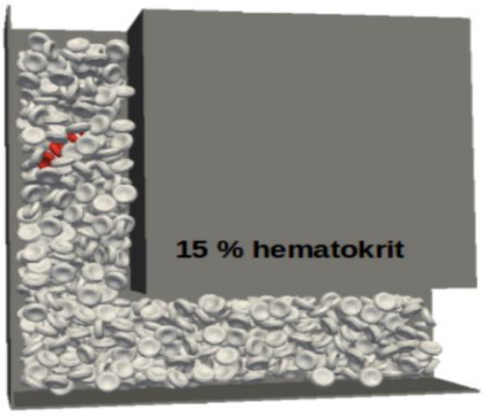

Figure 4: Simulation of red blood cell suspension with 15% hematocrit in a bent channel

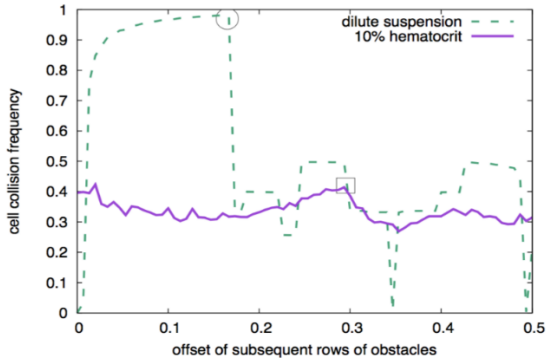

Figure 5: Cell collision frequency equal to 1 means that cell hits each row of obstacles. Lower values mean it passes some obstacles without touching. Maximal offset 0.5 means that the next obstacle is between the previous two, see Figure 6. Circle and square show different maxima for dilute and moderately dense suspensions.

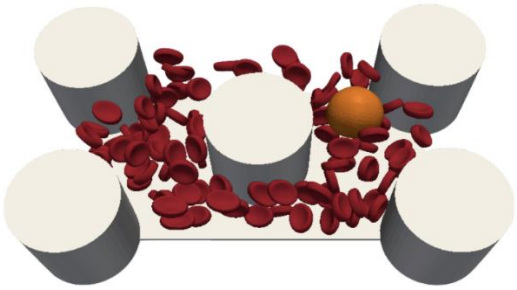

Figure 6: Simulation of a red blood cell suspension with a rare tumour cell giving information how red blood cells influence trajectory of the rare cell and its probability of capture on functionalized obstacles in periodic array

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Information systems for railway traffic planning, controlling and data management

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Research group designs, develops and maintenance several large information systems and software tools which serves in many branches of railway transport. All of them are in regular operation, but still under further development and improvement, connected to research and education activities of our department, faculty and university.

Main contractors are

- Railways of the Slovak Republic – infrastructure manager (ŽSR),
- Railway Infrastructure Administration – Czech Republic (SŽDC)
- Slovak railway company (ZSSK) – passenger transport operator Slovakia
- AŽD Praha Ltd (AŽD s.r.o) – Czech Republic,
- Scheidt&Bachmann A.G., Mönchengladbach, Germany

We briefly introduce our main activities and software tools. For more detailed information's you are welcome to contact us.

Expert - Infrastructure data collecting system

Graphic editor of railways infrastructure data developed in 1995-2000. Holds detailed proprietary database of Slovak and Czech railway infrastructure. Master source of infrastructure data for other railway information systems in Slovak Railways.

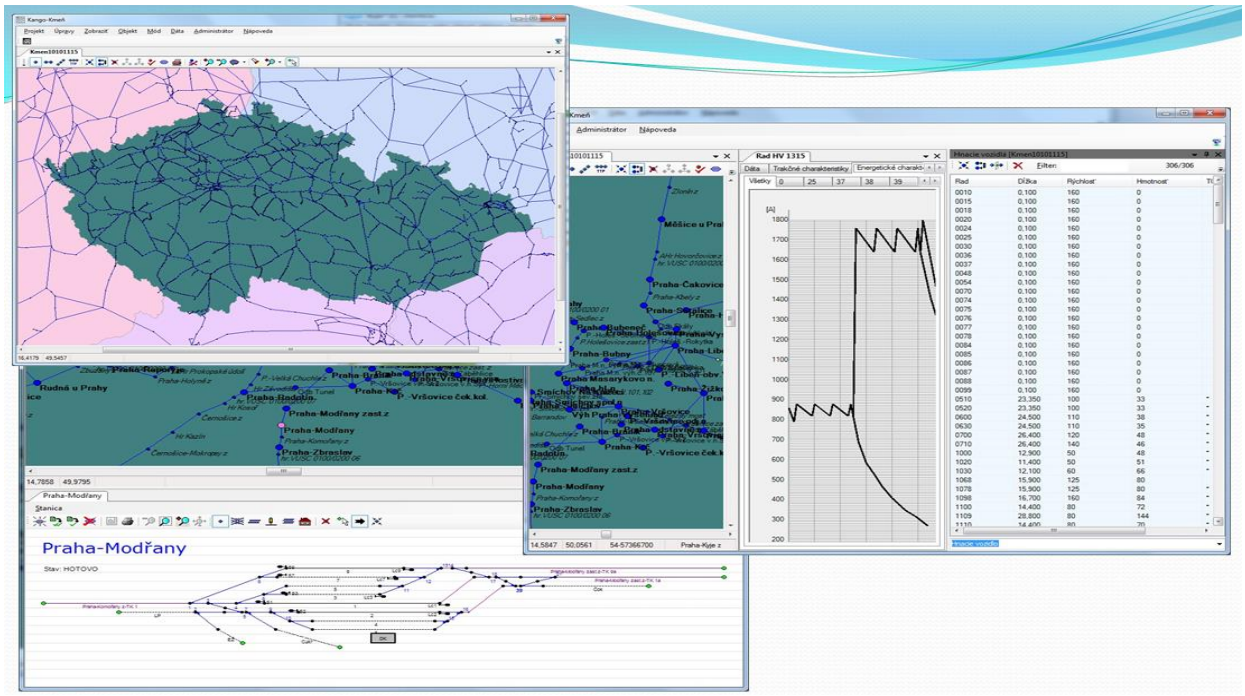

Figure 1 – Expert, KANGO Kmen: systems for railway infrastructure data management

KANGO Kmen – essentially improved infrastructure data collecting system for Czech Railway
Infrastructure Administration, developed 2008-2012. Detailed database based distributed system of Czech railway infrastructure. Master source and management tools of infrastructure data for other railway information systems in Czech Railways

ZONA and SENA railway schedule planning systems
First generation of time-table constructing systems for Czech and for Slovak railways Developed in 1990-1996 and used approximately until 2012-2014 as the main tool for long term railway traffic planning. Represents new approach and fundamental changes of the railway schedule planning process. Gives rise to quality increasing and further usage of obtained digital railroad transport plan.

MET – business train route editor
New generation graphical editor developed and used since 2009 in Slovak railways. Allows the basic input and editing train paths, assigning of train equipment essential attributes (driving vehicle, length, weight, assembly, ...), design of train time position. Strongly connected by two-way communication with the system ZONA.

KANGO-GVD – improved railway schedule planning systems for Czech railways
Based on new software and database architecture, allows centralized on-line timetable construction with new conception of data storage. Used from 2012.

EDYN – new generation of railway schedule planning systems for Slovak railways
New developed time-table construction system with new architecture, user interface and all algorithms and tools. In use since 2014.

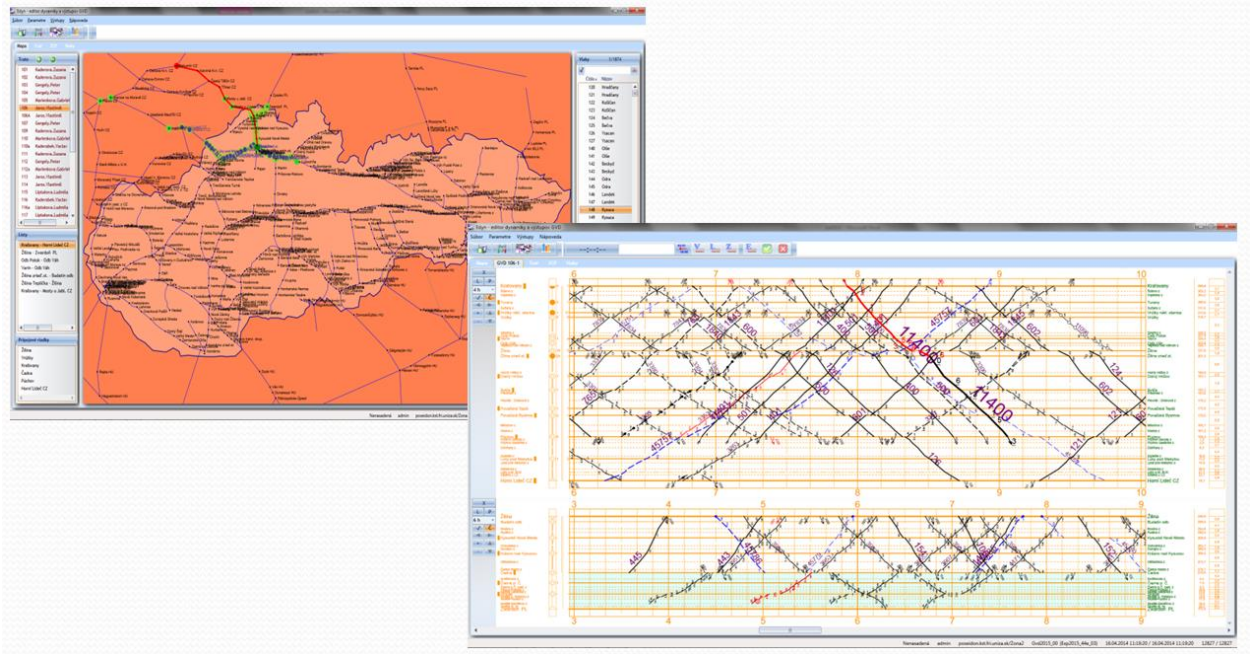

Figure 2 – Edyn - new generation of railway schedule planning systems for Slovak railways

