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Uncertainty and Imprecision in Decision Making and Decision Support: Cross-Fertilization, New Models, and Applications

Selected Papers from BOS-2016 and IWIFSGN-2016 held on October 12–14, 2016 in Warsaw, Poland

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Preface

This volume is composed of selected papers from two important conferences held on October 12–14, 2016, in Warsaw, Poland: Fourteenth National Conference of Operational and Systems Research, BOS-2016, one of premiere conferences in the field of operational and systems research not only in Poland but also at the European level, and Fifteenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets, IWIFSGN-2016, one of premiere conferences on fuzzy logic, notably on extensions of the traditional fuzzy sets, and also comprising a considerable part on the generalized nets (GNs), a powerful extension of the traditional Petri net paradigm. The first collocated conferences of the above type were held two years earlier, i.e., BOS-2014 and IWIFSGN-2014, also including the collocation with the IEEE Intelligent Systems IEEE IS'2014 conference, and this solution received a very positive reaction of the research community. That is why the collocation of BOS-2016 and IWIFSGN-2016 was continued in 2016 too.

Among many reasons for a positive opinion on such a collocation, one can certainly point out the following ones. First, the scope of the BOS conferences covers all kinds of problems related to systems modeling, systems analysis, broadly perceived operational research, notably optimization, decision making, and decision support, to just mention a few. In all these areas virtually all models used have to take into account not only the traditionally meant uncertainty, but also imprecision of information. That is, in addition to traditional probabilistic and statistical tools and techniques, the use of fuzzy set-based ones can be relevant. Even more so, the use of some extensions of the classic concept of a fuzzy set can be very useful. The use of the intuitionistic fuzzy sets, which are at the core of the IWIFSGN conferences, may be here a very good example.

One can therefore clearly see that the two conference series, and—to be more specific—the two conferences, BOS-2016 and IWIFSGN-2016, have been perfect venues for the exchange of ideas, cross-fertilization, and mutual inspiration. And, indeed, this has proved to happen what can also be seen from the papers contained in this volume.

The volume is composed of some parts that cover the main areas and challenges related to the above rationale and philosophy. The first part, "Issues in the Representation and Processing of Uncertain Information," contains papers that concern issues and problems of a more general interest, notably related to uncertainty and imprecision.

Jolanta Jarnicka and Zbigniew Nahorski ("Estimation of Means in a Bivariate Discrete-Time Process") consider a discrete-timenon-stationary stochastic process that is a sum of two other processes. Assuming that a data matrix of its realizations is given, they try to estimate and then analyze the mean values of the component processes as functions of time. Both the existence and uniqueness of a solution to this problem are dealt with. The authors propose an algorithm for the estimation of the mean values. The method is applied to the analysis and processing of uncertainty in National Inventory Reports (NIRs) on the emission of greenhouse gases (GHG) which is provided annually by the cosignatories to the UNFCCC and its Kyoto Protocol. Each report contains data on the GHG emission from a given year and also some revisions of past data, recalculated due to new or improved knowledge and methodology. Uncertainty is clearly present, and should be dealt with, when the GHG emissions are quantified. The method proposed can help to better deal with the inaccuracy and imprecision in processing the rough data. Applications for the data for Poland and some selected EU-15 countries are shown.

Ewa Straszecka ("On Fuzzy Focal Elements Combining") considers some aspects of the Dempster–Shafer theory of evidence, namely the case of its extension meant to include fuzzy focal elements. To be more specific, the author deals with the problem of a combination of knowledge by means of the conjunction of data-driven membership functions. In this study, emphasis is on medical knowledge, represented by focal elements and the basic probability assignment. Influence of the combination on the basic probability assignment is provided. Examples of applications of the method proposed for the transfer of medical knowledge are shown.

Daniela Kluvancová ("On the conditional expectation on Kôpka's D-posets") discusses some relevant extension of the MV-algebras, which are known to be a very important structure in many-valued logic, both in theory and in applications. In particular, probability theory on the MV-algebras, especially on the MV-algebras with product, has proven to be very useful. In this contribution, the author proceeds further to some generalization of the MV-algebras, the D-posets with product, which are called Kôpka's D-posets, and defines the conditional probability on Kôpka's D-posets, as well as a version of the conditional expectation on Kôpka's D-posets.

