ISSN 1727–6209

TERNOPIL NATIONAL ECONOMIC UNIVERSITY
RESEARCH INSTITUTE OF INTELLIGENT COMPUTER SYSTEMS
IN COOPERATION WITH V.M. GLUSHKOV INSTITUTE FOR CYBERNETICS, NATIONAL ACADEMY OF SCIENCES, UKRAINE

ТЕРНОПІЛЬСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
НАУКОВО-ДОСЛІДНИЙ ІНСТИТУТ ІНТЕЛЕКТУАЛЬНИХ КОМП'ЮТЕРНИХ СИСТЕМ
У СПІВПРАЦІ З ІНСТИТУТОМ КІБЕРНЕТИКИ ІМ. В.М. ГЛУШКОВА, НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ

International Journal of

Computing

Published since 2002

December 2012, Volume 11, Issue 4

Міжнародний науково-технічний журнал

Комп'ютинг

Видається з 2002 року

Грудень 2012, Том 11, Випуск 4

Постановою президії ВАК України № 1-05/3 від 14 квітня 2010 року науково-технічний журнал “Комп'ютинг” віднесено до переліку наукових фахових видань України, в яких можуть публікуватися результати дисертаційних робіт на здобуття наукових ступенів доктора і кандидата технічних наук

Тернопіль
ТНЕУ
2012

International Journal of Computing

December 2012, Vol. 11, Issue 4

Research Institute of Intelligent Computer Systems,
Ternopil National Economic University

Registered by the Ministry of Justice of Ukraine.
Registration certificate of printed mass media – KB #17050-5820PR, 15.07.2010.

It's published under resolution of the TNEU Scientific Council, protocol # 2, November 28, 2012

Editorial Board

EDITOR-IN-CHIEF

Anatoly Sachenko
Ternopil National Economic University, Ukraine

DEPUTY EDITOR-IN-CHIEF

Volodymyr Turchenko
University of Tennessee, USA

ASSOCIATE EDITORS

Svetlana Antoshchuk
Odessa National Polytechnic University, Ukraine

Plamenka Borovska
Technical University of Sofia, Bulgaria

Kent A. Chamberlin
University of New Hampshire, USA

Dominique Dallet
University of Bordeaux, France

Pasquale Daponte
University of Sannio, Italy

Mykola Dyvak
Ternopil National Economic University, Ukraine

Richard J. Duro
University of La Coruña, Spain

Vladimir Golovko
Brest State Polytechnical University, Belarus

Sergei Gorlatch
University of Muenster, Germany

Lucio Grandinetti
University of Calabria, Italy

Domenico Grimaldi
University of Calabria, Italy

Uwe Großmann
Dortmund University of Applied Sciences and Arts, Germany

Halit Eren
Curtin University of Technology, Australia

Vladimir Haasz
Czech Technical University, Czech Republic

Robert Hiromoto
University of Idaho, USA

Orest Ivakhiv
Lviv Polytechnic National University, Ukraine

Zdravko Karakehayov
Technical University of Sofia, Bulgaria

Mykola Karpinskyy
University of Bielsko-Biała, Poland

Volodymyr Kochan
Ternopil National Economic University, Ukraine

Yury Kolokolov
UGRA State University, Russia

Gennady Krivoula
Kharkiv State Technical University of Radioelectronics, Ukraine

Theodore Laopoulos
Thessaloniki Aristotle Univerity, Greece

Fernando López Peña
University of La Coruña, Spain

Kurosh Madani
Paris XII University, France

George Markowsky
University of Maine, USA

Richard Messner
University of New Hampshire, USA

Yaroslav Nykolaiychuk
Ternopil National Economic University, Ukraine

Vladimir Oleshchuk
University of Agder, Norway

Oleksandr Palahin
V.M.Glushkov Institute of Cybernetics, Ukraine

José Miguel Costa Dias Pereira
Polytechnic Institute of Setúbal, Portugal

Dana Petcu
Western University of Timisoara, Romania

Vincenzo Piuri
University of Milan, Italy

Oksana Pomorova
Khmelnytsky National University, Ukraine

Peter Reusch
University of Applied Sciences, Germany

Sergey Rippa
National University of State Tax Service of Ukraine, Ukraine

Volodymyr Romanov
V.M. Glushkov Institute of Cybernetics, Kiev, Ukraine

Andrzej Rucinski
University of New Hampshire, USA

Bohdan Rusyn
Physical and Mechanical Institute of Ukrainian NASU, Ukraine

Rauf Sadykhov
Byelorussian State University of Informatics and Radioelectronics, Belarus

Jürgen Sieck
HTW – University of Applied Sciences Berlin, Germany

Axel Sikora
University of Applied Sciences Offenburg, Germany

Rimvydas Simutis
Kaunas University of Technology, Lithuania

Tarek M. Sobh
University of Bridgeport, USA

Volodymyr Tarasenko
National Technical University of Ukraine "Kyiv Polytechnics Institute", Ukraine

Wiesław Winiecki
Warsaw University of Technology, Poland

Janusz Zalewski
Florida Gulf Coast University, USA

Address of the Editorial Board

Research Institute of Intelligent Computer Systems
Ternopil National Economic University
3, Peremoga Square
Ternopil, 46020, Ukraine

Phone: +380 (352) 47-5050 ext. 12234
Fax: +380 (352) 47-5053 (24 hours)
computing@computingonline.net
www.computingonline.net

© International Journal of Computing, 2012

Міжнародний журнал “Комп’ютинг”

Грудень 2012, том 11, випуск 4

Науково-дослідний інститут інтелектуальних комп’ютерних систем
Тернопільський національний економічний університет

Зареєстрований Міністерством юстиції України. Свідоцтво про державну реєстрацію друкованого засобу масової інформації – серія КВ №17050-5820ПР від 15.07.2010.

Друкується за постановою вченої ради ТНЕУ, протокол № 2 від 28 листопада 2012 року

Редакційна колегія

ГОЛОВНИЙ РЕДАКТОР
Анатолій Саченко
Тернопільський національний економічний університет, Україна

ЗАСТУПНИК РЕДАКТОРА
Volodymyr Turchenko
University of Tennessee, USA

ЧЛЕНИ РЕДКОЛЕГІЇ
Світлана Антощук
Одеський національний політехнічний університет, Україна
Микола Дивак
Тернопільський національний економічний університет, Україна
Орест Івахів
Національний університет “Львівська політехніка”, Україна
Володимир Кочан
Тернопільський національний економічний університет, Україна
Геннадій Кривуля
Харківський державний технічний університет радіоелектроніки, Україна
Ярослав Николайчук
Тернопільський національний економічний університет, Україна
Олександр Палагін
Інститут кібернетики ім. В.М. Глушкова НАНУ, Україна
Оксана Поморова
Хмельницький національний університет, Україна
Сергій Ріппа
Національний університет державної податкової служби України, Україна
Володимир Романов
Інститут кібернетики ім. В.М.Глушкова НАНУ, Україна
Богдан Русин
Фізико-механічний інститут НАНУ, Україна
Володимир Тарасенко
Національний технічний університет України “Київський політехнічний інститут”, Україна
Plamenka Borovska
Technical University of Sofia, Bulgaria
Kent A. Chamberlin
University of New Hampshire, USA
Dominique Dallet
University of Bordeaux, France
Pasquale Daponte
University of Sannio, Italy
Richard J. Duro
University of La Coruña, Spain
Vladimir Golovko
Brest State Polytechnical University, Belarus
Sergei Gorlatch
University of Muenster, Germany
Lucio Grandinetti
University of Calabria, Italy
Domenico Grimaldi
University of Calabria, Italy
Uwe Großmann
Dortmund University of Applied Sciences and Arts, Germany
Halit Eren
Curtin University of Technology, Australia
Vladimir Haasz
Czech Technical University, Czech Republic
Robert Hiromoto
University of Idaho, USA
Zdravko Karakehayov
Technical University of Sofia, Bulgaria
Mykola Karpinskyy
University of Bielsko-Biała, Poland
Yury Kolokolov
UGRA State University, Russia
Theodore Laopoulos
Thessaloniki Aristotle Univerity, Greece
Fernando López Peña
University of La Coruña, Spain
Kurosh Madani
Paris XII University, France
George Markowsky
University of Maine, USA
Richard Messner
University of New Hampshire, USA
Vladimir Oleshchuk
University of Agder, Norway
José Miguel Costa Dias Pereira
Polytechnic Institute of Setúbal, Portugal
Dana Petcu
Western University of Timisoara, Romania
Vincenzo Piuri
University of Milan, Italy
Peter Reusch
University of Applied Sciences, Germany
Andrzej Rucinski
University of New Hampshire, USA
Rauf Sadykhov
Byelorussian State University of Informatics and Radioelectronics, Belarus
Jürgen Sieck
HTW – University of Applied Sciences Berlin, Germany
Axel Sikora
University of Applied Sciences Offenburg, Germany
Rimvydas Simutis
Kaunas University of Technology, Lithuania
Tarek M. Sobh
University of Bridgeport, USA
Wiesław Winiecki
Warsaw University of Technology, Poland
Janusz Zalewski
Florida Gulf Coast University, USA

Адреса редакції :
НДІ інтелектуальних комп’ютерних систем
Тернопільський національний економічний університет
площа Перемоги, 3
Тернопіль, 46020, Україна
Тел.: 0 (352) 47-50-50 внутр. 12234
Факс: 0 (352) 47-50-53
computing@computingonline.net
www.computingonline.net

© Міжнародний науково-технічний журнал “Комп’ютинг”, 2012

CONTENTS

EDITORIAL

"ADVANCED COMPUTING SYSTEMS"

Guest Editor: Dana Petcu

This special issue at the International Scientific Journal of Computing includes selected invited papers presented at the Sixth IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS'2011), which was held in Prague, Czech Republic, September 15^{th}-17^{th}, 2011.

The Conference was organized by the Research Institute for Intelligent Computer Systems, Ternopil National Economic University, Ternopil, Ukraine and co-organized by the Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic.

The IDAACS Conference series are established as a forum for high quality reports on state-of-the-art theory, technology and applications of intelligent data acquisition and advanced computer systems. These techniques and applications have experienced a rapid expansion in recent years that have resulted in more intelligent, sensitive, and accurate methods of data acquisition and data processing. Subsequently, these advances have been applied to: manufacturing process control and inspection; environmental and medical monitoring and diagnostics; and intelligent information gathering and analyses for the purpose security and safety.

The IDAACS'11 workshop sessions were organized under the following topic areas: Advanced Instrumentation and Data Acquisition Systems; Intelligent Distributed Systems and Remote Control; Virtual Instrumentation Systems; Advanced and High Performance Computing Systems; Cluster and Grid Technologies, Parallel Software Tools and Environments; Embedded Systems; Artificial Intelligence and Neural Networks for Advanced Data Acquisition and Computing Systems; Advanced Mathematical Methods for Data Acquisition and High Performance Computing; Industrial Signal and Image Processing; Data Analysis and Dynamic Modelling; Intelligent Information and Retrieval Systems; Robotics and Autonomous Systems; Information Computing Systems for Education and Commercial Applications; Bio-Informatics and Homeland Security; Safety, Security and Reliability of Software; Wireless Systems – Special Stream.

The paper "*Spatial Data Processing Tools and Applications for Black Sea Catchment Region*" by ***Dorian Gorgan, Victor Bacu, Danut Mihon, Denisa Rodila, Teodor Stefanut, Karim Abbaspour, Pierluigi Cau, Gregory Giuliani, Nicolas Ray*** *and* ***Anthony Lehmann*** describes the development of the enviroGRIDS project that provides a set of tools, applications and platforms concerning with the processing of huge spatial data for the Black Sea catchment region. The paper highlights the main issues of interoperability between Geospatial and Grid infrastructures, and between different platforms supporting the Earth Science oriented tools and applications. The BSC-OS portal provides end user applications for spatial data management, hydrological model calibration, environmental scenario development and execution, workflow based satellite image processing, data reporting and scenarios visualization, and development of Earth Science oriented training materials.

The paper "*Synthesis of Modular-Structured Systems for Automatization of Decisionmaking Processes in Transport Logistics*" by ***Yuriy P. Kondratenko, Sylvia B. Encheva*** *and* ***Ievgen V. Sidenko*** presents in details the evaluation of the quality of transport services to select cargo shipping company using considerations of ranging analysis of transport logistics problems and decision-making methods. These problems are represented as subsystems of DSS module type.

Within the paper "*Competition Between Heterogeneous Agents in Complex Environment*" by ***Tomasz Owczarek*** considers the application of a complexity theory to study heterogeneous organizations in an environment filled with their competitors and complementors. An agent-based simulation model is used to analyze effects of interactions in an environment with different level of complexity. Agents, differing in size and adaptability, try to adapt to fitness landscape they are placed in order to increase their fitness level.

The paper "*Monalisa: A Monitoring Framework for Large Scale Computing Systems*" by ***Ciprian Dobre, Ramiro Voicu*** *and* ***Iosif C. Legrand*** describes a set of distributed services for monitoring, control, management and global optimization for large scale distributed systems. It is based on an ensemble of autonomous, multi-threaded, agent-based subsystems which are registered as dynamic services. They can be automatically discovered and used by other services or clients. The distributed agents can collaborate and cooperate in performing a wide range of management, control and global optimization tasks using real time monitoring information. The MonALISA includes a coherent set of network management services to collect in near real-time information about the network topology, the main data flows, traffic volume and the quality of connectivity.

In the paper "*Interactive Environment for Massive Neuroscience Simulations in Grid*" by ***Andrii Salnikov, Oleksandr Sudakov, Roman Levchenko, Ievgen Sliusar*** and ***Anton Savchenko*** the end-user oriented system for massive computations within a grid system is presented. The system provides support of user interfaces for input and output data staging, asynchronous jobs submission and control, tasks status and results monitoring. The main advantages of the described gridportal are flexibility in computations, back-ends support and possibility to interactively handle thousands of jobs. The described environment was implemented in Ukrainian National Grid infrastructure for massive simulations of non-linear dynamics in neuroscience.

In the paper "*Novel Chatterbot System of Estimating Current User Interests by Means of Web Information*" by ***Miki Ueno, Naoki Mori*** *and* ***Keinosuke Matsumoto*** proposed the novel chatterbot which can estimate current user interests by means of Web information to solve a problem of human-like conversation. In proposed chatterbot, the interests are represented by the interest vectors that were created by Bulletin Board System data.

The paper "*Fusion of Recirculation Neural Networks for Real-Time Network Intrusion Detection and Recognition*" by ***Pavel Kachurka and Vladimir Golovko*** deals with a recirculation neural network based approach which allows detecting previously unseen type of computer attack in real-time mode and to further correct recognition of this type of an attack. They used recirculation neural networks as an anomaly detector as well as a misuse detector, ensemble of anomaly and misuse detectors, fusion of several detectors to correct detection and recognition of attack types.

The paper "*Modified Probabilistic Neuro-Fuzzy Network for Text Documents*" by ***Yevgeniy Bodyanskiy, Irina Pliss*** and ***Valentyna Volkova*** presents the usage of the modified probabilistic neuro-fuzzy network for text mining based on received knowledge and domain ontologies.

This selection of papers represents the topics of the IDAACS'2011 conference in the area of "Advanced Computing Systems". I hope it will be interesting reading!