GTN - Information System supporting the dispatcher and remote tracks control

Developed since 1996 in co-operation with AZD Prague Company. Contains a compact data, technology and software model of railway operation. Receiving information from the safety, interlocking and signalling equipment and from the other information and controlling railway systems serves as an supporting tool for dispatchers in the control centres. Performs saving, displaying and documenting of the traffic progression, trains movement and technological operations on them, displays the anticipated prognosis of the traffic situation and transmitting information about trains movement towards external IS, e. g. the passenger information systems at the stations etc. Currently 3rd generation of this system works on nearly 4000 km of Czech and Slovak railways.

Figure 3 – GTN system as a part o fcentral dispatching office

wVis - Train connection searching system

Used by Slovak railway company (ZSSK – passenger transport operator) for external and internal connection search. Developed since 2004 with cooperation of HP company.

EboEdit ERES – railways interlocking and signalling systems configuration Editor

In cooperation with Scheidt&Bachmann company developed and used since 2009 and used for Austrian, German and Poland interlocking systems design.

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Memristive Implementation of Fuzzy Logic for Cognitive Computing

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Today's digital computers are based on three cornerstones: von Neumann architecture, Boolean algebra, and transistor as the basic element. Approximately 70 year history of this concept has demonstrated a success for algorithmic computing. However, at present its disadvantages begin to appear in real time cognitive computing. Our aim is to elaborate the concept in which cognitive computing acts as a support for algorithmic computing, and the cognitive part is based on non-von Neumann architecture, Zadeh fuzzy logic, and resistive switch as the basic element [1].

We have found [2] that elementary circuits with resistive switches can give result for Min, Max, Avrg functions in voltage domain. This has the significant impact to the fuzzy computer architecture.

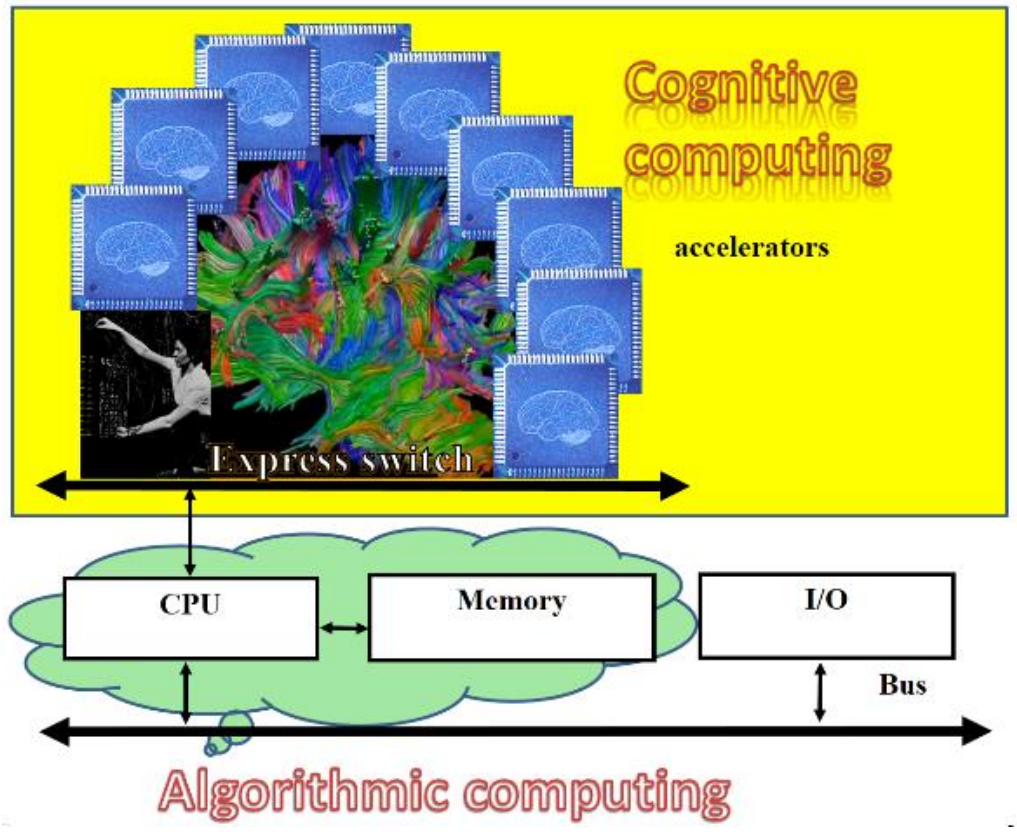

Figure 1 – von Neumann architecture accelerated by non-von Neumann architecture

Fig. 2 shows an example of the implementation of Y=Max(0,X) function using electrochemical metallization memory (ECM) resistive switches NEURO-BIT BT10001B14 [4]. To interpret this figure in terms of fuzzy logic, the input X after normalisation from <-1.5V, 1.5V> interval into <-1,1> interval represents the difference X=a-b in y=Max(a,b); a,b∈ <0, 1> function. Accuracy of mathematical function implementation depends mainly on switching threshold (approximately 0.2V for the measured resistive switches), and measurements repeatability. On the one hand, the non-volatility is useful, but on the other hand, the preservation of the switch state causes a memory-less in the input

– output relation in the Max circuit. More precisely, fuzzy logic circuits have to be assumed as state automata. Everything mentioned above for implementation of Max functions, is valid also for Min functions.

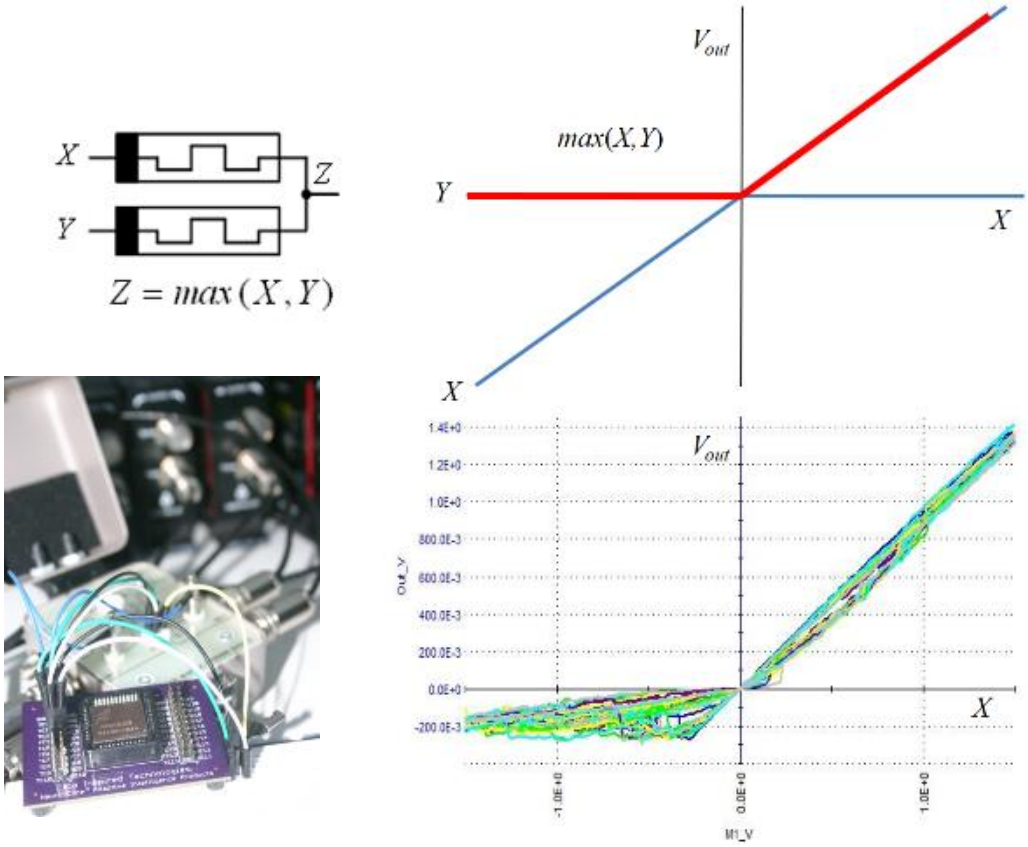

Figure 2 – The input/output characteristic of the Max circuit implemented by ECM memristors NEURO-BIT BT10001B14

Fig. 3 shows an example of the implementation of Y=Min(0, X1, X2) function. As the independent input is taken M1=X1, X1∈ <-1,1>, the second input is set into M2=1-0.7(1+X1), and the third one is a zero reference input. An impact of the switching threshold is visible even more than on Fig. 2.