Jaroslav Považan ("Strong Law of Large Numbers on D-poset") deals with the laws of large numbers, notably the strong law of large numbers, which is a very important result in the standard probability theory. The author obtains a more general version of the strong law of large numbers by changing the Σ-algebra by an algebraic structure called the D-poset introduced by Chovanec and Kôpka.

Leszek Klukowski ("Estimation of Trees on the Basis of Pairwise Comparisons with Random Errors") is concerned with the estimation of the trees on the basis of

multiple pairwise comparisons, with random errors. The estimators proposed are based on the idea of the nearest adjoining order. Two types of trees are examined: non-directed and directed. The approach is similar to the estimation of a preference relation with incomparable elements on the basis of binary comparisons. The estimates are obtained by solving a discrete optimization problem. The trees dealt with can be applied to the modeling of many phenomena and problems such as biological evolution, decision problems.

The second part of the volume, "Issues in the Representation and Processing of Imprecise Information," is concerned mostly with the imprecision of information and contains papers on both the traditional fuzzy sets and their extensions, notably the intuitionistic fuzzy sets, interval-valued fuzzy sets, etc.

Krassimir T. Atanassov ("On Extended Intuitionistic Fuzzy Index Matrices with Elements Being Predicates") extends his original concept of an index matrix and notably an extended intuitionistic index matrix, by assuming that their elements are predicates. The author defines some basic concepts and operations related to the newly introduced ideas.

Katarína Čunderlíková and Beloslav Riečan ("On Two Formulations of the Representation Theorem for an IF-state") are concerned with the representation and processing of an IF-state which is represented by some classical Kolmogorovian probabilities. The authors show that two formulations of an IF-state known from the literature representation are equivalent. The results can be very important for intuitionistic fuzzy set-based extensions of probability theory.

Andrzej Piegat and Karina Tomaszewska ("Optimal Representation (ORD) Method of Intuitionistic Fuzzy Defuzzification") propose a novel method of intuitionistic fuzzy defuzzification, called the Optimal Representation Defuzzification (ORD). In the method, in the first step, the membership and non-membership functions of the system's inputs and output are transformed into the membership functions of the interval type-2 fuzzy sets. Then, the inference process is run to determine activation degrees of the output fuzzy sets (conclusions of the rules). Subsequently, for all activated membership functions, one fuzzy set optimally representing them is determined. Finally, one crisp value, optimally representing this fuzzy set, is found as a defuzzification result. In the ORD method, each rule is treated as a local expert system. For illustration, the use of the method in an intuitionistic fuzzy controller of the fan speed of a room heater is shown.

Wojciech T. Dobrosielski, Jacek M. Czerniak, Janusz Szczepański, and Hubert Zarzycki ("Two New Defuzzification Methods Useful for Different Fuzzy Arithmetics") present new algorithms for the defuzzification block which is the final process of the fuzzy controller (fuzzy control system) in which a defuzzified value is to be applied as control to a given object. The new methods presented are based on the well-known, since the ancient times, Golden Ratio (GR) rule and the so-called Mandala Factor (MF), which is based on the interpretation of a drawing technique used in Asia consisting in arranging pictures of color sand grains. In the Tibetan Buddhism, this technique is known as Mandala, a symbol of perfection and harmony. The methods proposed are compared with other methods used in the defuzzification process, including the weight-averaging method, the centroid, and

the mean of maxima. The discussion proceeds in the context of the ordered fuzzy number (OFN) theory which also makes it possible to make use of the trend of a given phenomenon. A special property of the proposed methods is their sensitivity to the order of the OFN numbers used.

Paweł Drygaś and Anna Król ("Two Constructions of Ordinal Sums of Fuzzy Implications") discuss the important problem related to the fuzzy implications. They deal with ordinal sums of the fuzzy implications and propose two new generalized methods. The generalizations make it possible to consider summands on intervals of different types: open, closed, or half-open. The authors show the sufficiency properties of fuzzy implications as summands for obtaining a fuzzy implication.

The third part, "Novel Tools and Techniques in Modeling, Decision Making and Decision Support: Theory and Applications," has a stronger operational and systems research orientation and includes contributions mostly on various aspects of decision making, notably in multicriteria and gaming contexts, but also with uncertainty and imprecision playing a relevant role. Some applications in these and related areas are also shown.

Krzysztof Dyczkowski, Anna Stachowiak, and Maciej Wygralak ("A Decision-Making Model in an IVFS Environment Based on Sigma f-Count Cardinality") present a new approach to decision making when information, possibly incomplete, is provided by many sources. The proposed method is based on the scalar cardinality (sigma f-count) for the IVFSs (interval-valued fuzzy sets). First, a general algorithm is introduced, and next, an application for supporting medical decisions in the ovarian tumor differentiation (based on multiple diagnostic models) is presented and discussed.