Dana Petcu
Institute e-Austria Timisoara,
and Computer Science Department,
West University of Timisoara, Romania
petcu@info.uvt.ro

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

SPATIAL DATA PROCESSING TOOLS AND APPLICATIONS FOR BLACK SEA CATCHMENT REGION

Dorian Gorgan [1)], Victor Bacu [1)], Danut Mihon [1)], Denisa Rodila [1)], Teodor Stefanut [1)], Karim Abbaspour [2)], Pierluigi Cau [3)], Gregory Giuliani [4)], Nicolas Ray [4)], Anthony Lehmann [4)]

[1)] Technical University of Cluj-Napoca, {dorian.gorgan, victor.bacu, vasile.mihon, denisa.rodila, teodor.stefanut}@cs.utcluj.ro, http://cgis.utcluj.ro/
[2)] Swiss Federal Institute for Aquatic Science and Technology, karim.abbaspour@eawag.ch
[3)] Center for Advanced Studies, Research and Development in Sardinia, pierluigi.cau@gmail.com
[4)] University of Geneva, gregory.giuliani@unepgrid.ch, {nicolas.ray, anthony.lehmann}@unige.ch

Abstract: *The enviroGRIDS project has developed and provides through the BSC-OS portal a set of tools, applications and platforms concerning with the processing of huge spatial data for the Black Sea catchment region. The paper highlights the main issues of interoperability between Geospatial and Grid infrastructures, and between different platforms supporting the Earth Science oriented tools and applications. The BSC-OS portal provides end user applications for spatial data management, hydrological model calibration, environmental scenario development and execution, workflow based satellite image processing, data reporting and scenarios visualization, and development of Earth Science oriented training materials.*

Keywords: *spatial data; grid computing; hydrological model; satellite images; Earth Science.*

1. INTRODUCTION

Ecologically unsustainable development and inadequate resource management, in the context of climate, land cover and population changes, in the Black Sea catchment region, are the main concern of the enviroGRIDS (Black Sea Catchment Observation and Assessment System supporting Sustainable Development) FP7 project [1]. The quantity and quality of waters are extremely important as well as understanding the evolution of the complex environmental systems over the coming decades. The enviroGRIDS project aims to develop, calibrate, and make available the hydrological model of the Black Sea catchment region by four main achievements:

- Collection of large transnational data sets;
- Adequate management and sharing processes of the environmental data by a dedicated Spatial Data Infrastructure (SDI);
- Distributed computing in order to allow running a high-resolution hydrological model;
- Providing a set of tools and applications to specialists and citizens in order to access data processing and visualization, and analyze environmental scenarios.

One main challenge of the project is to experiment and implement the interoperability between different technologies, platforms, and applications. One such a case is the interoperability between the Geospatial and Grid infrastructures, in order to extend the features provided by the both technologies. The Geospatial technologies offer very specialized functionalities for Earth Science oriented applications meanwhile the Grid technology is able to support high performance computation by scalability, and distributed and parallel processing.

The resources of the enviroGRIDS system are accessible to the large community of users through the BSC-OS (Black Sea Catchment Observation System) portal. By single sign-on authentication technique the portal provides Web applications for data management, hydrological models calibration and execution, satellite image processing, report generation and visualization, and virtual training center.

This presentation focuses on the BSC-OS portal architecture, and the main challenges and issues regarding the development of environmental tools and applications regarding the Black Sea catchment.

The paper is structured as follows. Section 2 presents the works and achievements related with the enviroGRIDS project. Section 3 sketches the portal architecture and the set of tool and application categories. Each of the next six sections describes a tool and application category such as data management, SWAT model calibration and scenario execution, satellite image processing, spatial data visualization and reporting, two demonstrator applications oriented to citizens and decision makers, and virtual training center. The last section concludes on the portal development and future work.

2. RELATED WORKS

The enviroGRIDS project develops the SWAT model as a high-resolution (i.e., sub-catchment spatial and daily temporal resolution) water balance model to the entire Black Sea catchment region. The model is calibrated and validated by using river discharge data, river water quality data, and crop yield data as in [2]. The Black Sea watershed related hydrological model is very complex due to the highly interconnected and continuously evolving interactions at many spatial and temporal scales, and requires to gather and integrate different sets of environmental data (e.g. physical, chemical, biological) [3]. Other European projects aim environmental related subjects [4]. IS-ENES project develops the European Network for Earth System Modeling (ENES), which calls together the European climate/Earth system modeling community in order to work on understanding and prediction of future climate change. The ENSEMBLES project was a joined effort to develop an ensemble prediction system for climate change based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe. The METAFOR project addresses the fragmentation and gaps in availability of metadata for climate data that are currently found in existing repositories. The goal of the DRIHMS project is to systematically build a bridge between the HMR (Hydro-Meteorological Research) and ICT (Information and Computing Technology) communities, and to identify requirements of HMR users and match them to capabilities of the newly developed ICT infrastructure. The GENESI-DEC project aims to provide guaranteed, reliable, easy, effective access to a variety of data, facilities, tools and services to an ever increasing number of Digital Earth users from all disciplines.

The projects EGEE, SEEGRID-SCI, and C3Grid, provide solutions for sharing complex spatial and environmental data sets, and Grid based processing tools and applications. The aim of the C3Grid project for instance, is to create a grid-based working environment for earth system research.

Manny other European projects such as SAW-GEO, CYCLOPS, GDI-Grid, GEO-Grid, DEEGREE, DORII, and GENESI-DR address the management of spatial data and environmental tools and applications.

Other EU projects such as OBSERVE, EGIDA, Balkan GEONET, enviroGRIDS, BalkanGEONet, and GEONetCab have significant contribution to the development of the environmental network and observation capacity in the South East Europe.

The enviroGRIDS project gathers solutions and experience from many of these mentioned projects in order to approach the particularity of the Black Sea catchment region in terms of SDI, platforms interoperability (i.e. Geospatial and Grid, and software platforms like URM, gSWAT, ESIP, GreenLand, gProcess, eGLE, etc), high resolution models, processing scalability, user interaction usability, and processing efficiency.

3. BSC-OS PORTAL

The BSC-OS portal consists of a set of Web applications through which the users access the system resources such as spatial data, hydrologic models, environmental scenarios, data processing tools, visualization facilities, environmental reports, and training materials (Figure 1).

There are five categories of users such as data providers, earth science specialists, decision makers, citizens, and system administrators. The user may access the features of an individual application by local authentication, or all published applications of the portal by the single sign-on authentication.

The main user tool and application categories provided by the portal are [xx]:

- *Data management* – provides the user with spatial data management and operations. The user may enter data and metadata, visualize, modify, update, and remove spatial data from repositories;
- *Hydrologic model management* – provides the Earth Science specialists with hydrologic model configuration, scenario and model development, model calibration and scenario running. One of the water quality models used in the enviroGRIDS project is SWAT (Soil Water Assessment Tool) [6]. It is a model designed to estimate impacts of land management practices on water quantity and quality in complex watersheds. The SWAT model requires specific information about weather, soil properties, topography, vegetation, and land management practices of the watershed;
- *Satellite data processing* – the specialist may process satellite data and images in order to search for relevant information (e.g. land cover, vegetation, water, land use, soil

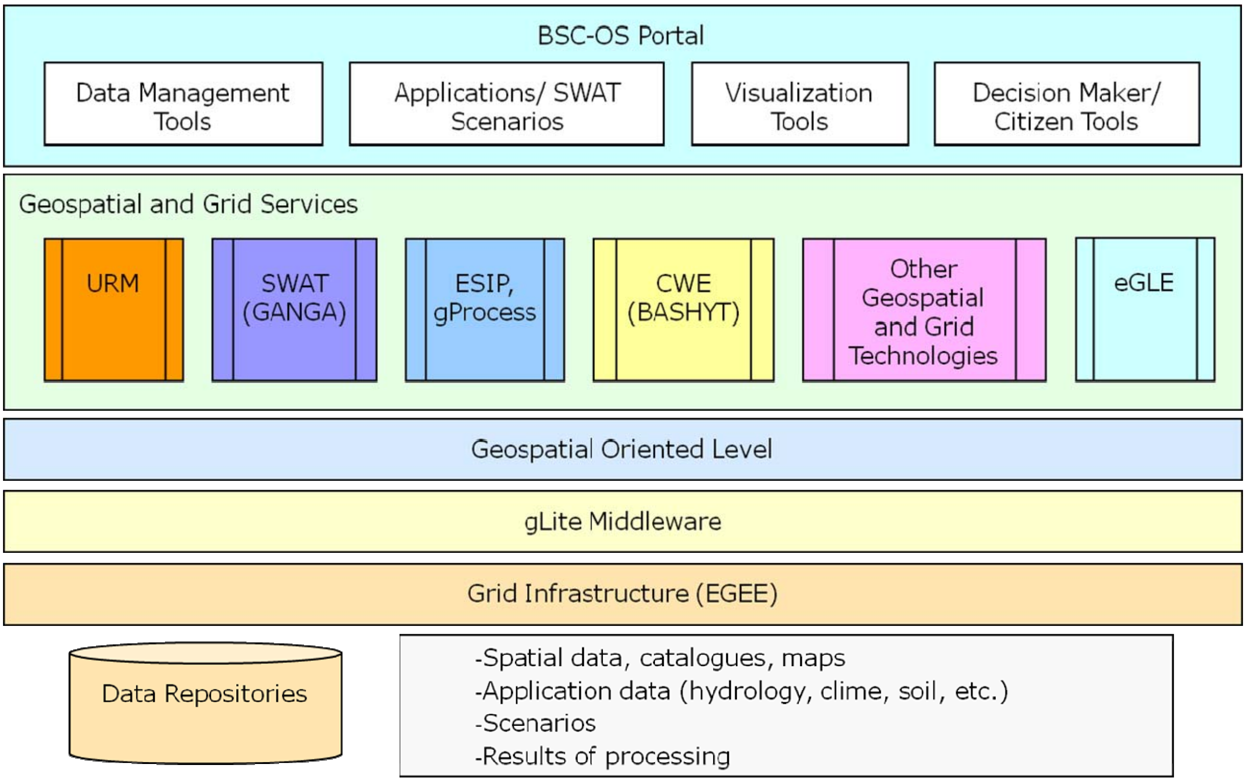


Fig. 1 – BSC-OS portal architecture

composition, etc);

- *Data visualization and report* – the specialists visualize various spatial data in different formats and views and compose environmental reports for decision makers and citizens;
- *Decision maker and citizen applications* – provide the decision makers with the interactive and graphical tools to access the private environmental reports. The user may visualize data that make possible statistical analysis and predictions;
- *Virtual training center* – supports the specialists to develop Earth Science oriented training materials and the users to execute the lessons.

The regular users visualize the reports generated by the specialists as results of executing environmental scenarios. The input data for the reports are built up by the specialists by running hydrological models of the Black Sea catchment area and by processing related satellite data. All data sets required for building up the hydrological models, environmental scenarios, and spatial models are provided and entered into the system by the data providers.

4. DATA MANAGEMENT

The URM (Uniform Resource Management System) platform [7] allows users to search and share spatial and non-spatial information, and establish a network to encourage a broader community to adopt and support the GEOSS concept of data sharing for a more sustainable environment. The URM Geoportal is not the one integrated solution, but a set of modules and services, which are able to communicate through interoperable services defined by OGC (Open Geospatial Consortium), and W3C (World Wide Web Consortium). URM Geoportal consists of four basic blocks interconnected through metadata:

1. Metadata management is supported by the MicKa toolset for editing and management of metadata for spatial information, Web services and other sources;

2. Data management by the DataMan application. It supports the import, export, and management of spatial data in files or databases, for both raster (IFF/GeoTIFF, JPEG, GIF, PNG, BMP, ECW) and vector (ESRI Shapefile, DGN, DWG, GML) data types;

3. Data visualization, provided by the MapMan software tool. It supports publication of spatial compositions from locally stored data with external WMS (Web Map Service), WFS (Web Feature Service) data services;

4. Content management for publishing in context and connections with social networks, is supported by the SimpleCMS toolset.

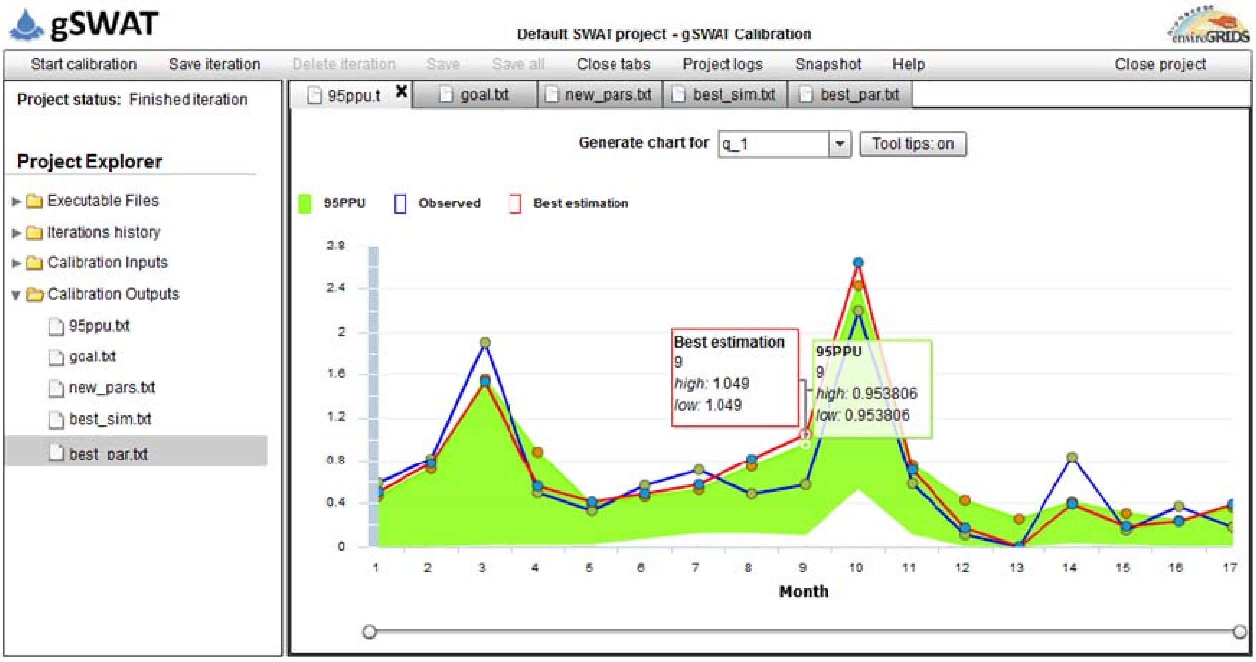


Fig. 2 – Detailed visualization of the gSWAT calibration results

5. SWAT MODEL CALIBRATION AND SCENARIO EXECUTION

The SWAT model supports the specialists on making predictions on the effects of management decisions on water, sediment, nutrient and pesticide yields with reasonable accuracy on large, engaged river basins [8]. The data package of the model could be quite large (up to 20 thousands) and its running requires great storage capacity and high power computation resources.

A. gSWAT Application

The gSWAT application has been developed in enviroGRIDS project and available through the BSC-OS Portal in order to support the development, calibration and execution of the SWAT model [9]. Grid based computation infrastructure is the basic solution for parallel and distributed processing of the hydrological model in the gSWAT application.

It is developed as a Web application that hides to the user the complexity of the Grid infrastructure (Figure 2). The application provides support for scalable models in terms of geographical area, modeling resolution, and number of users. Multicore architecture and GPU cluster based solutions are explored as well in order to speed up and optimize the hydrological model processing [10].