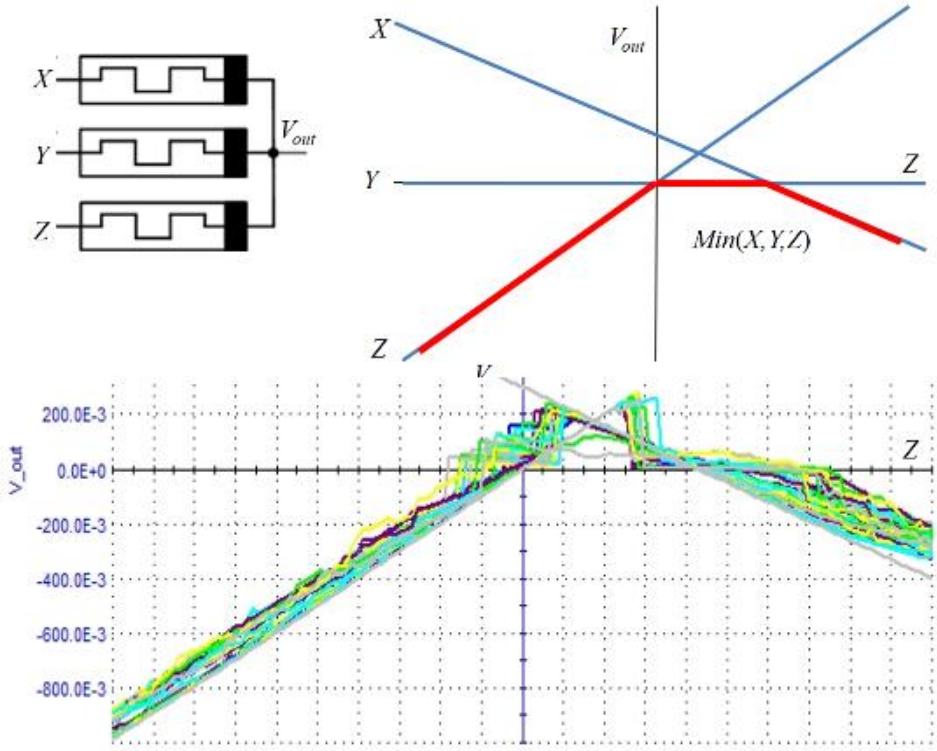

Figure 3 – The input/output characteristic of the 3 inputs Min circuit implemented by ECM memristors NEURO-BIT BT10001B14

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Mobile robots and their integration into the IoT world

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Mobile robotics systems for educational purposes come still more and more to the foreground especially in terms of modern teaching. This progress goes hand-in-hand with OpenHW systems advancements, which enable a wide community of people to enter the world of computer engineering.

Yrobot high-school education kit was for the first time introduced at 2014 RAAD conference. From that time, already after 18 months, the robot was successfully integrated into the educational process in more than 20 high schools in Slovakia. During 2015, we decided to extend the kit with additional application modules to target an actual problematic of wireless communication and derived areas, such as Internet of Things; Collaborative Signal Processing; Distributed Signal Processing; etc. For that reason, Yrobot modules „Y-WiFi“, „Y-BlueTooth“ and „Y-ZigBee“ were introduced.

These modules can be easily installed within the platform, where provided functionalities, which can be easily translated into educational process. Especially in the popular fields such network administrator or network specialist.

To understand the concept of Yrobot, we have to mention an effort of Volkswagen Foundation, which was supporting the project continuously from 2013. The idea behind was to develop an educational kit that can be used for the purposes of IT education among the Slovak high schools. Original intent of authors was, by using of a simple technical device, to increase the motivation of secondary-school-students in the study of technical fields. Among the others, especially to arise their interests in information technology. The concepts of the system, its features and functions, as well as initial results from deployment in teaching were presented in international conferences on robotics.

As supporting activities, different workshops, where particular teachers got in first touch with the platform, were realized. To facilitate the work with Yrobot, the textbook where basic principles together with programming examples were described by the usage of simple, friendly and easy-to-understand way was published (Figure 1).

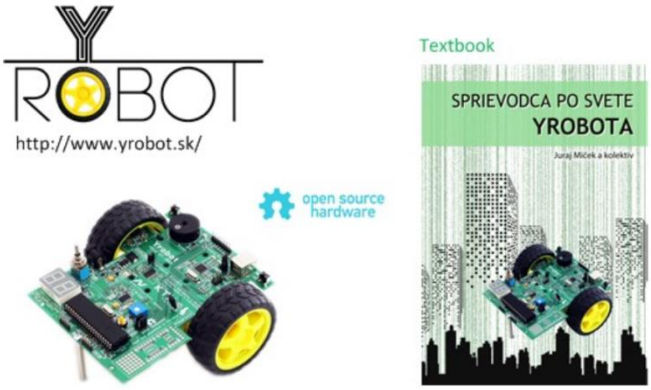

Figure 1 – Yrobot with textbook (Slovak Release)

RF Communication Expansion Modules

The Yrobot was originally developed as an autonomous Yrobot device capable to solve simple tasks by reading the status info of installed sensors (e.g. moving across the line, avoiding obstacles, discovering the space, ect.). Implementation of wireless communication allows transformation of Yrobot from single and autonomous functioning to robust multirobotic system able to solve the robust challenges and to bring the complex solutions. For an effective operation of the system it is possible to use various communication technologies, protocols and different network topologies. In our approach, we decided to implement three separate communication modules operating in the 2.4 GHz ISM band.

Figure 2 – Yrobot with Y-WiFi module

An extension of the Yrobot kit by the set of network modules significantly expands the variety of applications that can be implemented under it. The kit is since its inception conceived and designed for the needs of teaching of subjects in IT. In addition to this primary function, the kit serves also the popularization function. The kit should be used for an encouragement of the students for the study of the technical subjects/fields.

In the near future, the focus will be put on the development of interesting and original applications designed according to experiences with the communication modules usage. The delivery of supplementary textbook is in this case more than necessary. In the textbook, the basic capabilities of individual RF network technologies supplied with the simple examples, that will illustrate the benefits and limitations of wireless communication, will be described. Hopefully, other interesting applications, which could motivate the students to the own further development, will be part of the textbook too.

Further steps are, beside the textbook development, oriented in the development of additional modules in the field of RF communication. At the present time, RFID, NFC, Z-Wave modules, together with the chosen proprietary communication systems in the free ISM bands (e.g. RFM70), are being developed. It is expected that these extensions will expand the current status of the kit with other interesting ICT applications.

Fair optimal and reliable emergency system design

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Efficient and reliable emergency rescue systems, such as emergency ambulance system, police or fire brigades, are important for everyday life of concurrent societies. To ensure the reliable services, that an emergency rescue system has to provide, it is important to consider the reliability criterion, when the system is designed and not only while it is already in operation. The reliable system should have the ability to withstand consequences of failure events that may occur as the system is serving users. The probability of such events is relatively low but such events may have serious consequences and may significantly affect the quality of services that are provided by the system. In addition, very often when designing the emergency rescue systems, it is applied the criterion taking into account "the average user". As a consequence, the proposed system is incompatible with the requirements/expectations of users – taxpayers, who would like to have an equal (fair) access to the offered services. Here arises the need to apply fair approaches when placing service centres, which are able to consider for example the situation of the worst placed user. Emergency rescue systems can be considered as public service systems.

Our research team has long-term experiences in developing algorithms and decision support tools to solve large-scale public service systems based on modern information technologies which enable providing an effective decision support on how to use available resources efficiently to achieve various goals. Such decision support tools are necessary mainly if there are many feasible solutions available and it is not easy to choose the best ones or it is hard to find any solution which would meet the requirements at all. From the viewpoint of designing a solution for a defined decision problem, the first step consists of creating a model expressing the desired objective and a mathematical expression of the options how to achieve the objective. Using a suitable optimization algorithm integrated into a decision support tool, one or more feasible solutions can be found. The solutions are then provided to people responsible for decision-making in the particular field.

The field of designing the structure of emergency rescue systems has been one of our core research areas for a long time. Currently, we deal with the research projects that has the following objectives:

- To propose methods allowing considering various criteria of fairness in access to the provided service and propose efficient algorithms for designing reliable emergency systems
- To propose algorithms that will be able to solve tasks with quality criterion, which is more complex than commonly used min-sum criterion. We focus on criteria, where user interaction with multiple centers is taken into account and criteria, which reflect stochastic properties of the system such as reliability.
- To acquire new methods and techniques for solving public service system design problems with fair sharing criterion
- Based on real examples, to evaluate the relationship between the service system effectiveness and the fairness level in access to services that the system provides

Development of optimization methods

In the field of optimization methods, we are seeking new possibilities of applying general optimization tools such as Xpress-IVE. Here, we have proposed efficient methods of approximate solving of location problems by their transformation to a case of set-covering problem that is less time consuming. In the field of specialized algorithms, we have suggested and developed new exact algorithms that enable effective solving of large-scaled location problems. Furthermore, we focus on development of new heuristic and evolution algorithms.