Lech Kruś ("On Computer-Based Support in Noncooperative Multicriteria Games") deals with noncooperative games, in which each player has some number of criteria measuring his or her payoff. A decision support system is considered as a computer-based tool that allows the players to make an analysis of the conflict situation, taking into account their preferences. The analysis can be done using an interactive, learning procedure utilizing methods of multicriteria optimization. An algorithm supporting the analysis of payoffs in the multicriteria game and derivation of the best response strategies, satisfying preferences of the players, is proposed. The reference point approach based on the respective achievement functions is used in the interactive procedure in which payoffs of the players are calculated closely to their preferences. A parametric characterization of the multicriteria gains representing preferences of the players is used, and relations among equilibria in the multicriteria games and the respective classic games are discussed.

Ignacy Kaliszewski, Janusz Miroforidis, and Dmitry Podkopaev ("Multiple Criteria Decision Making and Multiobjective Optimization – A Toolbox") present an integrated approach to solving multiple criteria decision problems in the sequence of intelligence, modeling, choice, and review phases, often with iterations, to identify the most preferred decision variant. The approach taken is human-centric, with the (human) user taking the final decision to be a sole and sovereign actor in the decision-making process. To ensure generality, no

assumption about the decision maker's preferences or behavior is made, neither about the underlying formal model. The intended goal of the approach is to lower the cognitive barrier related to an unsupported use of multicriteria methodologies in a day-to-day practice. Some successful applications are shown.

Urszula Bentkowska, Józef Drewniak, Paweł Drygaś, Anna Król, and Ewa Rak ("Dominance of Binary Operations on Posets") deal with a dominance property of binary algebraic operations on a partially ordered set, and not—as traditionally— of the direct inequality or inclusion. Such a dominance is strictly connected with a generalized distributivity of the operations. Consequences of the bisymmetry assumption and the existence of a neutral element for the operations are presented. Some results known for operations on the unit interval are generalized to the case of a partially ordered set or a lattice.

Evdokia Sotirova, Sotir Sotirov, Lilia Atanassova, and Krassimir Atanassov ("Game Method for Modeling with Intuitionistic Fuzzy Rules") are concerned with the game method for modeling (GMM) introduced in the mid-1970s as a modification of Conway's game of life (CGL). The authors extend the traditional approaches by introducing intuitionistic fuzzy estimations for the rules of the GMM. An example of a relevant application for predicting the forest dynamics is shown.

Łukasz Apiecionek, Hubert Zarzycki, Jacek M. Czerniak, Wojciech T. Dobrosielski, and Dawid Ewald ("The Cellular Automata Theory with Fuzzy Numbers in Simulation of Real Fires in Buildings") consider the use of cellular automata extended with fuzzy numbers for the simulation and testing building conditions with respect to fire. The tests performed on real accidents showed that using some extension of the fuzzy numbers could give a realistic simulation of human evacuation. The authors analyze real accidents and prove that the method proposed is very effective and efficient in particular in the cases of building renovations or temporary unavailability of escape routes.

Desislava Vankova, Sotir Sotirov, and Lyubka Doukovska ("An Application of Neural Network to Health-Related Quality of Life Process with Intuitionistic Fuzzy Estimation") consider a very important problem of the quality of life (QoL) assessment in the context of health care. For the modeling, the authors use a neural network model and employ intuitionistic fuzzy estimations to enrich the possibilities to represent information.

Jacek M. Czerniak, Hubert Zarzycki, Wojciech T. Dobrosielski, and Janusz Szczepański ("Application of OFN Notation in the Fuzzy Observation of WIG20 Index Trend for the Period 2008–2016") discuss an important problem of seeking patterns in trends expressed in a linguistic form. The linguistic variables are assumed to take on their values as a result of the calculations in the ordered fuzzy number (OFN) notation. First, the fuzzification of the source data is performed. Daily quotations (min, max, the opening value, the closing value, and the direction of change) are interpreted as a single OFN number, representing five different parameters in a single number. A dedicated computer program for performing the pattern search is implemented and tested on data on the main index of the Warsaw Stock Exchange, i.e., WIG20, for the period 2008–2016.