B. *SWAT Oriented Services*

gSWATSim is a server side extension of the gSWAT platform that is exposed as a collection of REST Web Services supporting the user to create new projects (i.e. new scenarios), modify some information related to projects (e.g. project name, description, etc.), run environmental scenarios, upload results to visualization module (i.e. BASHYT), and visualize the execution status of scenarios.

C. *SWAT Model Development and Running*

The hydrological model could be developed, calibrated and run through various approaches based on the gSWAT, gSWATSim services, and BASHYT platforms. The specialist could use the following solutions:

1. gSWAT application – The specialist develops the SWAT model by using ArcSWAT and ArcView tools on his desktop. By using the gSWAT application the user uploads the model onto the gSWAT server and performs interactively the calibration of the model [9]. The user controls the convergence to the optimal calibration (i.e. parameters, simulations, and iterations) by interactive techniques provided through the Web graphical user interface (Figure 2). Finally the user may download the resulted calibrated model.

2. gSWAT and BASHYT tools – The applications "work together" by separate working sessions that are connected just at the data level. The main advantage of this solution is the independency of the tools. The user performs the following steps: develop the SWAT model just in BASHYT, and then downloads the archived SWAT files and metadata. Now, follows the calibration by gSWAT as in the first solution. Finally the user uploads the results into BASHYT and visualizes the environmental information.

Fig. 3 – GreenLand platform and application for Grid based satellite image processing

3. gSWATSim services – The applications work together through a common Storage Element and dedicated Web Services. The working session is in BASHYT through which the user develops the model and defines the scenario. The user exports to gSWATSim the data onto the Storage Element, then through the dedicated Web Service the execution environment is customized, and the scenario is executed. Scenario execution progress can be monitored directly in BASHYT. Finally after the execution, the results are available automatically into BASHYT for visualization. In this solution the user does not need to switch between the applications. BASHYT accesses a new functionality available through gSWATSim services, which allows the execution and the monitoring of running scenarios.

6. SATELLITE IMAGE PROCESSING

Satellite images could reveal information on land cover, precipitations, geographic areas, pollution, and natural phenomena. Spatial and environment related data could be acquired by imagery classification that is actually a data mining throughout the multispectral bands. It is a multivariable process taking in account satellite image types (e.g. MODIS, Landsat), particular geographic area, soil composition, vegetation cover, and generally the context (e.g. clouds, snow, and season). All these specific and variable conditions require flexible tools and applications to support an optimal search for the appropriate solutions.

One of the basic platforms supporting the development of the Grid oriented applications for satellite image processing are ESIP (Environment oriented Satellite Data Processing Platform) and gProcess [11]. ESIP supports a workflow based flexible description of the satellite images complex processing over the Grid. Actually ESIP includes as well the gridified GRASS functionality [12]. The gProcess platform supports the management and execution of workflows (i.e. task distribution, management of parallel and sequential tasks) over the Grid infrastructure.

The ESIP based applications have been developed according with the methodology reported in [13]. The BSC-OS portal publishes the GreenLand end user application that is accessible by Web browsers (Figure 3). The GreenLand application layers on the gProcess and ESIP platforms and extends the satellite image processing related functionality:

- Supporting the scalability, in terms of number of users, number of projects, number of workflows;
- By using the OGC Web services in order to search, visualize, fetch, and store the satellite images;
- Interoperability between GreenLand and URM is supported by standard OGC services (e.g. WMS, WCS, and WFS);
- GreenLand publishes satellite data by OGC services provided by GeoServer, and registered on the URM server;
- The GreenLand functionality and operators are published as WPS services (e.g. NDVI, EVI, and Accuracy Assessment);
- Two editors support the development of Basic Operators and Workflows. The first editor includes into the GreenLand platform the

basic operators, which are used later to develop complex functionalities as workflows. The Workflow editor supports the diagrammatic description of complex processing to be executed over the Grid.

The main features of the GreenLand cover the requirements defined three main use cases in enviroGRIDS project: land cover monitoring for the Istanbul area in Turkey, Rioni River in Georgia, and Mosaic scenario related with the Black Sea catchment region.

7. DATA VISUALIZATION AND REPORTING

BASHYT (The Basin Scale Hydrological Tool) [14] is a Web based interface to SWAT that works together with ArcSWAT and AvSWAT [15]. It can be used to manage many watersheds/scenarios at once and exposes on the Web a template to produce environment oriented applications. The applications can be edited directly through the browser. BASHYT implements the Driving forces-Pressures-States-Impacts-Responses paradigm and is able to produce reports on environmental states that can be visualized in different ways.

In BASHYT the SWAT models are stored into a relational database. A preprocessing step is required to import raw data (vector, raster and tabular data) into the system. After importing SWAT models BASHYT could offer tables, charts, and maps in a transparent way to the end users.

8. CITIZENS ORIENTED APPLICATIONS

Two demonstrator Web applications for citizens have been developed within the enviroGRIDS project and available through the BSC-OS Portal. The first application, which is related to near real time dissemination of environmental data to citizens, a flood forecasting demonstrator is applied on the Somes Mare catchment in northern Romania. For the second application, related to long term planning in river basins a demonstrator for long-term planning of remediation strategies regarding flooding, sediment and ecosystem problems along the Danube River section between the towns of Braila and Tulcea has been selected.

The first application is supported by the HEC-HMS [16] hydrological model executed over the Grid infrastructure, and the second one is supported by the SOBEK 1D/2D [17] hydrodynamic model of flow and sediment transport. Geospatial data is available through the enviroGRIDS URM Portal by standard OGC services, while for water-related time series data the emerging WaterML standard is used.

On the client side, for both applications the main interfaces are map-based (e.g. OpenLayers, Google maps, and Google Earth platforms), over which the additional data are overlaid as spatially distributed data, or point data containing time series of modeled results.

9. TRAINING MATERIALS

The BSC-OS Portal provides the virtual training center based on eGLE (GiSHEO eLearning Environment), developed initially through the GiSHEO project [18]. The training system has as generic users the teacher and the student. The teacher is the Earth Science specialist who authors teaching materials and coordinates the training sessions. The student is the trainee who accesses the teaching objects organized by lessons in order to get presentations, experiment algorithms on spatial data, process satellite images, execute environmental scenarios, and visualize reports already prepared by the specialists.

The teaching material is built as lessons in terms of templates, patterns, and tools. The Earth Science related content of the lessons may be fix or dynamically fetched from data repositories by standard OGC services such as WMS and WCS, (Figure 4).

The teacher may use the Grid based execution to process satellite images, to execute specific algorithms through workflow descriptions or to visualize previously created teaching resources (i.e. already processed satellite images, geographical maps, diagrams, algorithm workflow descriptions, etc.). The students have only the ability to execute the lessons according to the constraints established by the teacher. Depending on the interaction specified level, they could as well be allowed to describe and experiment new workflows (i.e. algorithms, scenarios) or choose different input data (e.g. satellite images, parameters) for existing ones.

10. CONCLUSIONS

The development of the BSC-OS portal and generally the research through the enviroGRIDS project have revealed a lot of challenges regarding the gathering data into a dedicated SDI, interoperability between Geospatial and Grid infrastructures, connections through standard OGC services, and interoperability between platforms developed by different partners (e.g. URM, gSWAT, ESIP, gProcess, GreenLand, gLite, BASHYT, and eGLE), huge spatial data sets involved in the development of hydrological models and environmental scenarios (e.g. Danube, Mosaic, Black Sea Catchment, Istanbul, and Rioni River in Georgia), security and access management in different platforms, application development in distributed and heterogeneous systems, etc.

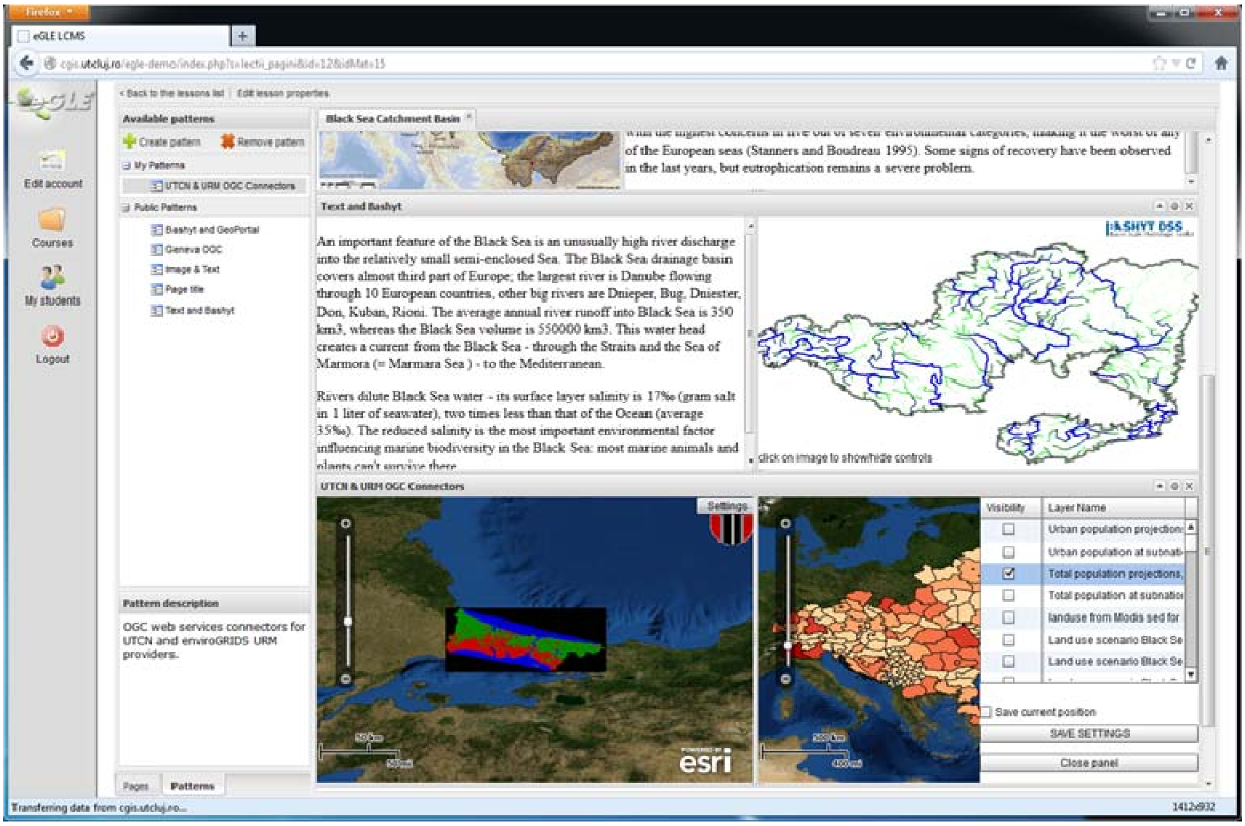


Fig. 4 – eGLE eLearning platform for teaching materials development and execution

Another issue the portal development has to face is the compatibility with new technologies and functional requirements. One main concern is the compatibility with the new European Middleware Initiative (EMI) that aims to improve and standardize the dominant existing middlewares in order to produce one simplified and interoperable middleware [19]. EMI attempts to unify a few Grid platforms such as ARC, gLite, Unicore and dCache. The EMI and Globus platforms will empower the EGI (European Grid Infrastructure) with more stable, useable and manageable software.

The main work aims to develop extended and high resolution models and scenarios, to improve the tool and application functionality, and to improve the user interaction techniques with spatial data models.

The service oriented architecture, multicore, GPGPU based systems, Cloud processing are other technologies that are explored in order to extend the scalability, interoperability, standard connectivity, functionality, usability of end user applications, system efficiency, and to improve the performance of data processing.

11. ACKNOWLEDGMENT

This research is supported by the FP7 enviroGRIDS Project funded by the European Commission, through the Contract 226740.

12. REFERENCES

[1] enviroGRIDS project – Black Sea Catchment Observation and Assessment System supporting Sustainable Development, http://www.envirogrids.net/

[2] K.C. Abbaspour, J. Yang, I. Maximov, R. Siber, K. Bogner, J. Mieleitner, J. Zobrist, R. Srinivasan, Spatially-distributed modelling of hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT, *Journal of Hydrology*, 333 (2007), pp. 413-430.

[3] The Full Picture, *GEO – Group on Earth Observation*, *Geneva*, Switzerland (2007), 278 p. http://www.earthobservations.org/documents/the_full_picture.pdf.

[4] European Commission, *Research and Innovation – Environment* (2012), http://ec.europa.eu/research/environment/.

[5] D. Gorgan, K. Abbaspour, P. Cau, V. Bacu, D. Mihon, G. Giuliani, N. Ray, A. Lehmann, Grid based data processing tools and applications for Black Sea catchment basin, *IDAACS'2011 – The 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, Prague, IEEE Computer Press, (2011), pp. 223-228.

[6] J.G. Arnold, R. Srinivasin, R.S. Muttiah, and J.R. Williams, Large area hydrologic modeling and assessment: Part I. model development, *Journal of the American Water Resources Association*, (34) 1 (1998), pp.73-89.

[7] K. Charvat, S. Kafka, M. Splichal, M. Alberts, URM for agriculture, environmental education, and knowledge sharing, *WCCA 2008 – 6th World Congress on Computers in Agriculture*, Tokyo, Japan, (24-27 August, 2008), pp. 455-460.

[8] SWAT – soil and water assessment tool, http://www.brc.tamus.edu/swat/index.html.

[9] V. Bacu, D. Mihon, D. Rodila, T. Stefanut, D. Gorgan, Grid based architectural components for SWAT model calibration, *HPCS 2011 – International Conference on High Performance Computing and Simulation*, Istanbul, Turkey, (4-8 July, 2011), pp. 193-198.

[10] D. Rodila, V. Bacu, D. Gorgan, Comparative analysis of multicore and grid based execution of SWAT model, *3PGCIC 2011 – Sixth International Conference on P2P, Parallel, Grid, Cloud and Internet Computing*, October 26-28, 2011, pp. 273-278.

[11] D. Gorgan, V. Bacu, D. Rodila, F. Pop, D. Petcu, Experiments on ESIP – environment oriented satellite data processing platform, in *Earth Science Informatics Journal*, Springer, Vol.3/4, (2010), pp. 297-308.

[12] GRASS GIS – Geographic Resources Analysis Support System Project (2011), http://grass.osgeo.org/.

[13] D. Gorgan, T. Stefanut, V. Bacu, D. Mihon, D. Rodila, Grid based environment application development methodology, *Large-Scale Scientific Computing, LNCS*, Vol. 5910, (2010), pp. 499-506.

[14] S. Manca, C. Soru, P. Cau, G. Meloni, M. Fiori, The BASHYT DSS: A Web based decision support system for water resources management, *5th International SWAT 2009 Conference*, (August 3-7, 2009), available at http://www.brc.tamus.edu/swat/4thswatconf/docs/rooma/session5/Cau-Bashyt.pdf.

[15] M. Di Luzio, R. Srinivasan, J.G. Arnold, A GIS-coupled hydrological model system for the watershed assessment of agricultural nonpoint and point sources of pollution, *Transactions in GIS Journal*, (8) 1 (2004), pp. 113-136.

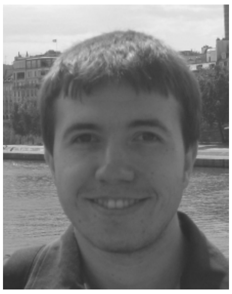
[16] HEC-HMS – The Hydrologic Modeling System, http://www.hec.usace.army.mil/software/hec-hms/

[17] SOBEK Suite, Delaters Systems, http://www.deltaressystems.com/hydro/product/108282/sobek-suite

[18] D. Gorgan, T. Stefanut, V. Bacu, Grid based training environment for earth observation, *Advances in Grid and Pervasive Computing, LNCS* Vol. 5529, (2009), pp. 98-109.