We use experiences that we have collected while solving our research projects where we dealt with mixed integer problems and with the optimal design of public service systems. We built tools that are able to solve real-world instances of public service system design problems. Considering, that the application area of these projects were public service systems, the suitability of the resulting system design is typically evaluated using the sum of all costs that are proportional to the distance between users and facility locations. In addition to this, we have also modelled the demand of users using utility. Special case is the utility that takes into account individual users. This approach leads to the fair optimization and objective function that take into account equality. Considering the equality criterion, we have constructed the approximate algorithm that allows to find high quality solutions for real-world sized problems.

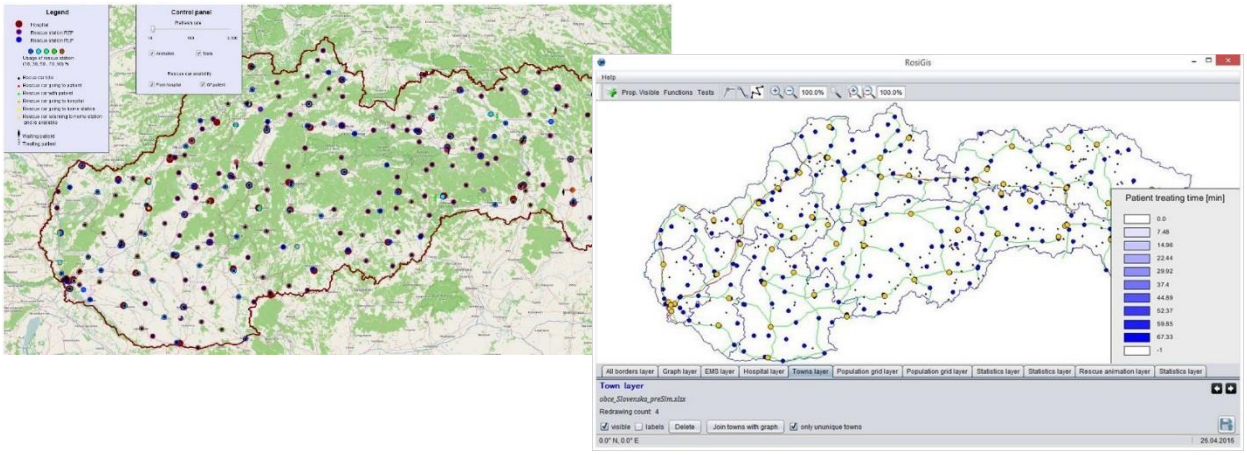

Figure 1 – Evaluation of emergency medical system proposal (location of ambulance stations)

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Reliability Analysis of complex Multi-State System

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The present status and level of technology brings new needs in the development of the reliability engineering. The current technology allows for a virtually fail-free operation of technical systems; under such conditions, the reliability engineering methods in the traditional interpretation of unusable. A wide range of tasks exists for which the reliability analysis, guarantying interoperability, decreasing the risk of adverse situations or events and created reliability engineering methods are an efficient tool for solution. For example, they are tasks such as assessing the risk of terrorist business analysis reliability, estimate the risk and consequences of technological accidents and others. Such systems are complex in its structure, non-homogeneous due to their physical nature and also contain components with different failure processes, degradation and failure. Therefore, complex systems and socio-technical systems are actual investigated subject in reliability engineering. Examples of such systems are nuclear power control systems, oil and gas transportation systems, healthcare system.

Therefore, development of the basic conceptions of the reliability analysis has to account the specific of the actual technologies. The reliability engineering elaboration will be based on the principal modification of basic conceptions and one of them is change of the mathematical interpretation of the initial object. There are two principal mathematical models in reliability analysis. These models are Multi-State System (MSS) and Binary-State System (BSS). BSS allows representing the initial system as mathematical model with two possible state that are complete failure and perfect working. MSS permits to consider more that only two states in behaviour of system reliability or availability. But these mathematical representations don't use in reliability analysis widely because has two disadvantages. First of them is computational complexity. The introduction in the analysis additional system performance levels and components states causes dramatically increase of the mathematical model dimension. The second is complication in development of methods and algorithms for estimation of MSS. At the present time there are not a lot of effective methods and algorithms to calculate different indices and measures of MSS. **Therefore, the development new approach in MSS analysis is actual problem in reliability analysis.** We propose to develop MSS analysis based on mathematical approach of Multiple-Valued Logic and representation of initial object by structure function (Fig.1). The concept of the structure function is used to represent BSS and MSS and associates the space of component states and system performance levels.

In most studies, structure function is usually assumed to be precise and ambiguities are not taken into account: the structure function defines correlation between components states and system performance level for all possible components states. Therefore, the definition and construction a structure function can be a complex problem in some cases. This means that the structure function may not be realistic in real-world applications, because data about the real system is uncertain, as a rule.

The uncertainty of initial data for the construction of the structure function can be caused by two factors. The first one is ambiguity and vagueness of collected data, because any value for this data has an inaccuracy or error of measurement. For example, this ambiguity can be caused by an error of measuring instruments. Therefore, the collected data values are associated with imprecision. The second factor is incomplete specification of data, because some values of system components states or performance levels cannot be obtained. This factor brings about some incomplete values of the

system components states or performance level. However, it will be very expensive in terms of resources or time to obtain a complete set of data. Therefore, the uncertainty of initial data must be considered in the structure function construction and development of methods for its analysis.

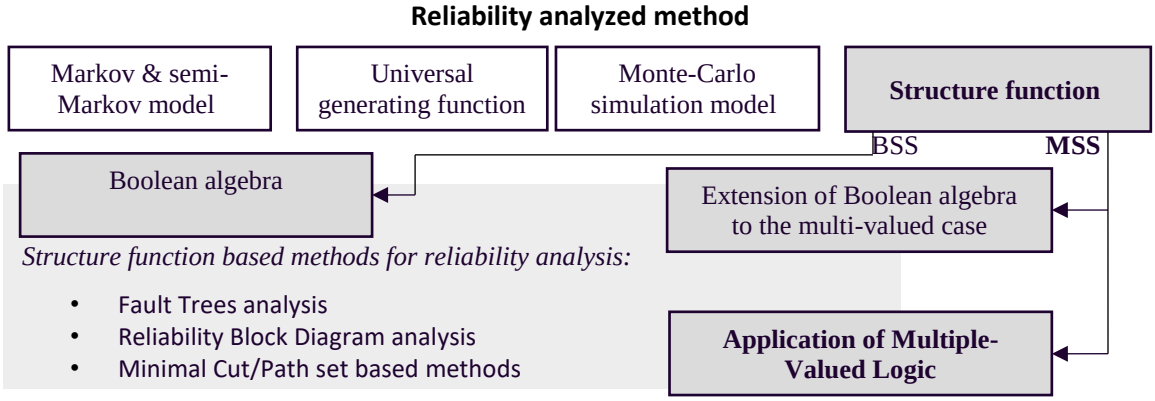

Fig.1. Classification of methods for MSS reliability analysis

We propose a method based on the application of Fuzzy Decision Tree (FDT) that includes next steps (Fig. 2): collection of data in the repository, representation of the system model in the form of an FDT, construction of the structure function based on the FDT. This method is used in analysis of many applications. One of these applications is analysis of healthcare system for Regional Anaesthesia - Regional Anaesthesia Simulator (developed under the RASimAs project no 610425 funded by the European Union's 7th Framework Program)

Fig.2 Regional Anaesthesia Simulator prototype

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Complex database management system

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The main research area of the team is the complex database management approach. With a significant data amount increase in information systems, there is significant pressure for efficiency, analytics, processing, storing and subsequent retrieval of data from the database. Therefore, such research has considerable potential. Data entering the system have different characteristics and structures and should be handled sophistically. Common characteristics, is, however, time as important element affecting system performance supported also by the number of processes, spectral analysis, decision support and so on. However, time must be managed during the entire spectrum highlighting complexity – period of validity, transaction authentication, incorrect data processing with regards on data corrections and comparing significance of changed attribute values based on Epsilon value parameters, quality and reliability. In our research and development, we therefore deal with extensive data processing, storage management, time processing with reflection on automated state management. Whereas data structures to be stored have different characteristics, our proposed solutions highlight transformation of object granularity to attributes themselves or group of attributes. Thus, it requires complete rebuilding of paradigm defined by conventional database access. Our team manages data using different data layers defining temporal management. Consequently, proposed solution significantly reduces and eliminates data amount to be stored and rapidly increases system performance. The first phase is to create optimized design of the data model structure. Consequently, it is necessary to define the access methods, to define structure and types of queries. Complex data management is protected by the integrity management. Moreover, to optimize performance, multiple index structures and types are defined and then evaluated to emphasize suitability profile and actual statistics enabling creating optimal environment. We also concern on the correct parameter settings of the database server itself, its administration, optimization and bottleneck identification at all levels.

Finally, because the area of research focuses mainly on intelligent transport systems and hospital information systems, mostly covered by brain tumor detection, result set of the processing, evaluating and storing. Fig. 1 and fig. 2 show the hospital information system based on marker value processing. In this field, it is inevitable to ensure also the overall security of the database system.