The fourth part, "Advanced IT/ICT Applications," is focused on one of the most important areas of science and technology that is decisive for the progress in virtually all fields in the present-day world, i.e., information technology or, maybe more generally, information and communication technology.

Włodzimierz Ogryczak, Tomasz Śliwiński, Jarosław Hurkała, Mariusz Kaleta, Piotr Pałka, and Bartosz Kozłowski ("Large-scale Periodic Routing Problems for Supporting Planning of Mobile Personnel Tasks") discuss issues related to the implementation of a decision support system for large-scale periodic time-dependent vehicle routing and scheduling problems with complex constraints supporting the planning and management of mobile personnel tasks (sales representatives and others). The case of complex, non-uniform constraints, related to the frequency, time windows, working times, etc., is discussed. Fast adaptive procedures for operational rescheduling of plans in the presence of various disturbances are discussed. Five individual solution quality indicators with respect to a single personnel member are considered.

Grzegorz Zalewski and Włodzimierz Ogryczak ("Network Dimensioning with Minimum Unfairness Cost for the Efficiency") consider network dimensioning, a specific kind of optimization problems. Basically, the main goal in this task is to ensure a connection between given pairs of nodes (source-target) with a possibly high efficiency. When each pair (demand) brings different revenue, the problem of blocking less attractive demands can occur. Usually, this situation is caused by not including any fairness criterion into the optimization model and thus optimizing only the total (revenue) efficiency of the system. Another complication is the fact of inverse proportionality of these criteria. In this paper, an optimization model has been examined which takes into account a fairness criterion and minimizes the loss of system efficiency. It may also be understood as optimizing the ratio of fairness degree to the mean of the traffic flow in the network. For the implementation of the model, the CPLEX package is used, and an example problem is solved. The approach is evaluated by using, e.g., the standard deviation, kurtosis, and the Gini coefficient.

Rafał Bieńkowski, Krzysztof Leśniewski, and Weronika Radziszewska ("Spatial Data Analysis in Archaeology: Computer-Aided Selection of Priority Location for Archaeological Survey") describe a GIS-based method to help experts selecting the most probable locations of settlements inhabited by the people in Crete under the Venetian rule (1204–1669). The method ranks a possible location in a designated area on the basis of some criteria, geographic and anthropogenic, but also considering natural obstacles, e.g., characteristic features of the terrain. This multicriteria problem is solved using a modification of the Bellman–Ford algorithm for each criterion and then combining them using the weighted sum. An example on real data is provided.

Łukasz Apiecionek, Jacek M. Czerniak, Wojciech T. Dobrosielski, and Dawid Ewald ("New Proposal of Fuzzy Observation of DDoS Attack") show a potential use of the implementation of fuzzy observation for discovering and protecting a computer network from the Distributed Denial of Service (DDoS) attacks. Such attacks can block Web servers and could be started from any place in the network.

Some real experimental results are presented. A developed network and DDoS attack tool are used for collecting IP packets during an attack, and then, some extension to fuzzy logic is implemented and used for discovering an attack.

Stefka Fidanova, Vassia Atanassova, and Olympia Roeva ("Ant Colony Optimization Application to GPS Surveying Problems: InterCriteria Analysis") consider the use of the ant colony optimization (ACO), which has been applied successfully to solve many hard combinatorial optimization problems, to provide near-optimal solutions for the Global Positioning System (GSP) surveying problem. In designing a Global Positioning System (GPS) surveying network, a given set of earth points must be observed consecutively (schedule). The cost of the schedule is the sum of time needed to go from one point to another. The problem is to search for the best order in which this observation is executed, minimizing the cost of the schedule. The authors use the InterCriteria Analysis (ICrA) for the results obtained to examine some relations between the considered GSPs and the ACO algorithm performance.

Marcin Woźniak, Michał Terlecki, Piotr Brażkiewicz, Krzysztof Wosiński, Adam Baszyński, Tomasz Gromacki, Michał Iwicki, and Paweł Splitt ("Ontology Usage for Database Conversion in Practical Solution for Military Systems – Case Study") present ADTA (Automated Data Transformation and Aggregation) system to achieve interoperability between systems which use different data exchange protocol versions and different database structures. This mechanism is modeled using semantic transformation. In this paper, an ADTA mechanism is presented and some practical results of test case solutions are described.