[19] EMI – European Middleware Initiative (2012), http://www.eu-emi.eu/.

Prof. Dorian Gorgan *is PhD supervisor in Computer Science and Information Technologies at the Technical University of Cluj-Napoca. He is the chair of the Computer Graphics and Interactive Systems Laboratory. His fields of interest concern with graphical modeling and processing based on graphics clusters, Grid and Cloud computing, interactive and distributed applications, Earth Science applications and tools development, Geospatial and Grid infrastructures interoperability. He was the initiator and the director of the MedioGrid project, developing the first national Grid infrastructure for research and academic community. He is involved as well in other Grid related international research projects such as EnviroGRIDS, GiSHEO, and SEE-GRID-SCI and has developed satellite image processing tools, applications and platforms such as: gProcess, eGLE, ESIP, GreenView, and GreenLand.*



Victor Bacu *is junior lecturer in Computer Science at the Technical University of Cluj-Napoca. He is the member of the Computer Graphics and Interactive Systems Lab. His research contributes to national and international projects including MedioGrid, SEE-GRID-SCI, GiSHEO and enviroGRIDS. His research interest focus on Grid and Cloud application development, cluster based visualization, computer graphics, graphical model and simulation, tool packages for flexible classification in the satellite images.*

Danut Mihon *is Researcher in Computer Science and Information Technologies at the Technical University of Cluj-Napoca. His fields of interest concern with satellite image processing over distributed architectures, spatial data processing and visualization, Earth Science oriented application development, Grid and Cloud computing. He has been involved in the SEE-GRID-SCI, GiSHEO and*

enviroGRIDS research projects. He is the main developer of the GreenLand platform and Web application.

***Denisa Rodila** is Researcher in Computer Science and Information Technologies at the Technical University of Cluj-Napoca. She is a member of the Computer Graphics and Interactive Systems Laboratory and her research contribution is included in national and international projects such as GiSHEO and enviroGRIDS. She has edited several papers in the areas of distributed computing and her research interests include distributed computing and intelligent systems, with focus on Grid, Cloud, cluster and service oriented technologies.*

***Teodor Ştefănuț** is junior lecturer in Computer Science at the Technical University of Cluj-Napoca. He is the member of the CGIS Laboratory. His research contributes to national and international projects including mEducator, I-Trace, SEE-GRID-SCI,GiSHEO, and enviroGRIDS. His research interests include new user interactions techniques, development of Grid applications for non-technical specialists, eLearning platforms based on distributed architectures, graphical annotation as user interaction technique in the context of a lesson.*

***Dr. Karim Abbaspour** is a soil scientist and hydrologist. He has studied at UBC in Vancouver, Canada, and ETHZ in Switzerland. He has been working at the Eawag, Swiss Federal Institute of Aquatic Science and Technology since 2000. His main specialization is in application of flow and transport models at small and large scales. He is also working on methods of model calibration, validation, and uncertainty analysis.*

***Pierluigi Cau** is an hydraulic engineer graduated at the University of Cagliari. Researcher for the Water Resources Management group, Energy and Environment Program of CRS4, since 2000.*

***Dr. Gregory Giuliani**, after obtaining a degree in Earth Sciences, went on to complete a master in Environmental Sciences, specializing in remote sensing and GIS. He previously worked as a GIS Consultant for the World Health Organization, as a University tutor in remote sensing and GIS and as a GIS Developper in a local Swiss GIS company. He works at UNEP/GRID-Europe since 2001 and is the focal point for Spatial Data Infrastructure (SDI).*

***Dr. Nicolas Ray** is the enviroGRIDS project manager. He holds a Master in Environmental Sciences, a PhD in Biology from University of Geneva in the field of Human Population Genetics, and a postgraduate certificate in Computer Sciences. Nicolas' research activities focused on the modeling of animal movement and habitat, with the development of several spatial and statistical analysis tools to integrate various data types (genetic, environmental, demographic). Through his research and various consultancy works, Nicolas acquired solid competencies in GIS, spatial analysis, software development, and grid computing integration. After six years of postdoctoral research in Australia, UK and University of Bern, he recently joined the Institute of Environmental Science at University of Geneva and UNEP/GRID-Europe to dedicate his time to the enviroGRIDS project.*

***Dr. Anthony Lehmann** is the EnviroGRIDS project initiator and coordinator. He holds a Masters Degree and a PhD in Aquatic Biology from the University of Geneva, and a Postgraduate Master in Statistics from the University of Neuchâtel. He specialized during his career in combining GIS analyses with statistical models. At the University of Geneva he is in charge of the enviroSPACE laboratory exploring Spatial Predictions and Analyses in Complex Environments.*

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

SYNTHESIS OF MODULAR-STRUCTURED SYSTEMS FOR AUTOMATIZATION OF DECISION-MAKING PROCESSES IN TRANSPORT LOGISTICS

Yuriy P. Kondratenko [1], Sylvia B. Encheva [2], Ievgen V. Sidenko [1]

[1] Petro Mohyla Black Sea State University, 68th Desantnykiv Str. 10, Mykolaiv 54003 Ukraine,
y_kondratenko@rambler.ru, emoty@mail.ru
[2] Stord/Haugesund University College, Klingenbergvegen 8, N-5414 Stord, Norway, silvia.encheva@hsh.no

Abstract: *The ranging analysis of transport logistics problems and decision-making methods were held in the paper. The problems, which are represented as subsystems of DSS (Decision Support System) module type, were considered. One of which, in particular, evaluation of the quality of transport services to select cargo shipping company, was considered in details.*

Keywords: *transport logistics, DSS, fuzzy logic, knowledge base, services quality.*

1. INTRODUCTION

Formation and organization of cargo shipping chains work is associated with intense and rapid exchange of information between participants of transport process [1]. Transport companies need to select kind and type of vehicles and organize transportations providing the required level of shipping quality, which determines the profit of company, its image, and competitiveness [2]. To increase the efficiency of cargo transportation the significant role is assigned to informational technologies and software tools that allow accompanying the stages of transport logistics on the new intellectual level [2].

2. PROBLEM STATEMENT

Customers of transport services often are not satisfied with the quality of services, as there take place violations of delivery terms, spoiling and loosing cargo [1]. This is due to the complexity of cooperation process of large number of forwarders, carriers and logistic companies. This raises a difficulty of constructing rational routes of cargo transportation, absence of universal program systems that accompany processes of cargo transportation in real time [2]. The important aspect of modern transport logistics is to ensure continuity of controlled processes in transport nodes, where while cargo passing nets of different transport agencies are crossing, an exchange of information between different nets takes place. It concerns, for example, transshipment points (ports, railway stations, etc.), and organization of uninterrupted mixed transportations [3, 4].

Development of decision-making support system (DSS) will allow resolving problem issues of coordination of interaction between different objects-participants of cargo transportation process, selecting optimal routes and others [5, 6].

Solving complex of problems associated with the organization of cargos movement implies a previous classification of transport logistics problems [5]. It is necessary to increase efficiency of decision making. Herein it is reasonable to define methods that are the most effective to use in the process of solving determined tasks.

The analysis and research of transport logistics tasks [5, 6, 7] allows to outline the main ones that are presented in the form of DSS subsystems module type in Fig.1

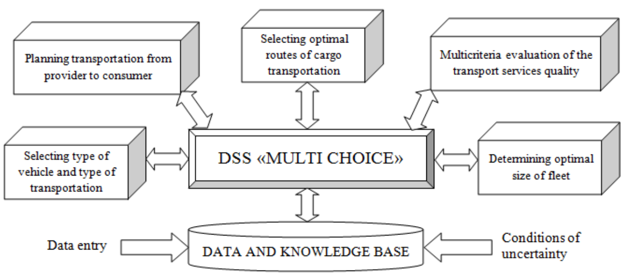


Fig. 1 – Module structure of DSS "MULTI CHOICE"

The purpose of this paper is developing approaches of structural and algorithmic organization of DSS modules to solve transport logistics tasks, in particular, to estimate the quality of transport services.

3. MODULES' CHARACTERISCTICS OF DSS "MULTI CHOICE"

DSS module (Fig. 1) to select type of vehicle and type of transportation.

The task of selecting the type of vehicle is solved in conjunction with other logistics tasks, in particular, creating and maintaining optimal stocks level, choosing type of packing and others. The basis of transport selection, optimal for a specific transportation, is information about features of different types of vehicles. Currently there is a problem of a large number of advantages and disadvantages for each type of vehicle [1].

Transport logistics identifies five types of transport (railway, road, air, marine and pipeline) [1, 2, 3]. Herein selection of optimal transport depends on conditions of transportation of a particular company.

When selecting railway transport the main advantages are transportation of large consignment of goods under any climatic conditions, their regularity, low cost of cargo delivery. While low speed and impossibility of delivery to remote locations refer to serious disadvantages [2].

The main advantages of road transport are high mobility of vehicle, delivery directly to the place of destination, sending cargos over short distances. Herein the urgency of loading off cargo, high cost of cargo transportation and relatively low cargo capacity of road vehicles imposes similar restrictions on the process of transportation [2].

When choosing a type of marine and air transport should be noted dependence on navigation and weather conditions, and also the low frequency [4].

The analysis [1-4] of pro and cons of each type of transport means allows to identify the main criteria of selecting the optimal type of transport. These include (Fig. 2): the possibility of cargo delivering to any point in the territory (K1), timeliness of delivery (K2), security of cargo (K3), frequency of cargo transportation (K4), transport expenses (K5), cargo capacity (K6), ability to transport different types of cargo (K7), independence from climatic conditions (K8), overcoming large distances (K9), urgency of loading off (K10). As alternative variants there are main types of transport (Fig. 2): road (A1), railway (A2), marine (A3), air (A4) and pipeline (A5).

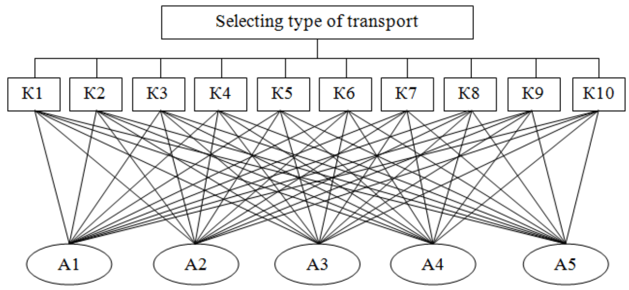


Fig. 2 – The structure of DSS module

The task of selecting the optimal type of transport is reduced to solution of the decision tree (Fig. 2) using method of Analytic Hierarchy Process. For a specific DM the priority of criteria with respect to main goal may vary. It depends on conditions of uncertainty in the transportation process (time and distance constraints, weather conditions) and strategies of transport companies [8].

The process of cargo delivery using one type of transport is typical for unimodal type of transportation [9]. However, to increase the efficiency of shipping transport companies combine advantages of different types of transport, while avoiding disadvantages. Such type of transportation is called mixed or multimodal. The problem of corresponding cargo transportation lies in complexity of actions coordination of different participants of the cargo transportation process. Herein the cost and time of transportation increase. Selection of cargo transportation type in each individual case is determined by cost of delivery, speed of order execution and other factors. The analysis of literature and scientific researches shows that usage of the critical path method allows to determine optimal combination of several transport types [9, 10]. Thus at the final stage is planning to get optimal combination of logistics intermediaries, which take part in the cargo transportation process.

DSS module (Fig. 1) to select optimal routes of cargo transportation.

Selection of optimal transportation routes depends on specifics of the cargo, its size and purpose. Particular difficulty presents selection of route for large size and dangerous cargos [1].

In the result of analysis and comparison of possible alternative routes DM selects the optimal variant for the specific criteria. Among them may be: minimum transportation path length, time of transportation, transport expenses, cargo residues when implementing routes and others [5].

Investigation and analysis of problems of selecting the optimal transportation routes allow to outline main tasks of combinatorial optimization (class NP-hard problems), solving of which leads to solution of corresponding problem. To such tasks correspond: travelling salesman problem (TSP), vehicle routing program (VRP) with restrictions on cargo capacity (CVRP) and "time windows" (WRPTW), problem of the pack (KP). Thus finding the optimal route requires full search of all possible alternative decisions. There is a problem of increasing computational expenses by increase of the vector of input information dimension [11].

Let's consider the example of the deterministic task of planning routes for 33 nodes ($N = 33$), when all initial information is known (coordinates of diversified transport system nodes and volume of orders in the form of distinct values).

Coordinates of nodes $X_i, Y_i, i \in \{1, 2, ..., N\}$, where cargo consumers are, are presented in Table 1, cargo capacity of transportation unit $D_{\max} = 5$ tons, order $Q_i, i \in \{1, 2, ..., N\}$ in nodes are presented in Table 2.

Table 1. Coordinates of diversified transport system nodes

№ node	X_i	Y_i	№ node	X_i	Y_i	№ node	X_i	Y_i
1	26	59	**12**	66	14	**23**	31	76
2	40	66	**13**	44	13	**24**	22	53
3	55	65	**14**	26	13	**25**	26	29
4	35	51	**15**	11	28	**26**	50	40
5	62	35	**16**	7	43	**27**	60	40
6	62	57	**17**	17	64	**28**	60	15
7	62	24	**18**	41	46	**29**	47	66
8	21	36	**19**	55	34	**30**	30	60
9	33	44	**20**	35	16	**31**	30	50
10	9	56	**21**	52	26	**32**	12	17
11	62	48	**22**	43	26	**33**	15	14
$X_0 = 40, Y_0 = 40$ – coordinates of base node (#=0),where warehouse complex and transportation company are situated								

Table 2. Cargo ordering in each set of nodes

node #	Q_i	node #	Q_i	node #	Q_i
1	0,8681	**12**	0,8791	**23**	0,3472
2	0,6997	**13**	0,4565	**24**	0,1072
3	0,7929	**14**	0,1406	**25**	0,5455
4	0,8111	**15**	0,0981	**26**	0,7128
5	0,1842	**16**	0,5704	**27**	0,7950
6	0,2531	**17**	0,1034	**28**	0,6341
7	0,9053	**18**	0,2872	**29**	1,0205
8	0,4809	**19**	0,3286	**30**	0,3373
9	0,8336	**20**	0,2594	**31**	0,6244
10	0,5102	**21**	0,5658	**32**	0,0400
11	0,6735	**22**	0,7832	**33**	0,2592

Using data (Table 1, 2) let's form routes of vehicles with cargo capacity $D_{\max}$ on the basis of results of saving-algorithm for total orders (Fig. 3).