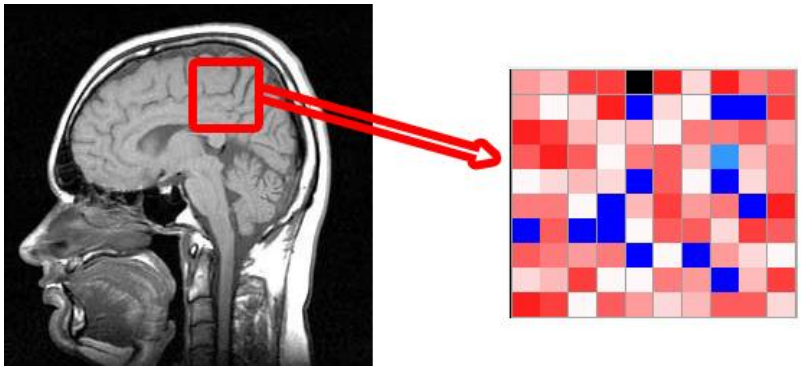

Fig. 1. Brain tumour detection

Hence, the emphasis of our research and development is also data security, SQL injection, audit, profiling, data hiding at column and row granularity level, definition of access rights as well as system administration to protect data and eliminate access to sensitive data stored in the database.

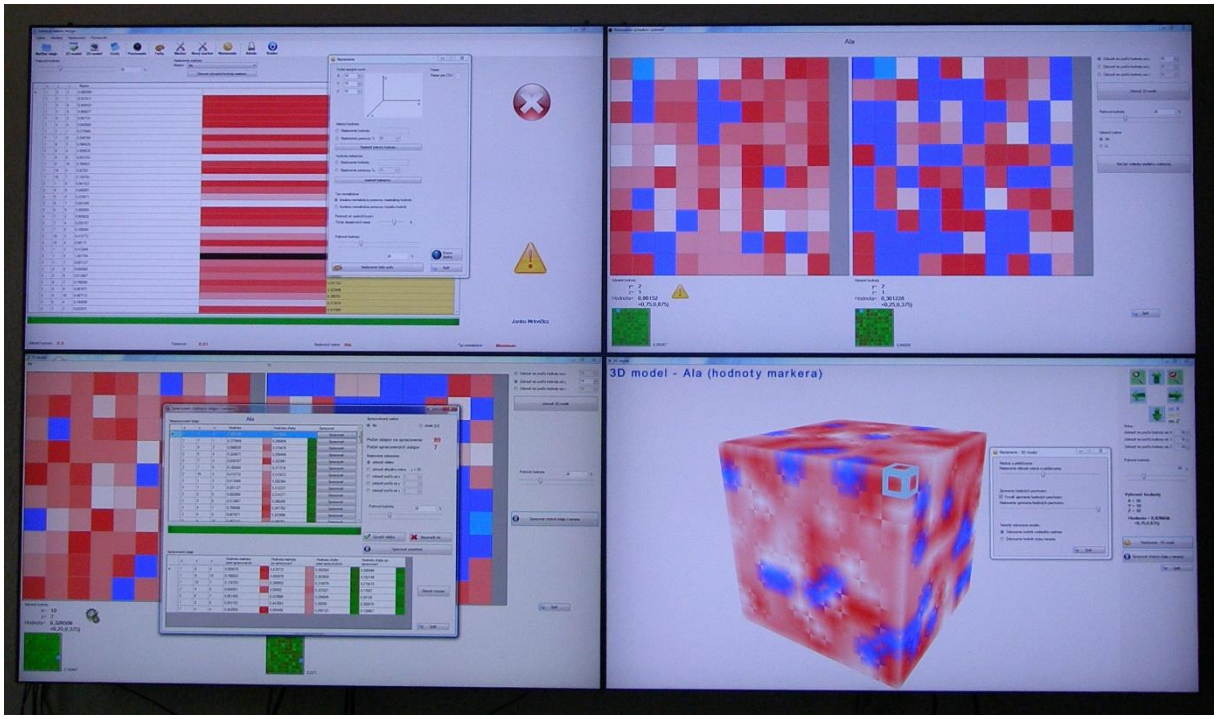

Fig. 2. Brain tumor detection system - visualisation and processing using 4 monitors

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Innovation Management - the process strategy and performance

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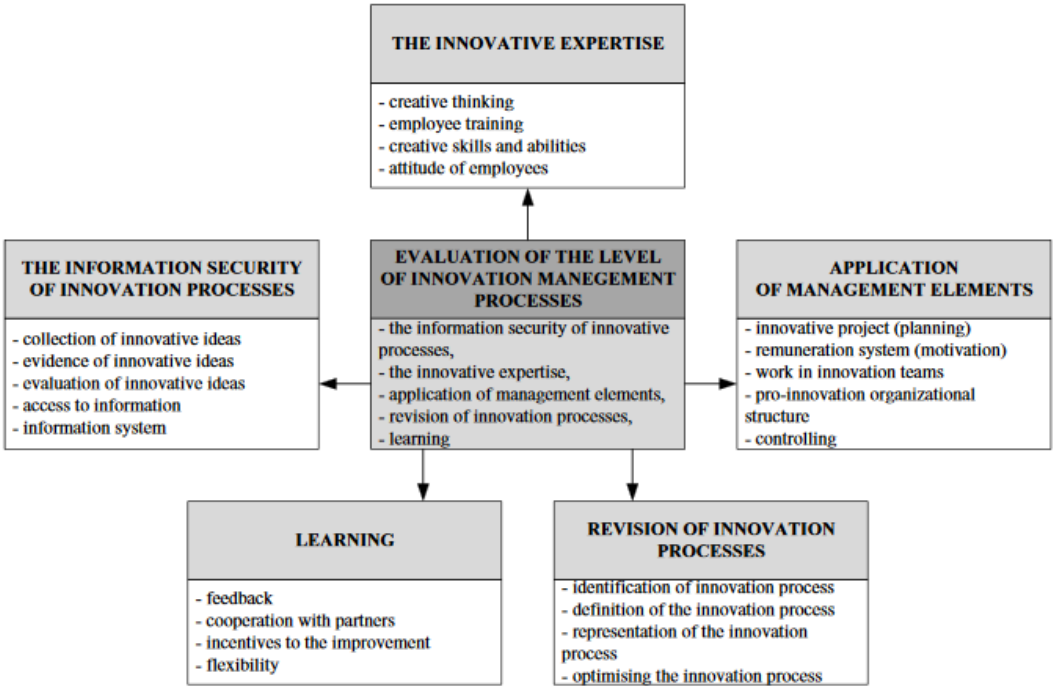
The research concerns with an important and current issue of work with innovation, focused on analysis of current state (research and statistical surveys, formulation of basis, preparation of innovative processes, proposal of innovation strategy (preparation, proposal and implementation), assessment of innovation performance (proposal and implementation) as essential elements of innovation management in the business. Presents and develops methods, approaches and techniques of work with innovations and proposes the corresponding procedures for solving particular tasks of strategic management. The result of this project is collect of theoretical and practical knowledge and proposals of selected work procedures with innovation, innovation processes, model innovation strategy and evaluation of innovative performance. Project is helping to develop theoretic bases and make for development of scientific base of management specific important area in competitive advantage assurance of business – innovation management.



The main goal of the research is the creation and development support of scientific foundations of innovation management – expanding knowledge basis in management, based on work with innovations.

Innovation and business innovation capability is now considered as essential condition its competitiveness in global markets. In a changing business environment, there are increasingly demanding customer requirements, increasing competition, technological development and globalization, innovations are the tool for adapt to these changes.

Research solution is divided by content into four basic problem areas. These areas are treated as relatively independent topics in the project – sub-projects. Each subproject has its own distinctive object, instruments, manner and other requisites, so it may be solved separately as well. Obviously, such partial approach is coordinated jointly to fulfil the above-mentioned main goal of the research.

The objective of the problem area A. is the analysis and design of theoretical and practical basis for working with innovation in terms of successfully operating businesses.

The goal of the problem area B. is continuing in drafting the basic premises for the work with innovations - primarily the preparation of innovative processes in businesses.

The goal of the problem area C is the concretization of work with innovation in the business in the form of training, development and implementation of innovative strategies in the business.

The goal of the problem area D is the concretization work with innovation in the business in the form of business innovative performance evaluation model.

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Diagnosis of Specifics and Determinants in Strategic Management of Sporting Organizations.

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The research project deals with the specific issue of management of sporting organizations in Slovakia. The project is aimed at diagnosing the specifics of management of sporting organizations and the scientific determination of the determinants of their effectiveness, analyses the current state (research and statistical surveys), formulation of baseline (synthesis and systemization) and the actual design own model of strategic management of sports organizations. Presents and develops methods, approaches and techniques work necessary to ensure effective strategic management and marketing of top sporting organizations and suggests to them the corresponding processes and solutions. The result of the project is organize of specific theoretical and practical knowledge to model effective strategic management of sporting organizations, including appropriate guidance, tools for effective management a marketing and cooperation activities, taking into account innovative approaches to tackling these problem.