Hubert Zarzycki, Wojciech T. Dobrosielski, Dawid Ewald, and Łukasz Apiecionek ("Effective Search of Proteins in the DNA Code") discuss an important issue that is related to the processing of large amounts of data associated with the genome. The statistics of gene content of the human genome is demonstrated accompanied by important information about how the proteins are stored in the DNA code, and RNA transcription, splicing, and protein translation processes are performed. This is followed by the description of a practical algorithm for searching protein and pattern matching in the DNA code for given complete genome and protein data.

Urszula Bentkowska and Barbara Pękala ("Generalized Reciprocity Property for Interval-Valued Fuzzy Setting in Some Aspect of Social Network") discuss interval-valued fuzzy relations, notably introduce the fuzzy negation-based reciprocity property, and examine the connection of this property with the weak transitivity and some equivalence relation for the interval-valued fuzzy relations, as well as the preservation of such a reciprocity by some operators. The authors present an algorithm to find the best alternative in decision-making problem with the use of their new reciprocity concept. An example from the area of social network analysis is provided.

The last, fifth part, "Generalized Nets: Theory and Applications," is concerned with the use of tools and techniques of the Generalized Nets, a substantial extension of the Petri nets, which can provide powerful tools and techniques for the analysis and solution of many kinds of discrete event type problems.

Stanislav Simeonov, Vassia Atanassova, Evdokia Sotirova, Neli Simeonova, and Todor Kostadinov ("Generalized Net of a Centralized Embedded System") discuss some issues related to embedded controlling computer systems in which multiple servicing subsystems can process multiple tasks. The problem arises from an optimal centralized distribution of the tasks among the multiple subsystems. This problem is solved by designing a generalized net (GN) model to organize the behavior of these servicing devices and the performance of the various tasks assigned to them in parallel.

Veselina Bureva, Stanislav Popov, Evdokia Sotirova, and Krassimir T. Atanassov ("Generalized Net of MapReduce Computational Model") consider some issues related to the well-known MapReduce paradigm, a programming model for parallel processing of large volumes of data in a distributed environment, which can be of much use while dealing with various big data type problems. MapReduce is applied in the clusters of commodity machines. The workflow of the MapReduce computational model is constructed using the tools and techniques of generalized nets (GNs).

Todor Petkov, Sotir Sotirov, and Stanislav Popov ("Generalized Net Model of Optimization of the Self-Organizing Map Learning Algorithm") describe the optimization of the algorithm of self-organizing map neural network. The proposed algorithm is employed during the learning trial. The authors take into consideration the number of epochs so that their number needs to be decreased. In order to do that, for each epoch the distance from each cluster unit to all training vectors is measured. If the total distance is the same as the distance estimated from the previous epoch, then it is assumed that the network is trained and the learning trial stops. The process of optimization is described with the generalized net.

Lenko Erbakanov, Krassimir T. Atanassov, and Sotir Sotirov ("Generalized Net Model of Synchronous Binary Counter") propose a new generalized net (GN) model of a synchronous binary counter which is one of very important and basic logical circuit. The time delays are considered by using tools and techniques of the theory of generalized nets (GNs).

Simeon Ribagin, Krassimir T. Atanassov, Olympia Roeva, and Tania Pencheva ("Generalized Net Model of Adolescent Idiopathic Scoliosis Diagnosing") discuss the diagnosis of one of the main postural disorders found in the population, the idiopathic scoliosis, affecting 2% to 4% of adolescent population. The authors present the use of generalized nets (GNs) to model the diagnosis process for a timely detection of adolescent idiopathic scoliosis and its categorization.

We hope that the inspiring and interesting contributions, included in this volume, will be of much interest and use for a wide research community.

We wish to thank the contributors for their great works, as well as other participants of the BOS-2016 and IWIFSGN-2016 conferences, whose contributions appeared in different proceedings, for their active participation, the vivid discussions, eagerness to exchange and share new ideas, and friendly atmosphere. Special thanks are due to anonymous referees whose deep and constructive remarks and suggestions have helped to greatly improve the quality and clarity of contributions.

And last but not least, we wish to thank Dr. Tom Ditzinger, Dr. Leontina di **Cecco, and Mr.** Holger Schaepe for their dedication and help to implement and **finish this** important publication project on time, while maintaining the highest **publication** standards.

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Contents

Advanced IT/ICT Applications

Generalized Nets: Theory and Applications

Ontology Usage for Database Conversion in Practical Solution for Military Systems - Case Study

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Abstract. Nowadays IT systems are used for quick share lot of data. These data are collected in databases which are working in a special rules. These rules describe how data are stored the structure of database and how it can be added or removed from them. The process of changing structures in databases is very complicated. Polish company TELDAT develop mechanism called ADTA (Automated Data Transformation and Aggregation) to achieve interoperability between systems which are using different data exchange protocol versions and different database structures. This mechanism is using semantic transformation. In this paper an ADTA mechanism is presented and some practical results of test made on international exercises are also described.