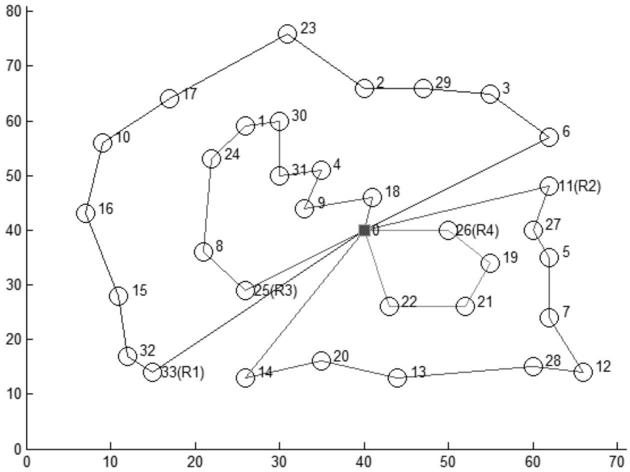


Fig. 3 – Routes of transportation

According to Hamiltonian cycles, formation of which is based on saving-algorithm, there are designated $S = 4$ routes $R_i, i \in \{1, 2, ..., S\}$ of different length and structure (Fig. 3). It depends on cargo capacity of vehicles and volume of orders in nodes. For shipping of total orders 4 transportation units are needed for 4 routes accordingly. In the Table 3 there are presented length of each route $L_r, r \in \{1, 2, ..., R\}$, the amount of carried cargo $Q_r, r \in \{1, 2, ..., R\}$ and residual amount of cargo ΔD_γ. Herein there are determined the total length of all routes $L_\Sigma = 448,3$ km, the volume of orders in nodes $Q_\Sigma = 16,91$ tons and performance indicator of vehicles workload $E = 0,85$ by equation (1).

$$E = \frac{1}{R} \sum_{\gamma=1}^{R} \left(1 - \frac{\Delta D_\gamma}{D_{\max}} \right) \qquad (1)$$

Table 3. Routes characteristics

R	Route structure	L_r	Q_r	ΔD_γ
1	0-33-32-16-16-10-17-23-2-29-3-6-0	176,74	4,69	0,31
2	0-11-27-5-7-12-28-13-20-14-0	130,41	4,93	0,07
3	0-25-8-24-1-30-31-4-9-18-0	91,48	4,90	0,10
4	0-26-19-21-22-0	49,67	2,39	2,61

Depending on conditions of uncertainty (volume of orders in nodes) and cargo capacity of vehicles, the amount and the structure of routes can vary.

The task of planning transportation routes becomes more complicated if orders in nodes are represented as fuzzy numbers, for example, triangular shape of membership function [14]. Usage of DSS module (Fig. 1) to select optimal routes of cargo transportation also is designed for solving problems of corresponding complexity.

DSS module for planning transportation from suppliers to consumers (Fig. 1).

Analysis of literature [1, 2, 14] shows that one of the approaches to solving tasks of cargo transportation planning is bringing it to transportation task of Monge-Kantorovich. It is a mathematical problem of linear programming to find optimal plan to separate homogeneous objects from suppliers (warehouses) to consumers. Herein expenses on transportation should be minimal.

At present we know several methods (algorithms) of solving transportation problem of linear programming. These include: methods of northwest corner, minimum value, Vogel (to get initial plan), method of potentials to improve key plan and to get the best variant of cargo transferring. In many transportation companies the problem of planning routes of cargo delivering and passengers is solved with the help of the distribution method, the delta-method, network methods, etc. But such problems are often compounded by varied conditions and restrictions, in particular, the necessity of cargo delivering in minimum time, the availability of cargo and demand for it are not balanced, etc. [15]. One of the disadvantages of transport problem is that the model of cargo transportation does not take into account the heterogeneity of freight cargo and vehicles. Solution of this problem is achieved by means of considering multiindex (three-planar T-3P and three-axial T-3A) transportation tasks [16]. Solution of such class of problems allows to get optimal plan of transportation of diverse cargo by different types of vehicles.

Let's consider the example of apple transportation planning from 3 companies $\{P_1, P_2, P_3\}$, which grow them, to 6 customers $\{K_1, K_2, ..., K_6\}$. Moreover, each of them should get the appropriate amount of products. It is necessary to develop such transportation plan, when total expenses on its realization are minimal. Scheme of transport links between suppliers and customers are presented in Fig. 4.

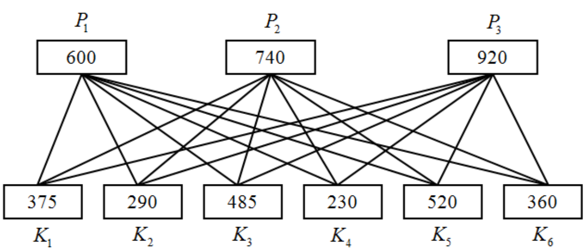


Fig. 4 – Scheme of transport links

In table 4 there are represented accurate values of transportation expenses $c_{ij}, i \in \{1,2,...,P\}, j \in \{1,2,...,K\}$ on transportation of product unit from suppliers $P_i, i \in \{1,2,...,P\}$ to customers $K_i, i \in \{1,2,...,K\}$

Table 4. Matrix of transportation expenses

	K_1	K_2	K_3	K_4	K_5	K_6
P_1	4	1	2	7	8	5
P_2	7	5	3	4	6	8
P_3	8	4	6	2	5	10

With the help of linear programming methods we find initial plan, and then improve it to optimum, for example, ss-method. We get the decision tree (Fig. 5), in the root of which there is an alternative decision (plan) E_1^1 with a value of objective function $Z_1 = 10545$ uah. Further the initial plan improves till on the next stage the value of objective function is not changing.

This means that the optimal plan found.

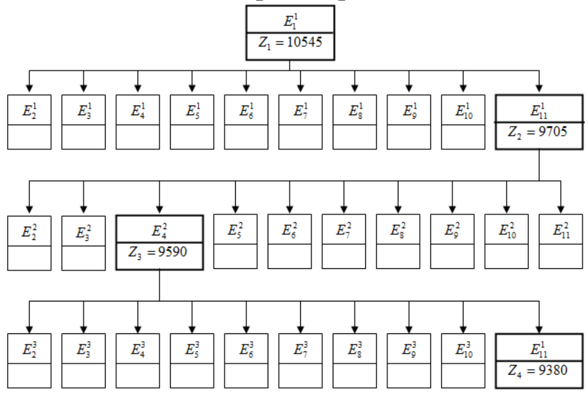


Fig. 5 – Decision tree for transportation planning

For considered example the transportation plan, that meets alternative decision E_{11}^3 with the value of the objective function $Z_3 = 9380$ uah., is optimal (Table 5).

Table 5. Optimal transportation plan

	K_1	K_2	K_3	K_4	K_5	K_6	*Offer*
P_1	375	120				105	**600**
P_2			485			255	**740**
P_3		170		230	520		**920**
Demand	**375**	**290**	**485**	**230**	**520**	**360**	**2260**

One of the problems of cargo transportation planning is unpredictability of the input data changes, where take place orders and expenses on transportation in the form of fuzzy numbers. Algorithm of the ss-method allows to get over to solving of problem of transportation planning in the assumption that the costs are fuzzy [13]. For convenience in performing corresponding calculations and easiness of getting fuzzy data we will fuzzy numbers of triangular shape (FNT) that, for example, correspond to values of expenses q_1 for external conditions F_1, q_2 for external conditions F_2 and q_3 external conditions F_3. In Fig. 6 there is represented FNT $\underset{\sim}{q} = (q_1, q_2, q_3)$ that characterize expenses on cargo unit transportation.

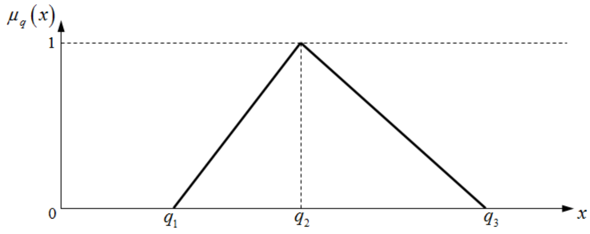


Fig. 6 – Expenses on cargo unit transportation

To use ss-method it is necessary to do operations of addition, subtraction and comparison of FNT [12]. Comparison can be made in various ways, one of which is based on identifying deviations according to formula (2).

$$\xi(\underset{\sim}{A}, 0) = \frac{a_1 + 2a_2 + a_3}{2},\ a_1, a_2, a_3 \in R \quad (2)$$

Of the two alternative decisions is chosen that, which deviation is lower. For example, for the alternative decision (transportation plan) E_3^1 with value of performance function in form of FNT $Z_3^1 = (1010, 1560, 2130)$, deviation will be $\xi(Z, 0) = 3130$. Thus for the alternative decision E_8^1 with value of function $Z_3^1 = (930, 1580, 2020)$ in the form of FTN, deviation is $\xi(Z, 0) = 3070$. In such case the alternative decision E_8^1 is better than decision E_3^1.

DSS module to select the optimal size of fleet (Fig. 1).

To determine the optimal size of the fleet it is necessary to consider cost metrics for formation of quantitative assessments $e_{ij}, i = 1, ..., M_\Sigma, j = 1, ..., 3$ of alternative variants of decisions E_i for different programs of general cargo transportation capacity F_1, F_2, F_3.

The general amount of alternative decisions M_Σ in matrix of decisions is determined as follows:

$$\begin{aligned} &E_1 = F_1 div D_{\max}; \\ &E_{R_{\max}} = F_5 div D_{\max} + 2 \geq R_{\max}; \\ &M_\Sigma = E_{R_{\max}} - E_1 + 1 \end{aligned} \quad (3)$$

The elements e_{ij} of matrix solution $\|e_{ij}\|$ are computed by the following algorithms:

– in case of chartering additional vehicles;
– in case of simple part of vehicles.

In the formed matrix of alternative decisions that correspond to the number of vehicles on criteria of decision making the best variant is chosen.

Let's consider one of the problems of this DSS module, in particular, the problem of finding the optimal number of vehicles with minimizing the cost of cargo transportation from supplier to consumer, involving transport terminals (warehouses) [1].

In each warehouse there is a known amount of cargo that needs to be transported from supplier to consumer by defined routes, each of which runs at different time of the day, that's why the amount of goods that needs to be loaded off from transport terminals will also vary [3].

Transportation costs for cargo shipping on each of the routes differ between each other as they include costs of fuel, shipping services, costs associated with keeping cargo in warehouses, freight costs and others [1].

Finding the optimal number of vehicles comes down to solving problems of linear programming with constraints on the cargo volume in warehouses of each route [14].

The usage of graphical method for solution of this problem is limited by the capabilities and easiness of finding the optimal decision. This is due to the use of only two or three variables in performance function (the solution is achieved by finding the optimal decision in two-dimensional and three-dimensional space of constraints). For solving such class of transport logistics problems it is appropriate to use the method of directed enumeration. This method allows to find the optimal decision by the performance function considering all restrictions. Thus for finding the decision they use Newton's method or the method of conjugate gradients [14, 17].

DSS module to estimate the quality of transport services (Fig. 1).

Let's consider in more details the principles of structural and algorithmic organization of DSS module by the example of subsystem of transport services quality evaluation (cargo delivering).

4. STRUCTURAL ORGANIZATION OF DSS MODULE FOR TRANSPORT SERVICES QUALITY EVALUATION

Analysis of literature [6, 7] shows that among input parameters, that impact on transport services quality evaluation, there can be determined 19 the most important ones [18]. Let's consider by the example the structural organization of DSS module for evaluation of cargo delivering quality with 11 indicators ($N = 11$), among which there are: x_1 –

custom costs; x_2 – costs related to possible situations on the road; x_3 – costs on transportation; x_4 – reliability of information about the cargo movement; x_5 – timeliness of giving information; x_6 – risk during transportation; x_7 – preservation by amount of cargo; x_8 – preservation by quality o cargo; x_9 – timeliness of delivery; x_{10} – possibility of cargo delivering to any place of territory; x_{11} – readiness for delivery.

Output signal is the transport services quality evaluation (y).

Before the beginning of formation process of fuzzy rules database it is important to determine the number and the type of linguistic terms (LT) for evaluation of input and output parameters. To evaluate input coordinates $\{x_1, x_2, ..., x_{11}\}$ of DSS module 3 LT were elected (L – "low", M – "medium", H – "high"), for output variable – 5 (L – "low", LM – "lower the medium", M – "medium", MH – "higher the medium", H – "high") with triangular shape of membership function.

In the process of DSS development on the basis of fuzzy logical derivation there is a possibility of sharp growth of fuzzy rules bases dimension. Herein there raises a complexity of structure formation and fuzzy rules synthesis. It is due to large dimension of input parameters vector, number and type of corresponding linguistic terms (LT). In such case it is hard for expert to describe cause-effect relationships with the help of fuzzy rules as in human memory can simultaneously store 7 ± 2 concepts-features [19].

Here is a structure of fuzzy rule of the productive type.

$$\begin{aligned} &IF\ \left(x_1 = IT_1^j\right)\ AND\ \left(x_2 = IT_2^j\right)\ AND\ ... \\ &AND\ \left(x_i = IT_i^j\right)\ AND\ ...\ AND\ \left(x_n = IT_n^j\right) \quad (4) \\ &THEN\ \left(y = OT^j\right), \end{aligned}$$

where IT_i^j is linguistic term j rule for evaluation of i input signal $x_i, i = 1, ..., N$;

OT^j is linguistic term j rule for evaluation of output signal y.

With such structural organization of rules the sensitivity of DSS towards changes of input coordinates $x_i, i = 1, ..., N$ ($N = 11$) decreases. It is related with complexity of formation of all possible dependences between system parameters.

The structure of DSS module (Fig. 7) is developed so that some inputs of each subsystem do not exceed five. It allows to reduce the number of fuzzy knowledge bases, thus improve the sensitivity of the system towards input variables (factors) actions. Herein it is necessary to conduct structuring of input variables only by common properties that serve as main (important) in frames of subsystem [20]. It I advisable to combine input coordinates in the following groups: $y_1 = f_1(x_1, x_2, x_3)$, $y_2 = f_2(x_4, x_5)$, $y_3 = f_3(x_7, x_8)$, $y_4 = f_4(x_9, x_{10}, x_{11})$, $y_5 = f_5(x_6, y_2)$, $y_6 = f_6(y_2, y_5)$, $y = f_7(y_1, y_4, y_6)$. Where $y_i, i = 1, ..., 6$ are intermediate variables of DSS module, including: y_1 – cost of transportation; y_2 – the level of informativeness o cargo delivery; y_3 – safety of cargo; y_4 – image of subjects-participants of cargo transportation; y_5 – reliability of delivery system; y_6 – level of cargo transportation.

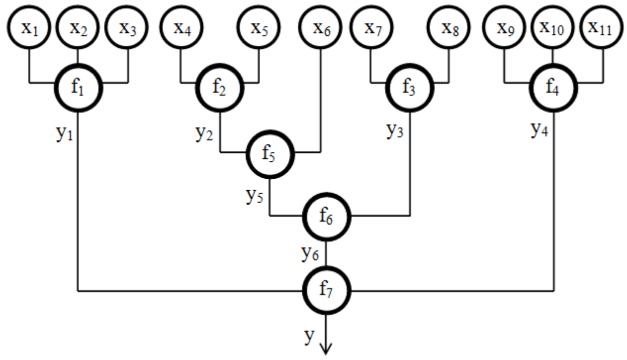


Fig. 7 – The structure of DSS module to evaluate transport services quality

In constructing fuzzy knowledge bases for DSS module (Fig. 7) there are used 3 LT with triangular shape of membership function that are presented for variables $\{x_1, x_2, ..., x_{11}, y_2, y_3, y_5, y_6\}$ in Fig. 8, for variables $\{y_1, y_4, y\}$ – 5 LT in Fig. 9.

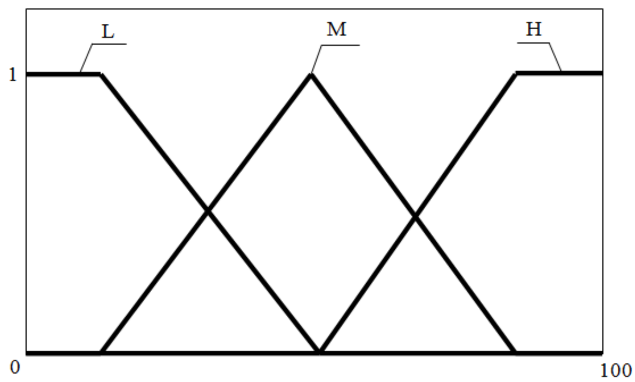


Fig. 8 – linguistic terms of coordinates $\{x_1, x_2, ..., x_{11}, y_2, y_3, y_5, y_6\}$

Number of linguistic terms can be changed before the creation of the rule databases [21].