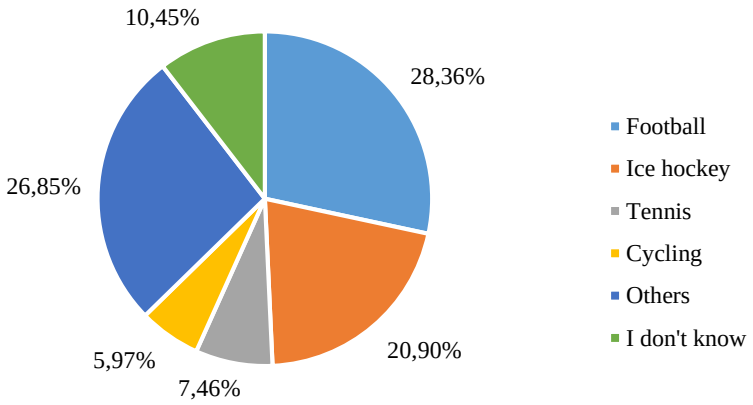

Figure 1: The best sport for sponsorship

Environment of sport has a special meaning in a society, covers a wide spectrum of stakeholders and is characterized by significant particularities that distinguish it from the business environment. The most significant differences are mainly in the nature of the stakeholders, which are typical for its dynamic interconnections and behavioural changes. Managers of sporting clubs and other organizations operating in the field of sport, often have the problem of these factors to understand and respond effectively. The problem resides mainly weak analysis environment, poor management skills and experience, as well as insufficient theoretical foundation. In terms of the level of professionalism of the management or ownership structures in Slovakia is high differentiation sports organization. The impact and relationship of individual factors in Slovakia is not yet proven exactly,

but it can be stated that successful but also unsuccessful sporting clubs and organizations on both sides of the spectrum. One of the most common reasons for unsuccessful action sports entity, it becomes particularly for smaller clubs is an amateur management, which is subject to frequent personnel changes. Club manager, respectively club management is often deals with problems in a given subject, only if the events have a vested interest in the club. Especially if their children, relatives are active in competitive sports and represent the club. As soon as the manager of the club will lose the motivation, the club went into the lead and are getting new people without any linkage with previous guidance. Thus the non-continuous taking over control and management of the club begins again, with a new vision. To follow a weak and ineffective marketing club activities. Clubs and sports organizations working in a very small extent using low-cost marketing and communication tools, channels, or poorly developed public relations and sponsors.

The base aim of the project is research, theoretical and methodological treatment of specific management of sporting organizations and propose model its strategic direction. Support for the creation and development of scientific foundations of management and marketing in organizations operating in the sport. The main objective of the project is based on a detailed diagnosis of expert scientific processing of the information obtained to design processes and models of effective management and functioning of sporting organizations. The project will be divided into two main parts. The first part will be analytically oriented, the other will develop proposals, models and publish the overall results achieved specifics of management of sporting organizations.

Model-making and strategic management of sports organizations in the Slovak Republic states for use in managerial praxis of management of sport organizations. Identification of individual circumstances and determinants of strategic management of sports organizations to establish and maintain a functional, efficient and sustainable management model sports organizations in practice.

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Stochastic modeling of decision-making processes in motivating human potential

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The reserach intends to develop a current knowledge base of scientific management and management systems and to create a stochastic model applicable to more efficient decision-making and more targeted to motivate employees and managers. Creation of the model will be drawn in two planes, in the managerial and in the mathematical, which overlap and interact. The model will respect the multidisciplinary managerial, psychological, sociological and behavioral approach, and on the other hand, a look that will try this whole process to express by the mathematical model as the system of the well-defined elements, their properties, relations and determine the measurable and quantifiable regularities. The model will be continuously tested using stochastic simulated random data and after the end of planned questionnaire validated by analysis and meta-analysis of empirical data (including data from previous surveys within the project VEGA 2004, 2007, 2011). An important attribute of the model should be its considerable.

Motivation as an intrapsychic process and motivation as managerial and behavioral process is very complex and contain a large number of parameters. These are mostly identified from the perspective of management. Their specification and analysis, however, take place only in verbal, descriptive plane, at most in the plane of the elementary statistical methods. Deeper mathematical analysis and quantification of complex relationships practically does not exist. As well the forecast of the future is mostly intuitive and empirical level, but it is missing the support of a specific validated mathematical theory. From a statistical point of view the model will have to be based on a sufficient amount of relevant empirical data obtained from polled appropriately. Crucial conditions, and motivating factors must be determined on the basis of statistical analysis and appropriate statistical and mathematical models.

Nature of the factors deciding on how to motivate

Nature of preferred factors in the motivational decision making	**Frequency of employees' expressions** (Number/%)	**Frequency of managers' expressions** (Number/%)
Quantitative factors *(required amount of performance, deadlines tasks, costing, labour productivity, number of improvements and the amount of savings, expected rewards)*	556 33,92 %	44 14,33 %
Qualitative factors *(create new value, the expected satisfaction and self-fulfillment, quality of relationships, the degree of belonging, improve skills, higher self-esteem)*	297 18,12 %	70 22,80 %
Quantitative as well as qualitative simultaneously	709 43,26 %	191 62,21 %
Without respondents' expression	*77* *4,85 %*	*2* *,65 %*

Complex goal of the1-st stage: A detailed analysis of existing theoretical basis, approaches, models in the branch of influencing work motivation expressed in the terms of management and mathematics. Partial goals:

- Establish uniform terminology so as to meet the managerial and mathematical language.
- Identify the applicable mathematical methods for model creation.
- Analysis of the existing methodology motivation and motivation, to prepare appropriate questionnaires for field research in the field of work motivation.

Complex goal of the 2-nd stage: Establish an initial decision model (prototype), realize its theoretical verification and prepare empirical data. Partial goals:

- Analyse various mathematical tools suitable for quantification of verbal data.
- Propose an initial mathematical model based on the managerial and mathematical view, from the perspective of the employee and the manager, make his test by simulated random data and perform continuous modification of the results obtained.
- Realize the field questionnaire survey.

Complex goal of the 3-rd stage: Create a final version of the stochastic decision-making model and its verification by empirical data. Partial goals:

- Analysing data from the questionnaire survey and prepare them as input data model.
- Verify model through empirical data, evaluate the data under the modified mathematical characteristics.

Many of the current managers have technical training and for them is more convenient austerely mathematical expression. Therefore, the created complex stochastic decision model of the human potential motivating with the predictive ability can be a significant help in their daily practice. Since the integral part of the model will be also the managerial perspective, it will be the significant help for all the people who have the ambition to motivate others, but also himself.

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Marketing management in cooperative environment - Proposal of strategic cooperation management implementation model

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The project is focused on issues of strategic marketing management in a specific market environment, which can be described as cooperative. Cooperation environment can be defined as specific relationship cooperative subjects. This environment is oriented competitively against other players on the market. Processes that lead to the success and development of inter-organizational cooperation will be scientific analysed, as well as the principles of strategic management such cooperative organizational structures. Based on the obtained knowledge will be created: model / models of strategic management of cooperative links; definitions of the main principles of strategic management of cooperative clusters (main recommendations based on detailed analysis of the literature, as well as real existing cooperative links); definitions of the main processes that lead to the creation and maintenance of a functional and effective cooperative clusters.

Cooperation management is based on long-lasting cooperation and partnership between several market subjects. These interconnections are oriented on gaining of competitive advantage. This alliance could be also an instrument of competitors' fight. All the relevant areas of cooperation management topic are related to the cluster principle; which main areas are crucial for every cooperation interconnection. Existence of successful clusters is evidence that small regions can also be successful in global competition. From the global point of view clusters have been an efficient form of organization of economic activities.

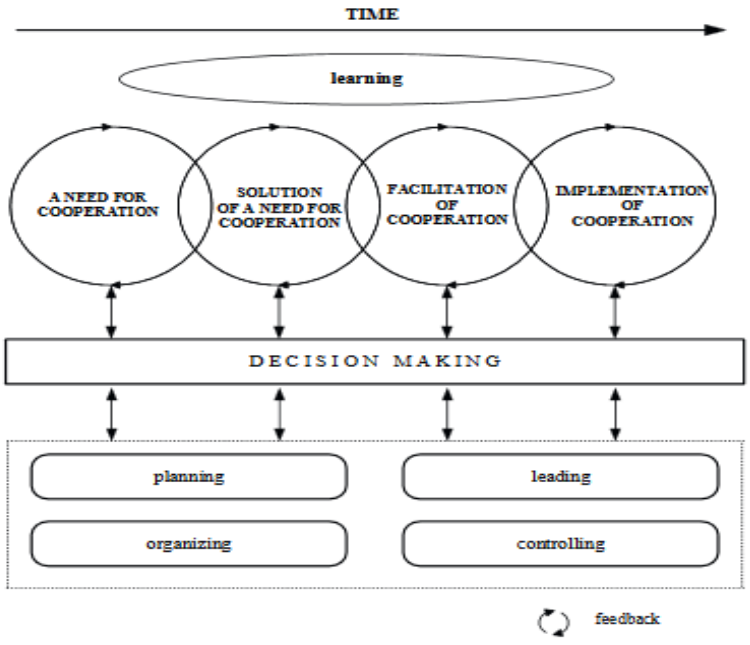

Fig. 1 Model for Effective Management of Cooperation Activities in a Company

The Project will be divided into two main parts. The first part will be an analytical one, the second part will present designs, models and publish total gained results. Scientific goals of the first phase of the Project:

- Analysis of relevant literature (mainly in databases science direct, Scopus, web of science...)
- Analysis of issues in Slovak republic
- Research in organizations based on co-operations (e.g. cluster Z@ICT)
- Analysis of secondary data
- Analysis of the matter of cooperation of selected examples from abroad: Analysis of the globally most successful cooperation interconnections (reason, focus, management methods, etc.)
- Analysis of main principles strategic management of cooperation's clusters
- Analysis of processes of making cooperation in selected states of EU and world: methodology, support, financial frame, positives, negatives and problems

Scientific goals of the second phase of the Project:

- Scientific expertise of the analyzed facts
- Elaboration of a model of making and strategic management of cooperation links in the Slovak Republic
- Recommendations and principles for management of cooperation's clusters: for its creation and sustainment; for strategic, tactical and operational management; for the use of the cooperation procedure under increasing competitiveness in the market

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Cost models in transportation companies

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The spheres of business of companies include manufacturing of products, provision of services or a combination thereof. In a transportation company the sphere of business includes mainly shipping services. Shipping activities, as any other activities of a production or service company, are immediately associated with costs. In comparison with other businesses, transportation companies have their characteristic features which result from the essence of the shipping activity. The main mission of transportation companies is to provide shipping services to their customers, i.e. they do not produce (manufacture) products.

Costs and proceeds fundamentally influence normal and sound functioning of any transportation company. The shipping costs make it possible to assess quality of the work as they express how much has been spent on one service, including its implementation. Decision-making about implementation of a shipping performance is nearly always based on comparison of the costs and proceeds. Transportation companies use the term of costs in the sense of consumption in general. It is reasonable to use the term working costs because they represent costs relating to a particular performance, activity or department of the company. The working costs in transportation represent consumed materialized and live work and financial means expended on shipping and other performance in a particular period of time, under typical conditions of a reproduction process in the individual transportation departments or transportation companies.

Cost management seeks to change the course of implementation of the shipping activity so that the costs decrease, with subsequent search for the means and sources to reduce them in the future. This can be achieved if the company has a developed cost management procedure. Scientific research has confirmed that the use of modern methods of process management makes it possible to improve the performance. Fig. 1 shows a general and comprehensive cost management procedure which can be adapted to specific conditions of a company.

The aim of our research is:

- Creation process of cost management based on holistic approach to improve business performance,
- Differentiation of cost management approach by business activities,
- Decomposition of aggregate variable costs, to seek resources and means to reduce emissions to ensure long-term development of business growth,
- Linking of management value with the value expression of the transformation process (costs, revenues, profit).

Our research was carried within the scientific projects:

- VEGA 1/0652/16 Impact of spatial location and sectoral focus on the performance of businesses and their competitiveness in the global market,
- VEGA 1/0421/13 Attribute efficiency and human capital

- VEGA 1/0526/13 Modelling multilateral relations of economic entities and increase the quality of their decision-making processes with ICT
- VEGA 1/0495/08 The design of new approaches and methods for assessing the effectiveness of exploitation and optimal combination of production inputs with the application of macroeconomic and microeconomic a priority focus on human capital
- VEGA 1/0499/03 Diagnostics input entities of the transformation process of the company.

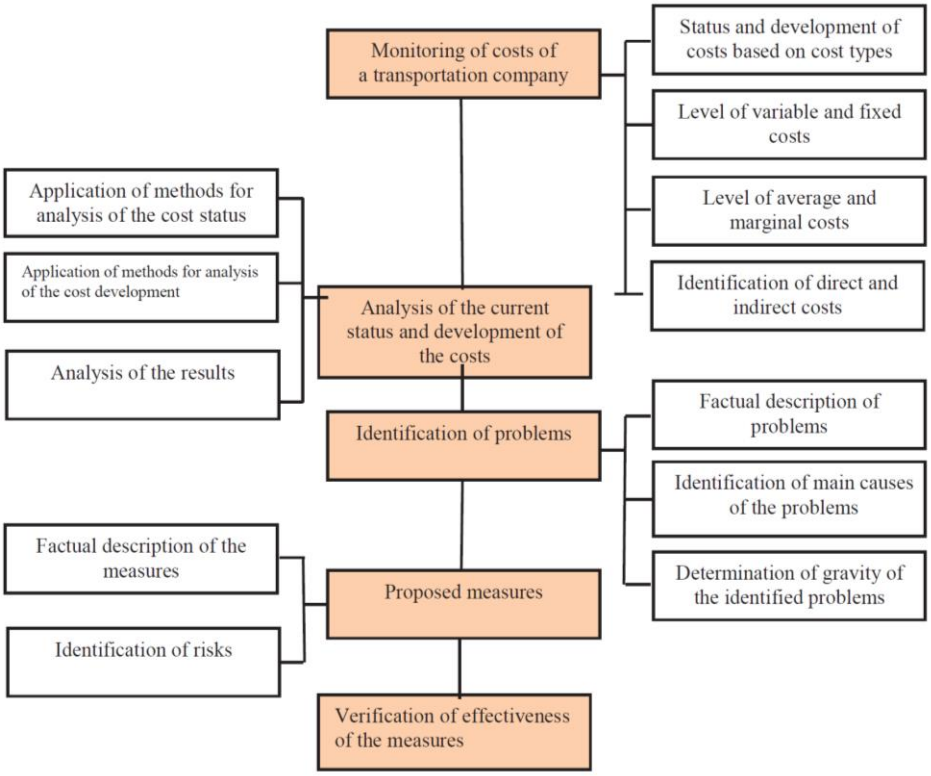

Figure 1: Costs management procedure in a transportation company

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Effective using of production inputs with a priority focus on human capital

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Each economy or enterprise needs to use and combine the available production inputs for producing the output in their transformation process. If they want thrive, in their own interest is efficiently use all of these inputs. One of production inputs is human capital. In the process of using the human capital are created the positive externalities, which are manifested as a higher level of knowledge of health and population, transfer of knowledge between members of the household and higher level of innovation, increased competitiveness of countries, businesses etc. If the company or economy wants to prosper, is in their own interest to make the effort effective use of all available inputs. The same is true regarding the use of human capital as a production input.

In the last period at the corporate level looks at human capital over the asset, one of the components of the market value of the company and, together with the structural capital as part of the intellectual capital. Human nature activities undertaken in enterprises which seek to efficiency, competitiveness and prosperity is just personified in the definition and understanding of human capital. It was therefore only a matter of time that is in technical terminology introduced the concept of human capital management.

There are several definitions and approaches to understanding human capital. After summary, comparison of all the above opinion, we can say that their common base is: definition of the human capital is the sum of inherited and during the lifetime of acquired knowledge, skills, experience of capacities. Based on our own experience, it is possible to expand the definition of human capital. The human capital considered also talent, intuition, creativity and competences of the individuals they are spending in achieving their, business and societal objectives.

After comparing different views on the definition and understanding of the human capital, we have proposed a classification of human capital: in principle there is microeconomic and macroeconomic approach. In microeconomic view, there are two basic approaches. In terms of business economics is human capital considered as production factor. Managerial view sees human capital as a business resource or asset which forms part of the market value of the company. Human capital is the component of the knowledge management, too. The macroeconomic approach sees human capital as one of the production factors, respectively sources of extensive and intensive economic growth.

The role of human capital management (HCM) is to combine the information that the management has available on the human capital in its enterprise for a number of purposes. It takes care to identify the relationship between the information and financial results. They tell us about what is going on in the enterprise. On the other hand, the data on the human capital explain why this has happened. Consequently, it is necessary for the management to get only relevant information, which will be the key to the management and improvement of the enterprise then. Only employees who are able to use their capital more efficiently can increase their share in achieving the objectives of the enterprise.

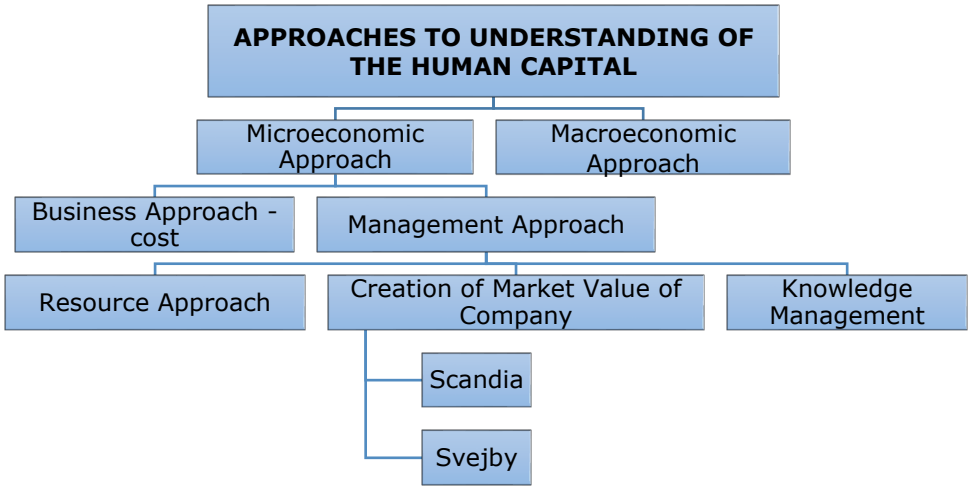

Figure1: Approaches to Understanding of the Human Capital

In connection with the application HCM began to appear information systems, which are provided by companies to implement IT systems or cloud applications. Information systems for HCM are based on the definition of human capital, which is currently in companies perceived as assets (human capital) whose current value can be measured and whose future value can be enhanced through investment.