Keywords: Semantic algorithm · Database conversion

1 Introduction

Nowadays IT systems are used for quick share lot of data. These data are collected in databases which are working in a special rules [1,12]. These rules describe how data are stored the structure of database and how it can be added or removed from them. Military systems are many time the most innovative ones. This fact is a reason while there often a requirement to change their databases structures. The process of changing structures in databases is very complicated. The countries who are a part of North Atlantic Treaty Organization required the same standardized databases for military systems. To achieve this goal, there are a Multilateral Interoperability Programme [27] established. The engineers who worked in this program are developing the protocols for exchanging data. During the last years there are a several protocols normalized: MIP 2.0, 3.0 and 3.1. But during the work there are not thinking about possibility to exchange information between systems which are used different version of MIP protocols. This is because these protocols are developed for working with different structures of databases. Polish company TELDAT develop mechanism

called ADTA (Automated Data Transformation and Aggregation) to achieve interoperability between systems which are using different MIP protocol version and different database structures [28]. This mechanism is using semantic transformation [24,30]. Without this transformation there will be no possibility to connect lot of NATO systems. In this paper an ADTA mechanism is presented according to this semantic algorithm [1,8]. Some practical results of test made on international exercises are also described. Finally some conclusion are made.

2   ADTA Transformation Mechanism

ADTA *Mechanism Decription*

ADTA mechanism is a unique Gateway which translate the MIP protocol between each version: 2.0, 3.0, and 3.1, which let to translate data between different database model. The protocol 2.0 is using C2IEDEM database model while protocols 3.0 and 3.1 are using the newer database model JC3IEDEM. This mechanism was implemented in Network Centric Data Communication Platform JASMINE by polish engineers from company TELDAT. This platform uses JC3IEDEM as a native standard of database. JC3IEDEM is a huge complex database format which describe the situation on military battlefield. This format was created using NATO requirements and many countries who participate in Multilateral Interoperability Program. During the time this model has evolved. The consequence of this evolution is a lot of command support systems which are using different version. These systems are unable to communicate. The engineers developed universal language which describe the changes in the model. This let to generate the program for translating message which comes from different model in automatic way. The final effect is a ADTA mechanism which let to translate the old model of database - C2IEDEM and the new one JC3IEDEM (Fig. 1).

Semantic Algorithm of Data Transformation

The ADTA transformation mechanism is primary based on the formal definition of JC3IEDM and C2IEDM ontologies. These ontologies are represented as the series of entities interconnected with relationships. As a result we can treat each ontology as a directed graph with nodes being Entities and edges being relationships [11–13].

The Entity is defined by its unique name and the series of attributes describing its current state. Every relationship also has its own unique name and set of specified attributes. [9,14,23] The most important relationship attribute is the Relationship Type descriptor which can have one of following values: Identifying, Non-identifying, Subtype. The example combination of entity and relationship may be expressed as a logical sentence: <Parent entity> <verb phase> <Child entity>, eg. ABSOLUTE-POINT is a CARTESIAN-POINT, ACTION-TASK references OBJECT-ITEM-ASSOCIATION.

The crucial part of defining transformation between two meta models it to define a semantic id for each of schema element. This way it is now possible to select a subset of similar entities in C2IEDM and JC3IEDM models. In most

Fig. 1. ADTA description

cases semantic identifier will be equal to entity name but there are some minor changes in JC3IEDM that requires manual involvement into this process. When the process of entity to semantic id mapping is complete for entities, relationships and attributes we have now a basic identity transformation that could handle some basic scenarios (assuming that any missing elements will be skipped) but in most cases it is not enough [7,18,20]. Each of the model has also set of business rules that needs to be fulfilled and as a result an additional mechanism was developed. The heart of ADTA is a special DSL (Domain Specific Language) that specifies what kind of operations should be performed in order to transform Entity between model representation.