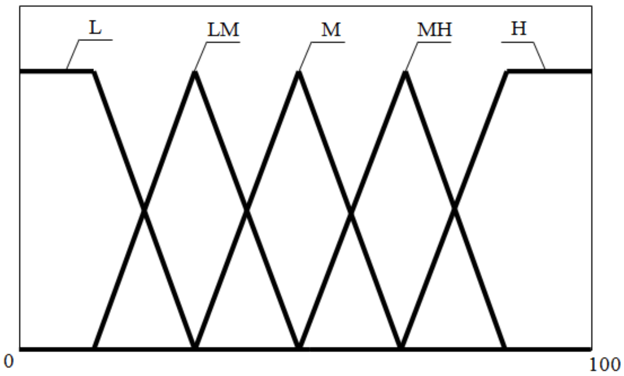


Fig. 9 – linguistic terms of coordinates $\{y_1, y_4, y\}$

Selective set $\{1,3,6,10,13,14,15,17,22,25,27\}$ of rules for the first homogeneous subsystem $y_1 = f_1(x_1, x_2, x_3)$ can be presented as follows:

R1: IF $x_1 = L$ AND $x_2 = L$ AND $x_3 = L$ THEN $y_1 = L$,

R3: IF $x_1 = L$ AND $x_2 = L$ AND $x_3 = H$ THEN $y_1 = LM$,

R6: IF $x_1 = L$ AND $x_2 = M$ AND $x_3 = H$ THEN $y_1 = M$,

R10: IF $x_1 = M$ AND $x_2 = L$ AND $x_3 = L$ THEN $y_1 = L$,

R13: IF $x_1 = M$ AND $x_2 = M$ AND $x_3 = L$ THEN $y_1 = LM$,

R14: IF $x_1 = M$ AND $x_2 = M$ AND $x_3 = M$ THEN $y_1 = M$,

R15: IF $x_1 = M$ AND $x_2 = M$ AND $x_3 = H$ THEN $y_1 = MH$,

R17: IF $x_1 = M$ AND $x_2 = H$ AND $x_3 = M$ THEN $y_1 = M$,

R22: IF $x_1 = H$ AND $x_2 = M$ AND $x_3 = L$ THEN $y_1 = M$,

R25: IF $x_1 = H$ AND $x_2 = H$ AND $x_3 = L$ THEN $y_1 = MH$,

R27: IF $x_1 = H$ AND $x_2 = H$ AND $x_3 = H$ THEN $y_1 = H$.

The structure of the fifth $y_5 = f_5(x_6, y_2)$ rules database (heterogeneous type) and the second $y_2 = f_2(x_4, x_5)$ (homogeneous type) are presented in Table 6.

Table 6. Rules database of fifth and second subsystems

$y_5 = f_5(x_6, y_2)$					$y_2 = f_2(x_4, x_5)$				
Linguistic terms of coordinates		x_6			**Linguistic terms of coordinates**		x_4		
		L	**M**	**H**			**L**	**M**	**H**
y_2	**L**	L	L	L	x_5	L	L	M	M
	M	L	M	L		M	L	M	L
	H	M	H	M		H	M	H	H

In Fig. 10 there is shown a characteristic surface for the first rules database of the first fuzzy subsystem $y_1 = f_1(x_1, x_2, x_3)$.

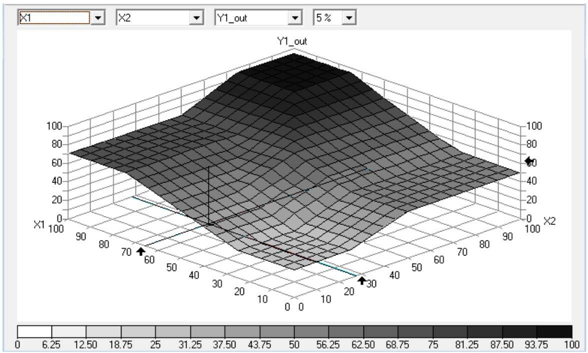


Fig. 10 – Characteristic surface of the first subsystem for the components (x_1, x_2)

There are several software products that allow to develop DSS on the basis of fuzzy logical derivation. Very famous is the software package MatLab, which includes tools "fuzzy" for development of such class of systems. Also there is an environment FuzzyTECH, which does not become such popular as MatLab, although in some respects it has higher possibilities to develop fuzzy DSS, neural networks and neuro-fuzzy system of forecasting.

5. SYNTHESIS OF PROJECT AND PROGRAM REALIZATION OF DSS MODULE

After describing the fuzzy system and developing the fuzzy rules database, the synthesis of fuzzy DSS module is done in the environment of FuzzyTECH. Any system of fuzzy derivation in program environment FuzzyTECH is presented as a separate project [22]. In Fig. 11 there is presented the project of DSS module for evaluation of transportation services quality.

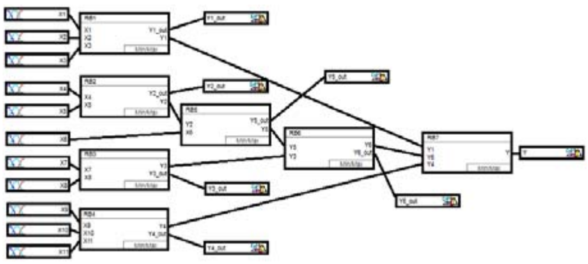


Fig. 11 – The project of DSS module for evaluation of transportation services quality

6. MODELING RESULTS

Simulation results of the DSS module to estimate the quality of transport services (Fig. 7) at different alternative variants (I, II, III, IV, V) of the input data are presented in the Table 7 and Table 8.

Table 7. Alternative variants of the input data

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
I	75	90	35	80	60	45	70	90	30	95	50
II	33	90	55	50	30	7	95	80	80	65	95
III	10	30	87	90	95	30	60	75	55	37	75
IV	50	45	60	47	20	20	85	80	95	45	85
V	25	15	30	90	95	5	35	30	20	35	50

Table 8. Modeling results

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y
I	58	94	85	33	61	83	57
II	55	15	94	96	59	94	71
III	33	92	68	66	85	82	54
IV	53	6	93	91	50	93	69
V	4	93	17	29	94	61	34

As a result of modeling with the help of fuzzy DSS module (Fig. 1) there were received the following values of the quality of transport services:

1) for alternative variant I – 57 balls;
2) for alternative variant II – 71 balls;
3) for alternative variant III – 54 balls.
4) for alternative variant IV – 69 balls.
5) for alternative variant V – 34 balls.

According to the simulation results it is observed, that in the context of estimation of the quality of transport services (71 balls) the best variant is the second (II) alternative variant, and the worst one is the fifth (V) alternative variant (34 balls).

Also modeling results of the DSS module to estimate the quality of transport services are presented on histogram (Fig. 12).

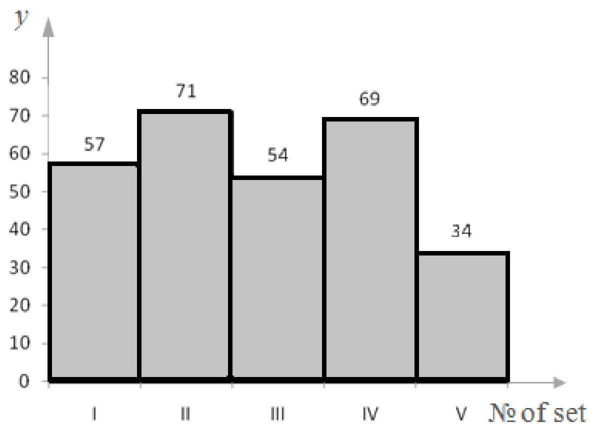


Fig. 12 – Histogram of modeling results

7. CONCLUSION

Modular organization of DSS based on fuzzy logic can automatically solve complex problems of transport logistics. It is possible to decide for each task separately.

Theoretic-methodological basis of hierarchically-organized structure of intellectual models and algorithms allows to structure and configure developed DSS to solve specific problems of transport logistics.

Method of correction (editing) the rules of fuzzy knowledge bases at different number of input coordinates of the system [23], which developed by the authors, can be used in a modular DSS.

8. REFERENCES

[1] L.B. Mirotin, *Transport Logistics,* Moscow, Examination, 2005, 501 p. (in Russian)

[2] M.P. Denisenko, P.R. Levkovets, L.I. Mikhailova, *Organization and Design of Logistics Systems*, Kyiv, Center of Educational Literature, 2010, 336 p. (in Ukrainian)

[3] E.V. Krykavskiy, N.I. Chukhrai, *Logistics*, Kyiv, Condor, 2009, 340 p. (in Ukrainian)

[4] A.M. Gadzhinskiy, *Logistics Fundamentals,* Moscow, Marketing, 1996, 124 p. (in Russian)

[5] Y.P. Kondratenko, Ie.V. Sidenko, Classification analysis of transport logistics problems and methods of decision-making, *2012 Conference on Modern Information and Innovation Technologies in Transport*, Kherson, Ukraine, pp. 172-173. (in Ukrainian)

[6] S. Encheva, Y. Kondratenko, M. Solesvik, S. Tumil, Decision Support Systems in Logistics, *2007 Proc. Intern. Electronic Conf. on Computer Science, IeCCS2007*, T.E. Simos and G. Psihoyios (Eds.), American Institute of Physics, CP1060, 2008, pp. 254-256.

[7] Y. Kondratenko, S. Encheva, Ie. Sidenko, Synthesis of fuzzy decision support systems for transport logistics problems, *Technical news, Journal of the Ukrainian Engineering Society in Lviv*, 1(31), 2(32), 2010, pp. 61-66. (in Ukrainian)

[8] T. Saaty, *Decision Making Hierarchy Analysis Method,* Moscow, Radio and Communication, 1993, 278 p. (in Russian)

[9] A.A. Bochkarev, *Planning and simulation of supply chain*, Moscow, Alpha-Press, 2008, 192 p. (in Russian)

[10] O. Kiryukhina, Optimization route delivery in mixed road and rail transportation, *Collection of scientific works*, Kyiv, Ukraine, 2008, pp. 194-205. (in Ukrainian)

[11] A.P. Kozhin, V. Mezentsev, *Mathematical methods in the planning and management of road freight transport*, Moscow, Transport, 1994, 304 p. (in Russian)

[12] J. Gil-Aluja, A.M. Gil-Lafuente, A. Klimova, The optimization of the economic segmentation by means of fuzzy algorithms, *Journal of Computational Optimization in Economics and Finance*, Vol. 1, Iss. 3, pp. 169-186.

[13] A.M. Gil Lafuente, *Fuzzy Logic in Financial Analysis. Studies in Fuzziness and Soft Computing*, Berlin, Springer, 2005, 223 p.

[14] A. Taha Hemdi, *Introduction to Operations Research*, Moscow, Williams, 2007, 912 p.

[15] L.G. Raskin, I.O. Kirichenko, *Multi-Index Linear Programming Problem*, Moscow, Radio and Communication, 1982, 240 p. (in Russian)

[16] D.B. Yudin, E.G. Holstein, *Linear Programming Problem of the Transport Type*, Moscow, Science, 1969, 535 p. (in Russian)

[17] Lukinskiy V.S. *Models and Methods of the Logistics*, St. Petersburg, 2003, 219 p. (in Russian)

[18] Y.P. Kondratenko, S.B. Encheva, E.V. Sidenko, Synthesis of intelligent decision support systems for transport logistic, *2011 Proceeding of the 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, *IDAACS'2011*, Prague, Czech Republic, pp. 642-646.

[19] G.A. Miller, The magic number seven plus or minus two, *Psychological Review*, 1956, pp. 81-97.

[20] A.P. Rotshtein, *Intellectual technologies of identification,* Vinnitsa, UNIVERSUM, 1999, 320 p. (in Russian)

[21] L.S. Globa, M.Y. Ternovoy, D.S. Shtogrina, Creating fuzzy knowledge for intelligent control systems, *International Journal of Computing*, Ternopil, Ukraine, (7) 1 (2008), pp. 70-80. (in Ukrainian)

[22] S.D. Shtovba, *The Design of Fuzzy Systems by Means of MatLab*, Moscow, Telecom, 2007, 288 p. (in Russian)

[23] Y.P. Kondratenko, Ie.V. Sidenko, Correction of the knowledge database of fuzzy decision support system with variable structure of the input data, *Modeling and Simulation*, A.M. Gil-Lafuente, V.V. Krasnoproshin (Eds.), *Proceedings of the International Conference MS'12*, 2012, pp. 56-61.

***Yuriy Kondratenko**, Doctor of Science, Professor, Professor of Intelligent Information Systems on Petro Mohyla Black Sea State University, Ukraine. He is received the Ph.D. (1983) and Dr.Sc. (1994) in Elements and Devices of Computer and Control Systems (EDCCS) from Odessa National Polytechnical University. He received several international grants and schoolarships for conducting research at Institute of Automation of Chongqing University, P.R.China (1988-1989), Ruhr-University Bochum, Germany (2000, 2010), Nazareth College and Cleveland State University, USA (2003).*

His research interests include intelligent decision support systems, control systems, fuzzy logic, elements and devices of computing systems.

***Sylvia Encheva** is a full professor of both mathematics and informatics and a director of a R&D program 'Applied Information Technology' at Stord/Haugesund University College, Haugesund, Norway. She obtained a Ph. D. in informatics at the University of Bergen, Bergen, Norway. She has more than 25 years of teaching experience and published over 350 research papers in refereed international journals and conference proceedings.*

Her research interests include decision support systems, non-classical logic, computer aided teaching, Web-based assessment and information security.

***Ievgen Sidenko,** is a PhD student of Petro Mohyla Black Sea State University, Ukraine. He is specialist in Decision support systems. He has gained several diplomas of junior specialist, bachelor, specialist and master of computer science and diploma of bachelor of enterprise economics.*

His research interests include expert systems, fuzzy sets theory and fuzzy logic, intelligent decision support systems, system programming, data mining.

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

COMPETITION BETWEEN HETEROGENEOUS AGENTS IN COMPLEX ENVIRONMENT

Tomasz Owczarek

Faculty of Organization and Management, Silesian University of Technology,
Zabrze, Poland, tomasz.owczarek@polsl.pl

Abstract: *The article applies complexity theory to study heterogeneous organizations in an environment filled with their competitors and complementors. An agent-based simulation model is used to analyze effects of interactions in an environment with different level of complexity. Agents, differing in size and adaptability, try to adapt to fitness landscape they are placed in (which is based on Kauffman's NK model) in order to increase their fitness level. Results of conducted simulations are presented and analyzed.*

Keywords: *agent-based modeling, NetLogo, complexity, competition, agents' heterogeneity.*

1. INTRODUCTION

It is believed that growing complexity of business environment changes interorganizational relationships and the way organizations perceive their rivals [1]-[2]. New ICT technologies and rapid growth of internet as sales and advertising medium are main causes of the more and more comprehensive (and thus more complex) products and services offered by firms. Firms have to operate in dynamic, complex environment and decide where to compete, because organizations today cannot operate alone. Sometimes their main partner in some activity is at the same time one of the largest competitors in another. The decision – which path to follow – is of strategic importance[3]-[4].