The aim of our research is:

- Identification and analysis of the present approaches, suggestion and the proposal of the new evaluation approaches and methods for the effective inputs utilising and their optimal combination on the macroeconomic (during the total product realisation) and microeconomic level (during the transformational process) with orientation on the human capital and with an accent on the globalisation processes and the future perspective.
- Research and propose a coherent system of new approaches, methods and metrics to measure the value of human capital (in companies from various sectors), assess efficiency and effectiveness of investment in human capital, on the macroeconomic, regional and enterprise level, so that the outputs of the project contributed to increasing the competitiveness of enterprises, economies, regions and also overcome regional disparities.

Our research was carried within the scientific projects:

- The Attribute of Effectiveness and the Human Capital,
- The proposal of the new approaches and methods for evaluation of the effective inputs utilising and their optimal combination with application of the macroeconomic and microeconomic aspect and with orientation to the human capital,
- Diagnostics of input entities of the enterprise transformation process.

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Multilateral relations and responsibility of economic entities

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The economic crisis of recent years fully proved how much the world interconnected in terms of financial and economic processes and also how much the world is vulnerable in many aspects too. The phenomenon of globalization from this perspective may seem like the biggest threat not only for a national economy (as a whole), but also for single economic entities (households and businesses). The impulse to design the content of this project was to assess the consideration factors determining the decisions of economic entities given by the multilateral nature of their relationship. Now the complexity of multilateral relations and the responsibility of economic actors are much greater and the weight of their particular decision is more important. For this reason, proposals and measures to solve of the current state of the problem can be particularly useful because any type of economic actor´s decisions of, i.e. both at the macroeconomic and microeconomic level can impact on a much greater space and time context, as we have been accustomed to in times of economic expansion.

Qualitative relevant details can reduce the risk of incorrect decisions and stimulate economic and social development. Behind our market diffusion research (Fig.1) the other research topic was the description of key performance indicators and their exploitation in the decision–making process. To improve this topic, considering of the new EU requirement to include sustainability factors as part of their annual financial report, we focused to find the way how to identify the right indicators of sustainability in the process of evaluation and reporting.

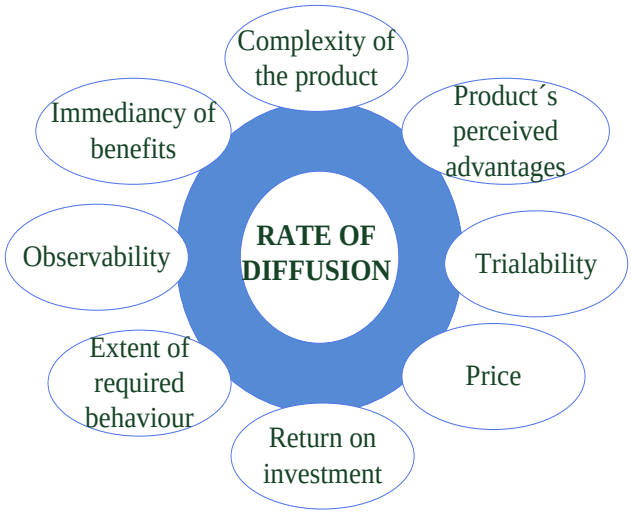

Figure 1: Factors affected the rate of diffusion

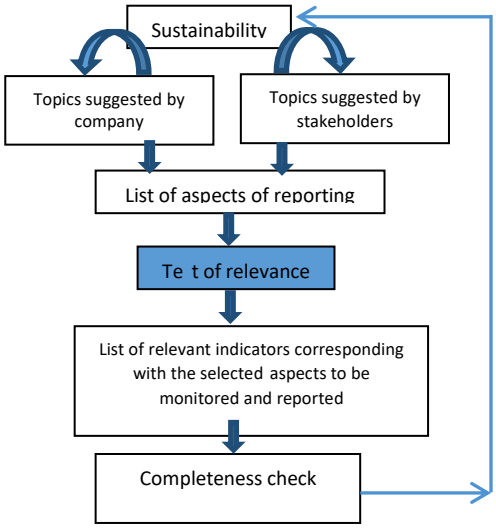

Figure 2: Process of topic selection for reporting

Our basic assumption was that there are various aspects how to report and evaluate the impact and intensity of company's business activities for their stakeholders. The selection of topics for activities and reporting should start on the basis of the dialogue of the stakeholders (Fig. 2). We expect that companies after publishing transparent information about their financial and non-financial performances will have lower costs, attract and retain more effective employees and will tend to be more successful in a long-term perspective. Our suggestion is that the proposed indicators for each

type of companies have to be compiled in accordance with the recommendations of the GRI. Evaluation of criteria can´t be selected randomly, but always should be taken into account the specificity of the industry, the unique conditions of a particular company, relevance of the criteria for a specific company. Now we would like to continue to wider analyse of company –stakeholder´s relations and their impact on the market.

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Analytical modelling and machine learning in management science

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To make efficient and good managerial decisions is a difficult process. Today, we are in the era of data. Ninety percent of data have been created in last two years and the growth is exponential. The potential of better decision is hidden in data. Today, all organizations try to achieve the competitive advantage from data. Analytics is a necessary condition to make the business successful today.[1] In today's world management is becoming more and more dependent on data and analytics due to increasing efficiency.[2] Data and predictive analytics are a great tool how to make the managerial decision process more effective. All areas are changing and quantitative models are becoming the must.

Our research is focused on machine learning. We have developed customized error-correction model of artificial neural network with improved accuracy properties compared to standard statistical and neural network models. The use of this model is in the financial management of various banking institutions. The base of the model is the feedforward artificial neural network. The suggested activation function is however modified; the RBF activation function is replaced by Generalized Normal Distribution function inspired by Autoregressive Conditional Heteroscedasticity models. This function activates potential of hidden neurons in the network. Thanks to this distribution the model is flexible and is able to capture some of special characteristics of financial data such as fat tails. The learning process is implemented using evolutionary computation as it showed to be more efficient than the standard backpropagation. To ameliorate the prediction accuracy of our model we add an external mechanism to improve the accuracy; we implement error-repairing mechanism and create Error Correction models of RBF neural networks. Thanks to this, our model has a long-term memory effect, i.e. is able to capture long-term effects. Using this model, we are able to model the data generating process in finance more accurately, make the managerial decision process in finance more reliable and to reduce risk from unexpected or unprecise development in the future.

The second part of our research deals with implementation of analytics techniques into the area of microeconomics. To aim of this is to suggest methodologies that make the process of using data and models more accessible and easier to implement for these subjects. Using these models companies are supposed to achieve the competitive edge as the ability to use and interpret data as well as the ability to interpret data and to be able to communicate results from them is critical in managerial decision-making even in small companies. Our research deals with following topics:

- how to use analytics in making effective cooperation bonds
- how to use data to find the most effective marketing communication in an area
- how to use regression techniques to evaluate the credibility of municipalities in Slovakia
- how to apply SVM models in transport and traffic area

[1] Kalyan Talluri, the head of managerial analytics in Imperial College Business School London
[2] Miriam Hernandez-Kakol, director of KMPG

- how to use data to determine the optimal number of students in the class from the socio-economics point of view

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… in brief

Faculty of Management Science and Informatics, University of Žilina was founded on July 17th, 1990 by approval of University Senate. The main idea of foundation was integration of developing knowledge from ICT in the Faculty Programmes of study. That was above all students and staff from Department of Technical Cybernetics existing from 1972 on the University (in that time University of Transport and Communication, Faculty of Mechanical-Electrical Engineering). From this time University and Faculty were going through many changes and development connected by evolution, as well events, caused by society changes and corresponding legislative.

Faculty of Management Science and Informatics is one of the seven Faculties at University of Žilina, where are:

- Faculty of Operation and Economy in Transport
- Faculty of Electrical Engineering
- Faculty of Mechanical Engineering
- Faculty of Civil Engineering
- Faculty of Security Engineering
- Faculty of Humanities

Activities of the Faculty are determined by new trends of information and communication technology development, where the high priority task is to insure the continual interconnection between research, education and acceptation of postgraduates in the praxis. The main education and professional activities lie with fields as design and realization of technical tools for information and control systems, analysis, synthesis and design of integrated information and control systems, management, marketing, logistics, entrepreneurship, activity of transportation and communication systems, control and optimization of goods and passenger transport, control and optimization of databases design and their transmission and data processing, problematic of multimedia information systems and graphic information systems, simulation mediums for communication networks and systems and mathematical modelling.

Faculty consists from seven departments:

- Department of Informatics
- Department of Information Networks
- Department of Management Theories
- Department of Mathematical Methods and Operations Research
- Department of Macro- and Microeconomics
- Department of Software Technologies
- Department of Technical Cybernetics