The basic ADTA transformations are as following:

- Dictionary lookup - if the old domain value does not fit into new domain attribute accepted values a new candidate should be selected according to provided value mapping. In most cases it will be NOS (Not otherwise specified) but for some Entities a nearly the same values exists in target model,
- Math expression - if there is need for degradation of information an additional computation is needed. For example C2IEDM model contains limited set of location and as a result some 3d location should be simplified and transformed into 2d representation. In such cases DSL provides and mathematic formula for performing transformation
- Entity creation - some concepts such as Plans And Orders are not present in C2IEDM and as a result additional steps need to be taken. In this particular case ADTA tries to mimic Plans And Ordered by creating other Entities and associating them with existing objects
- Model query - in order to perform transformation additional information from source or target model needs to be gathered. In order to perform

that another DSL has been introduced to get particular information. For example to obtain all friendly polish units from model state we should provide following query: /org: all()/ctx:status() -eq FRORG/ctx:status() -eq FRNO/oi:affiliations().geo().affiliation -eq POL/ which means to search in contexts of every organizations for all object items containing geopolitical affiliation of Poland/

Example rule expressed in ADTA with use of presented language may take following form:

if ENTITY[type] is OBJECT-ITEM:
TRANSFORM-ATTR LOCATION– > name func:truncate(12)
if (ENTITY– > LOCATION is-present) and (ENTITY– > LOCATION [type] is SPHERE-VOLUME):
TRANSFORM-CREATE ENTITY– > LOCATION as FAN-AREA
func:geometry:convert 3d_sphere_volume_into_fan_area()

As we can see such rule can be easily transformed into natural language and be showed to any domain expert. In this case we can say that: "In order to transform any Object Item location its name should be truncated to 12 characters and if it has a Spherical Volume location it should be transformed into its 2d representation - a fan area".

Translation Example
The example of data transformation between different MIP model is an information about object located on battlefield. This example is presented on Figs. 2 and 3.
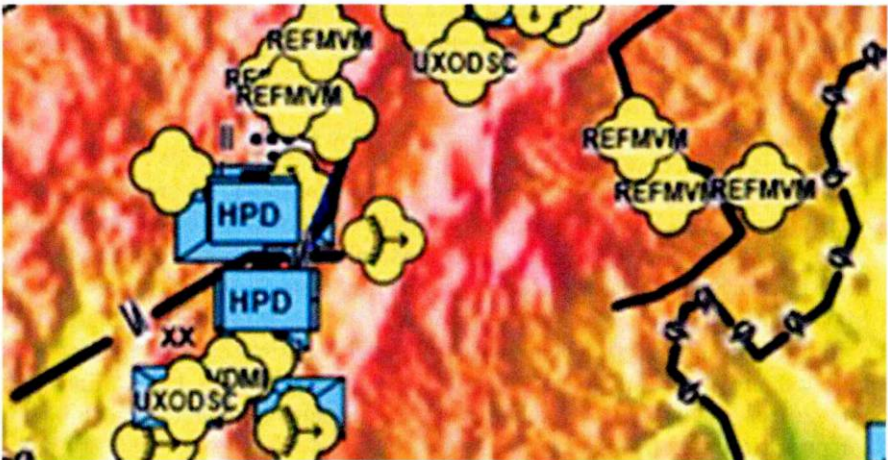

Fig. 2. The example battlefield in MIP Baseline 3

Some of presented tactical symbols have not got direct reflection in second model. In such situation the generic symbols are used and some geometrical approximation.
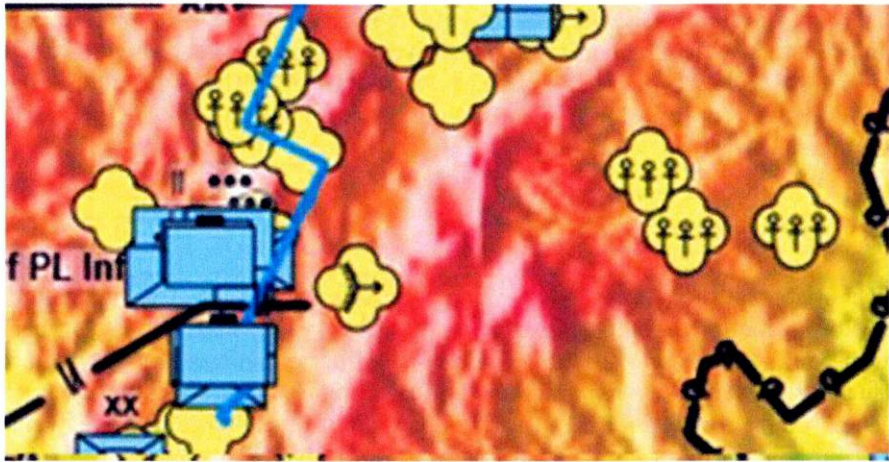
Fig. 3. The example battlefield in MIP Baseline 2