The term coopetition (which can be defined as cooperation with competitor) is getting more and more attention in strategic management [4]-[6], and different approaches are used to study this concept [7]. The article is an attempt to apply complexity theory [8] to study behavior of heterogeneous organizations in an environment filled with their competitors and complementors [5].

In the article agent-based model [9]-[11] is used to analyze effects of interactions in an environment with different level of complexity. In order to increase their fitness agents try to adapt to the fitness landscape they are placed in (which is based on Kauffman's NK model [12]) and at the same time they must decide where to compete with other agents. The model is an extension of the model presented in [13]. Two new parameters are presented: *firm-size* and *firm-agility*, which differentiate agents. The question we want to answer here is the impact of the size of firms and their ability to make more radical change in their inner structure on their fitness level. The results from [13] are used to limit the range of parameters of the environment.

The article is organized as follows. Section two presents the *NK* model used as a representation of environment with desired level of complexity. Section three describes the details of simulation model and introduces novel parameters in addition to the model presented in [13]. Results of conducted simulations are presented and analyzed in section four. Section five contains discussion and directions for future work.

2. NK MODEL

In Kauffman's *NK* model [12] agents are treated as systems. They consist of fixed number of elements (parts). The combination of values of each element is agent's inner structure. The *NK* model is an abstract representation of a fitness landscape i.e. a mapping from an agent's inner structure to its fitness level. Agent's fitness strictly depends on its inner parts. The set of parts, in the domain of organizations, can be interpreted as elements of its business strategy, human resource policy [14], resources owned, product features and so on.

There are two main parameters in the model.

Parameter N refers to the number of elements each agent consists of. Greater N means that there are more types of different possible agents. Parameter K is responsible for the number of interconnections between the elements, because each element contributes some fitness, but this contribution depends upon that element and upon K other elements. In the original Kauffman's model there is also additional parameter which specifies the number of possible values each element can have. In this paper it is assumed that each element can have two values: 0 or 1 so the number of all possible different agents is 2^N.

As it was said, each element s_i (i = 1,…, N) makes a fitness contribution w_i specified by NK model (usually it is a random value drawn from the uniform interval between 0.0 and 1.0). The fitness of agent A is defined as the average contribution of its elements:

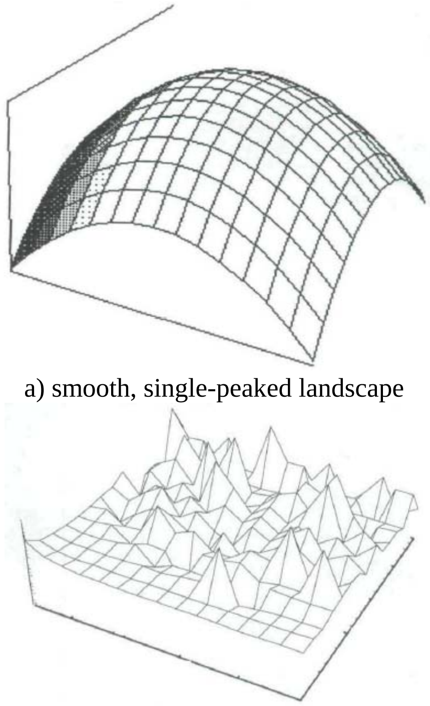
$$W^A = \frac{1}{N}\sum_{i=1}^{N} w_i^A \qquad (1)$$

Table 1 shows two models with N = 2, first with K = 0 (model a) and second with K = 1 (model b). Two examples of agents and their fitness are also presented.

Table 1. Examples of *NK* model

model a	elements	s_1 fitness	s_2 fitness
K = 0	(0, *)	0.6	-
(each	(1, *)	0.3	-
element is	(*, 0)	-	0.1
independent)	(*, 1)	-	0.4
Example 1: $W^{(1, 1)}$ = (0.3 + 0.4)/2 = 0.35			
model b	elements	s_1 fitness	s_2 fitness
K = 1	(0, 0)	0.4	0.8
(elements	(0, 1)	0.7	0.3
depend upon	(1, 0)	0.5	0.9
each other)	(1, 1)	0.6	0.5
Example 2: $W^{(1, 1)}$ = (0.6 + 0.5)/2 = 0.55			

The main feature of NK model is the possibility of establishing desired *ruggedness* level [15] of the generated fitness landscape, which depends upon the parameter K. When K = 0 the surface of a landscape seems smooth, with single optimum which can be reached from any point by series of local adaptations (Fig. 1a). When K = N – 1, the generated landscape is very rugged, with many local optima and a slight change in agent's structure can have a significant impact on its fitness (Fig. 1b).



a) smooth, single-peaked landscape

b) rugged, multi-peaked landscape

Fig. 1 – Different kinds of lanscapes [14]

Consider examples presented in Table 1. Changing the first element of the agent from example 1 will have a positive effect on its fitness (0.6 instead of 0.3) and it does not affect fitness contribution of its second element. The same change in the structure of agent from example 2 will decrease its overall fitness: it will increase the fitness contribution of its first element (from 0.6 to 0.7) but at the same time the fitness contribution of its second element will be worst (0.3 instead of 0.5).

Simply speaking, the more interconnections between elements of agent's structure (i.e. the greater value of K), the more complex is the environment it exists in.

3. SIMULATION MODEL

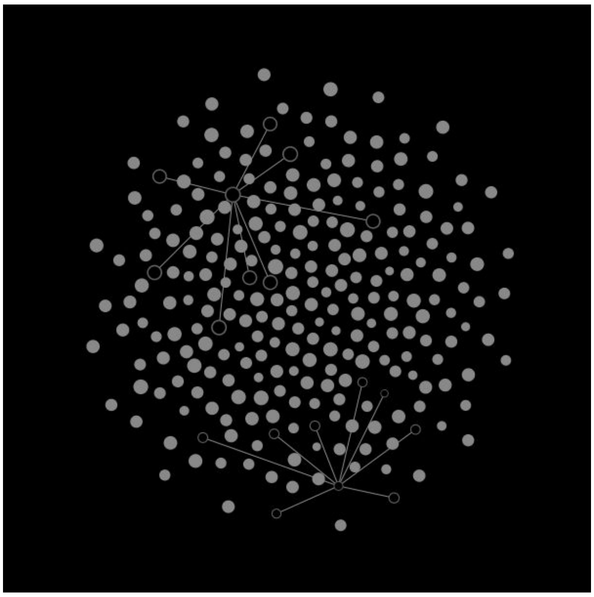
The simulation model was created and performed with NetLogo 5.0.1, a multi-agent programmable modeling environment [16]. The simulation consists of two steps: firstly, the fitness landscape with specified parameters N and K is generated and then agents are placed in the landscape and they try to adapt (in order to receive the greater utility) by moving from one place to another.

In the simulation model fitness landscape consists of 2^N nodes (called *places* in the model) which represent any type of agents' inner structure. Each place is connected with its one-mutant neighbors, i.e. places which differ in only one position. Places are the nodes of undirected graph and their position is based on the Fruchterman-Reingold layout algorithm [17] (function *layout-spring* in NetLogo). Each place has its fitness specified according to *NK* model described earlier.

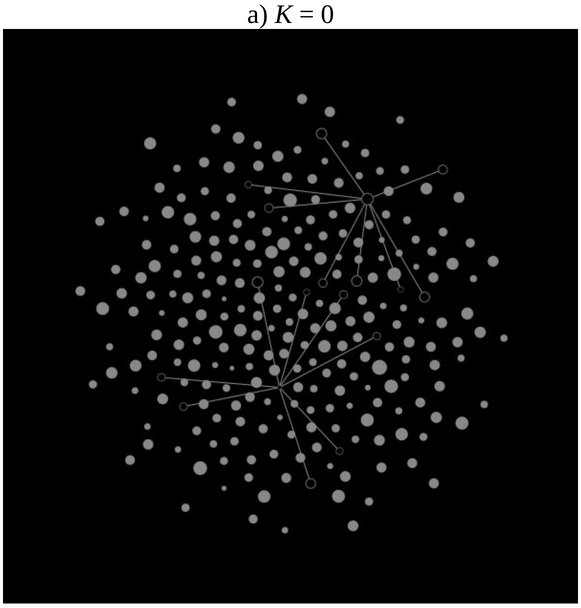
Fig. 2 presents two examples of generated fitness landscape. For more clarity most of the links between places were hidden. The size of each place corresponds to its fitness level (greater size means greater fitness). Both landscapes were created with $N = 8$.

Fig. 2a presents smooth landscape ($K = 0$). Two places were highlighted and their neighbors were shown. It is easy to notice that the sizes of the connected places are very similar.

Fig. 2b presents a fitness landscape generated with parameter $K = 7$. Also two places were highlighted. This time there are noticeable differences between fitness levels of connected places.



a) $K = 0$



b) $K = 7$

Fig. 2 – Examples of fitness landscapes generated in the simulation model (N = 8)

After the fitness landscape is constituted, F agents are distributed in random places. A place occupied by agent defines the agent's inner structure and its fitness. Agent's utility (gain) from occupying a place depends on the place's fitness but it is also modified by level of competition. In [13] the level of competition c_i is defined as the number of agents with the same value at the *i*-th position of their inner structure. Consider two agents: $A = (1,0,1)$ and $B = (1,0,0)$. They are perceived as competitors at the first two elements and as complementors at the third element. Agents which are occupying the same place are seen as direct competitors.

Let w_i be the fitness gained from *i*-th element of the occupied place, let c_i be the level of competition at the *i*-th element and let F be the number of agents. Then utility of agent is defined as:

$$U = \frac{1}{N}\sum_{i=1}^{N}\frac{F - c_i + 1}{F} w_i \qquad (2)$$

In each iteration agents calculate their current utility and check the potential utility of neighboring places. If the potential utility is greater than their current utility, they move to a new place.

Formula (2) generates some interesting outputs of the model. Fig. 3 presents one example of such output.

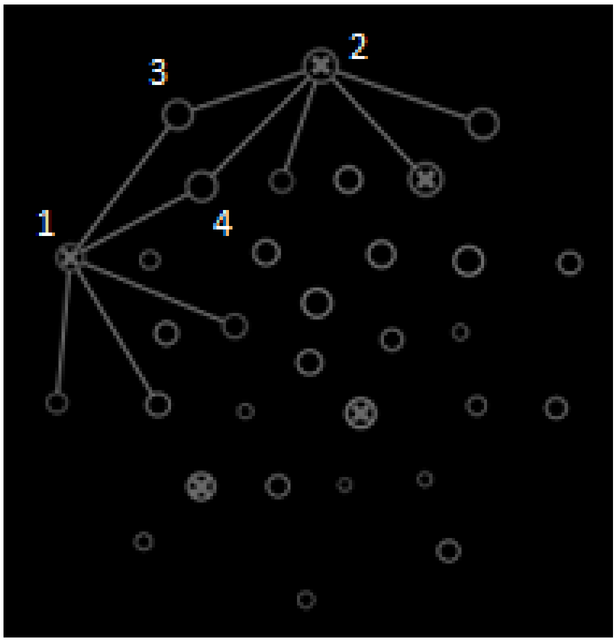


Fig. 3 – Example of the output of the model

As one can see from Table 2, the fitness level of places 3 and 4 are greater than the fitness level of place 1. But these places are neighbors of place 2, which is already occupied by 50 firms. That is why no firm from place 1 has incentive to move to place 3 or 4.

Table 2. Numerical values of the example.

place's number	fitness	number of firms
1	.574	9
2	.704	50
3	.626	0
4	.612	0

The main purpose of the model from [13] was to answer the question about the impact of the environment's complexity on the level of competition established between homogeneous agents. The most important results obtained are presented at the beginning of the next section.

In this model some heterogeneity between agent is included. Firms differ in two parameters. First one is *firm-size* – bigger firms gain bigger market share. This requires modification of the formula (2). Let F' be the sum of the sizes of all firms and let c_i' be the level of competition calculated as the sum of the sizes of firms with the same value at the *i*-th position of their inner structure. Then utility of agent A is defined as:

$$U_A = \frac{1}{N}\sum_{i=1}^{N}\frac{F' - c_i' + fs_A}{F'} w_i \qquad (3)$$

where fs_A is agent's A *firm-size*. According to formula (3) when two agents occupy the same place, firm with greater size gains more utility.

The second parameter is *firm-agility* which represents the ability of agent to perform bigger change in its inner structure in a single simulation step. Firms with *firm-agility* greater than 1 can monitor and choose between more distant places when choosing new place.

The results presented below were performed with the full knowledge of other agents (in [13] there were two variants considered – in the first one firms did not take into consideration their rivals when they decided whether to change place, but because of the little differences in performance this variant is abandoned here).

4. SIMULATION RESULTS AND DISCUSSION

The main results from [13] show that the level of competition between homogeneous agents (measured as the number of different places occupied by agents – less places mean stronger competition) depends from parameter K (representing complexity of the environment). But the relation between K and the number of occupied places is not linear. Greater level of competition (i.e. less occupied places) occurs with moderate values of K, while the extreme values of K correspond with lower levels of competition. Fig. 4 presents the average number (from 10 series of simulation runs) of occupied places when $N = 10$, the number of agents F was 20, 50 and 100 and K varied from 0 to 9. Fig. 5 presents the same results normalized to F which gives relative level of competition. Here 100% means the lowest possible competition (i.e. all firms occupy different places).

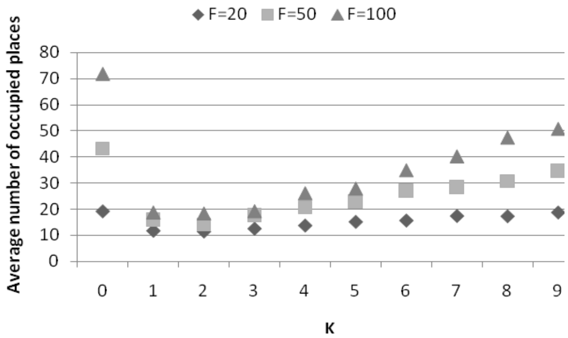


Fig. 4 – Average number of occupied places in the simulation runs [13]

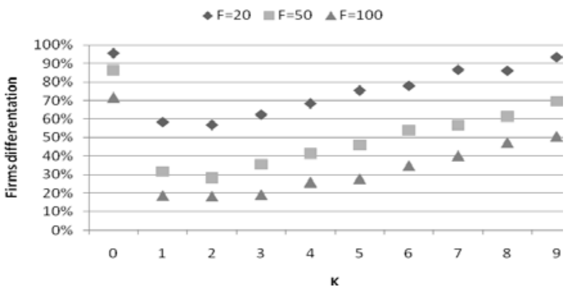


Fig. 5 – Firm differentiation in the simulation runs [13]

These results were used to limit the range of parameter K which controls the complexity of the environment. The following experiments were conducted for $N = 10$, $K = \{0, 2, 5, 8\}$ and number of firms $F = 100$. All results are average values from 30 simulation runs. Parameter *firm-size* was equal 1 for normal firms and 10 for bigger firms.

The aim of the first experiment was to check on the difference in utility gained between bigger and normal firms. The results are presented in Fig. 6 which shows the percentage difference between utility of bigger and normal firms. For example, the first triangle mark on the left means that when 5 bigger firms (firms with size = 10) were in the market, their utility was about 18% greater than other firms (i.e. firms with size = 1).