Test Results

Nowadays an ADTA mechanism was widely tested during international military exercises: CWIX (Coalition Warrior Interoperability eXploration, eXperimentation, eXamination, eXercise) [29] and Combined Endeavor [26]. It was used as a main element in the schema of the scenario which was tested. This mechanism let to use different NATO countries systems and build one operational view of battlefield [15–17, 22]. The schema of the connection on CWIX 2011 exercises is presented on Fig. 4. There was two world of MIP Baseline protocols: 2.0 and 3.1. Unfortunately the CWIX exercises are made on NATO secret network. There is no possibility to provide more test results and present database view according to security policy. During such exercises there is possibility to exchange expertise, collect experience and test solutions.

Fig. 4. The schema of the CWIX 2011

ADTA mechanism is one of the main innovative component of ICT JAS-MINE System. Of course military solutions require appropriate network protection using the best possible solutions [2,4,14]. In JASMINE system there are also implemented some mechanism for network protection [7] like Information Exchange Gateway [3,18,25].
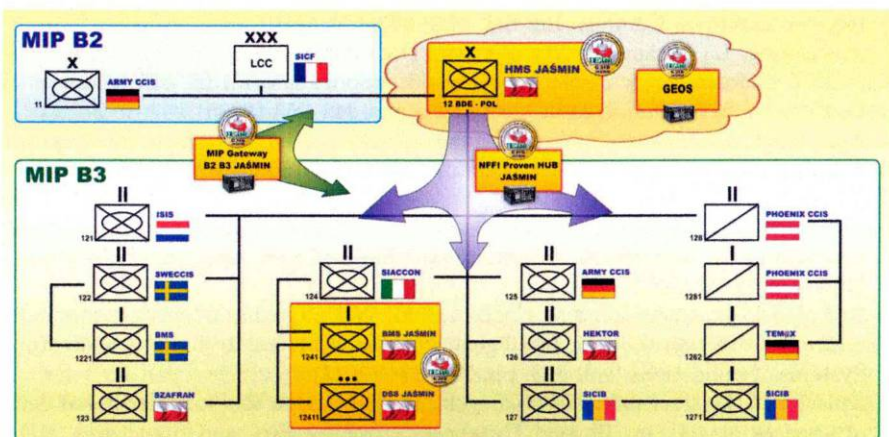
3   Conclusions

In this paper authors tries to describe the practical solution of using semantic transformation for different database model. This proves that using such mechanism could be effective [10,19,21]. The MIP programme was not provided for ensuring transformation for different database model but practical usage of the science could provide good results. Presented solutions is an innovative on military market developed by polish engineers and gives them lot of respect on international stage. The TELDAT engineers are known as innovative ones using some other research results like artificial intelligence [5,6,23].

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Uncertainty and Imprecision in Decision Making and Decision Support: Cross-Fertilization, New Models, and Applications

Selected Papers from BOS-2016 and IWIFSGN-2016 held on October 12–14, 2016 in Warsaw, Poland

This book presents selected papers from two important conferences held on October 12–14, 2016 in Warsaw, Poland: the Fourteenth National Conference of Operational and Systems Research, BOS-2016, one of the premiere conferences in the field of operational and systems research not only in Poland but also at the European level; and the Fifteenth International Workshop on Intuitionistic Fuzzy Sets and General Nets, IWIFSGN-2016, one of the foremost conferences on fuzzy logic, notably addressing extensions of the traditional fuzzy sets, as well as the Generalized Nets (GNs), a powerful extension of the traditional Petri net paradigm.

The scope of the BOS conferences includes all types of problems related to systems modeling, systems analysis, broadly perceived operational research, optimization, decision making, and decision support, to name but a few. In all these areas, virtually all models used have to take into account not only uncertainty in its traditional sense, but also imprecision of information. That is, in addition to traditional probabilistic and statistical tools and techniques, the use of methods based on fuzzy sets can also be sensible. Even more so, employing certain extensions of the classic concept of a fuzzy set can be very useful. Applying intuitionistic fuzzy sets, which are at the core of the IWIFSGN conferences, is a good example. Both conferences, BOS-2016 and IWIFSGN-2016, offered ideal venues for the exchange of ideas, cross-fertilization, and mutual inspiration.