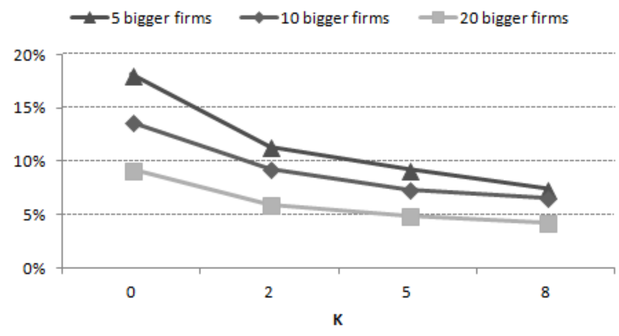


Fig. 6 – Difference between utility of bigger and normal firms (in %)

As one can notice, the advantage of bigger firms is greater with less bigger firms in the market. This is quite obvious – with more bigger firms each firm faces tougher competition and its utility calculated according to formula (3) is smaller. The advantage also drops with more complex environment because of the many local optima and more unpredictable way in which they are distributed. In more complex environment it is harder to find global optima, which explains why the differences in the advantage between different number of bigger firms for greater *K* are smaller as well.

In the second experiment all firms had the same size, but they were divided into two groups – the first one had *firm-agility* equal 1 (they could only move to neighboring places) and the second one had *firm-agility* = 2 (they could monitor and move to places at distance 2, i.e. differing in two elements from the place they were currently occupying). Fig. 7 presents the difference in average and total utility gained by these two groups (total utility is the sum of all the utility gained during simulation).

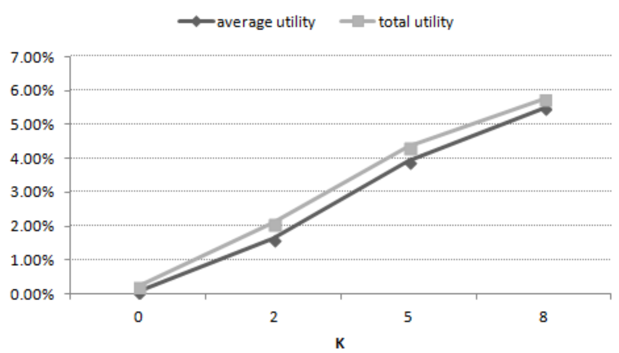


Fig. 7 – Difference in utilities between firms with different level of firm-agility (in %)

As one can see, the more complex the environment, the greater is the advantage of firms which have the possibility to make more radical change in single step.

In the last experiment it was assumed that smaller firms can make faster decisions and are able to change and adapt to new condition much quicker than bigger firms [18]. This variant was similar to the first experiment, with one exception – all bigger firms had *firm-agility* equal 1 and all normal firms had *firm-agility* equal 2. The aim was to check if greater ability to make radical changes could compensate smaller sizes of firms.

Fig. 8 presents the advantage in utility of bigger firms for different values of *K* and different number of firms with size 10 present in the market. The results show that the difference in utility gained by bigger and "agile" firms declines with more complex environment. For *K* = 8 (very complex environment) the average utility is very similar and with 20 bigger firms in the market it is even better to be smaller but "agile" firm.

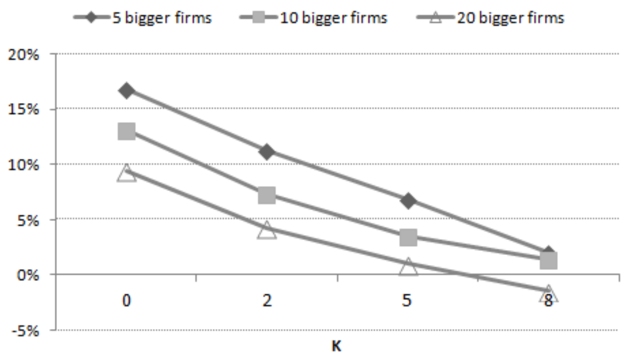


Fig. 8 – Difference in utilities between bigger firms and firms with firm-agility=2 (in %)

These results support our intuition. In more stable and predictable environment bigger firms perform explicitly better. When the complexity of the environment increases, the ability to make quicker decisions is a great advantage and it allows smaller firms (which can faster adapt to new conditions) to win their chances.

5. CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

The aim of the article was to check on the performance of firms with different size and different ability of adaptation to new conditions operating in complex environment. It proves that the agent-based simulation model presented in [13] is easy to extend and can be used for further, more advanced analysis. But, as noticed by R. M. Burton B. Obel, using simulation modeling is tricky and the right balance between the purpose, the complexity of the model and its analysis must be kept [19]. That is why any modifications should be performed with caution and with respect to the research question one wants to answer. We believe that two new parameters presented in the model are enough to catch the essence of the problem solved here.

The results show "relational equivalence" [20] with other works [18], which is another encouragement for its further development. In the future one can try to calibrate it with some empirical data to achieve “distributional equivalence”, but this can be really challenging [21]. Among some other modifications one can think of making the interactions between agents more sophisticated, for example with some game-theoretic mechanisms, as suggested in [13]. Also, the *NK* model is supposed to simulate the complexity of the environment. The problem however is, that it is static, once established the environment does not change. Adding some uncertainty and dynamism could give us maybe more insights into agents' performance in truly complex and uncertain environment.

6. REFERENCES

[1] J.C. Jarillo, On strategic networks, *Strategic Management Journal*, Vol. 9, 1988, pp. 31-41.

[2] B. De Wit, R. Meyer, *Strategy Synthesis: Resolving Strategy Paradoxes to Create Competitive Advantage*, Thomson Learning, London, 2005.

[3] M.A. Peteraf, M.E. Bergen, Scanning dynamic competitive landscapes: a market-based and resource-based framework, *Strategic Management Journal*, Vol. 24, 2003, pp. 1027-1041.

[4] Luo Y., A coopetition perspective of global competition, *Journal of World Business*, Vol. 42, 2007.

[5] A.M. Brandenburger, B.J. Nalebuff, *Coopetition*, Doubleday, New York, 1998.

[6] S. Yami, S. Castaldo, G.B. Dagnino, F. Le Roy, *Coopetition: Winning Strategies for the 21st Century*, Edward Elgar Publishing, 2010.

[7] C. Clarke-Hill, H. Li, B. Davis, The Paradox of co-operation and competition in strategic alliance: towards a multi-paradigm approach, *Management Research News*, (26) 1 (2003).

[8] P. Anderson, Complexity theory and organization science, *Organization Science*, (10) 3 (1999).

[9] C. Macal, M. North, *Managing Business Complexity. Discovering Strategic Solutions with Agent-Based Modeling and Simulation*, Oxford University Press, New York, 2007.

[10] S. Sanchez, T. Lucas, Exploring the world of agent-based simulations: simple models, complex analyses, *Proceedings of the 2002 Winter Simulation Conference*, San Diego, 2002, pp. 116-126.

[11] J. Epstein, R. Axtell, *Growing Artificial Societies: Social Science From the Bottom Up*. MIT Press, London, 1996.

[12] S. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, New York, 1993.

[13] T. Owczarek, Collaboration and competition in complex environment – an agent-based approach, *Proceedings of the 6th IEEE International Workshop on Intelligent Data Acquisition and Advanced Computing Systems*, Prague, 2011, pp. 594-597.

[14] D.A. Levinthal, M. Warglien, Landscape design: designing for local action in complex worlds, *Organization Science*, (10) 3 (1999).

[15] B. McKelvey, Avoiding complexity catastrophe in coevolutionary pockets: strategies for rugged landscapes, *Organization Science*, (10) 3 (1999).

[16] U. Wilensky, NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL, 1999.

[17] T.M.J. Fruchterman, E.M. Reingold, Graph drawing by force-directed placement, *Software-Practice and Experience*, Vol. 21, 1991, pp. 1129-1164.

[18] K. Eisenhardt, D. Sull, Strategy as simple rules, *Harvard Business Review*, Vol. 79, 2001, pp. 107-116.

[19] R.M. Burton, B. Obel, The validity of computational models in organization science: from model realism to purpose of the model, *Computational & Mathematical Organization Theory*, Vol. 1, 1995, pp. 57-71.

[20] R. Axelrod, Advancing the art. of simulation in the social sciences, *Japanese Journal for Management Information System*, (12) 3 (2003).

[21] J.M. Epstein, Agent-based computational models and generative social science, *Complexity*, (4) 5 (1999), pp. 41-60.

***Tomasz Owczarek**, received the M.Sc. in management from the Silesian University of Technology in 2005, and the M.Sc. in mathematics from the University of Silesia in 2006. Currently he is an employee in the Institute of Economics and Informatics at the Silesian University of Technology. His research interests are game theory, probabilistic graphical models and agent-based modeling and simulation.*

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

MONALISA: A MONITORING FRAMEWORK FOR LARGE SCALE COMPUTING SYSTEMS

Ciprian Dobre [1], Ramiro Voicu [2], Iosif C. Legrand [3]

[1] University POLITEHNICA of Bucharest, Spl. Independentei 313, Romania, ciprian.dobre@cs.pub.ro
[2] California Institute of Technology, Pasadena, CA 91125, USA, Ramiro.Voicu@cern.ch
[3] CERN, European Organization for Nuclear Research, CH-1211, Geneve 23, Switzerland, Iosif.Legrand@cern.ch

Abstract: *The MonALISA (Monitoring Agents in A Large Integrated Services Architecture) framework provides a set of distributed services for monitoring, control, management and global optimization for large scale distributed systems. It is based on an ensemble of autonomous, multi-threaded, agent-based subsystems which are registered as dynamic services. They can be automatically discovered and used by other services or clients. The distributed agents can collaborate and cooperate in performing a wide range of management, control and global optimization tasks (such as network monitoring, resource accounting) using real time monitoring information. MonALISA includes a coherent set of network management services to collect in near real-time information about the network topology, the main data flows, traffic volume and the quality of connectivity. A set of dedicated modules were developed in the MonALISA framework to periodically perform network measurements tests between all sites. We developed global services to present in near real-time the entire network topology used by a community. The time evolution of global network topology is shown in a dedicated GUI. Changes in the global topology at this level occur quite frequently and even small modifications in the connectivity map may significantly affect the network performance. The global topology graphs are correlated with active end-to-end network performance measurements, done using the Fast Data Transfer application, between all sites. Access to both real-time and historical data, as provided by MonALISA, is also important for developing services able to predict the usage pattern, to aid in efficiently allocating resources globally. For resource accounting, MonALISA collects information regarding the amounts of resources consumed by the users, which represent virtual organizations in a large scale distributed system. Besides providing statistical information, an accounting system can also be the base for managing distributed resources upon an economic model. In the MonALISA monitoring framework we developed modules that provide accounting facilities, collecting information from cluster managers like Condor, PBS, LSF and SGE. The usage statistics is used for an intelligent management of the resources.*

Keywords: *monitoring, large scale networks, topology, accounting, MonALISA.*

1. INTRODUCTION

An important part of managing global-scale systems is a monitoring system that is able to monitor and track in real time many site facilities, networks, and tasks in progress. The monitoring information gathered is essential for developing the required higher level services, the components that provide decision support and some degree of automated decisions and for maintaining and optimizing workflow in large scale distributed systems (LSDS). These management and global optimization functions are performed by higher level agent-based services.

MonALISA, which stands for **Monitoring Agents using a Large Integrated Services Architecture**, is a monitoring framework designed as an ensemble of dynamic services, able to collaborate and cooperate in performing a wide range of information gathering and processing tasks. Current applications of MonALISA's higher level services include resource accounting, optimized dynamic routing, control and optimization for data transfers, distributed job scheduling and automated management of remote services among a large set of distributed facilities. MonALISA is currently used around the clock in several major projects and has proven to be both highly scalable and reliable.

The main aim for developing the MonALISA system was to provide a flexible framework capable to use in near real-time the complete monitoring information from large number of jobs, computing facilities and wide area networks to control and optimize complex workflows in distributed systems.

Compared with other existing monitoring tools for LSDS, MonALISA is more generic and provides real-time, scalability, and dependability guarantees. Currently existing monitoring frameworks tend to be too dedicated to specific activities. For example, Ganglia, and Lemon are mainly used to monitor computing clusters while tools like MRTG, PerfSonar, Nagios and Spectum are used to provide monitor information for Wide Area Networks. In MonALISA we provide the functionality to easily collect any type of information and in this way to offer a more synergetic approach, necessary to control and optimize the execution of data intensive applications on large scale distributed systems.

In this paper we present the system architecture and its applications to monitor and control real-world LSDSs. In particular, we present details for two important monitored services: the accounting and networking components. We acknowledge that an important part of managing any global-scale distributed systems is the monitoring system that should be able to monitor and track in real time many site facilities, networks, and tasks in progress. The monitoring information gathered is essential for developing the required higher level services, the components that provide decision support and some degree of automated decisions and for maintaining and optimizing workflow in LSDSs.

In LSDSs an accounting component is used to records the resource consumption for each user, and may have other functionalities like enabling the administration of the storage of this information, and interacting with other related services. One of the functions of the accounting system is to enable an economically self-sustained distributed system. Such a system should provide the possibility to charge the users for the resources consumed, or the possibility to trade resources among organizations. Another function of an accounting system is to provide statistical information that can be further used to develop intelligent algorithms for scheduling and resource management.

As the importance of the accounting component is widely recognized (i.e., as a fundamental pillar of Cloud Computing), several projects have been initiated in this domain. Still, there are significant challenges in developing an accounting system, related mostly to the complexity and heterogeneity of LSDS environments. We distinguish between accounting systems and monitoring systems that include accounting features [1]: while an accounting system stores detailed information about single jobs/users, and can provide usage records for a particular job, a monitoring system usually collects statistical information such as the total number of jobs run by each user, or per-VO resource consumption (*VO* stands for *virtual organization*).

In MonALISA we concentrated on the latter approach, and developed a set of dedicated monitoring and accounting modules for LSDSs. The accounting modules collect information from job managers such as Condor, PBS, LSF and SGE, and the accounting data is further stored in the MonALISA databases.

The monitoring framework has to intelligently collect, in a LSDS environment, a large number of monitoring events that are generated by the system components during the execution or interaction with external objects (such as users or processes). Monitoring such events is necessary for observing the run-time behavior of the large scale distributed system and for providing status information required for debugging, tuning and managing processes. However, correlated events are generated concurrently and can be distributed in various locations, which complicates the management decisions process.

To illustrate this, we also present a set of services developed in the context of the MonALISA framework for monitoring and controlling large scale networks, as an extension of the work previously presented in [2].

The rest of the paper is structured as follows. Section 2 presents the MonALISA monitoring framework. In Section 3 we present the monitoring services for large scale networks, together with solutions for the representation of network topologies at different OSI layers. This is followed by a real-world use-case for monitoring network topology in case of one of the largest network supporting the LHC experiments at CERN. Section 4 describes the accounting modules, and several results obtained using the modules.Finally, in Section 5 we give conclusions and present future work.

2. SYSTEM DESIGN

MonALISA (Monitoring Agents in A Large Integrated Services Architecture) [3,15] is a globally scalable framework of services jointly developed by California Institute of Technology (Caltech) and University Politehnica of Bucharest (UPB). MonALISA is currently used in several large scale High-Energy Physics communities and grid systems including CMS [4], ALICE [5], ATLAS [6], the Open Science Grid (OSG) [7], and the Russian LCG sites. It actively monitors the USLHCNet production network, as well as the UltraLight R&D network [4].

As of this writing, more than 360 MonALISA sites are being monitored 24/7 throughout the world. The services monitor more than 60,000 computing servers, and thousands of concurrent jobs. More than 3.5 million parameters are currently monitored in near-real time with an aggregate update rate of approximately 50,000 parameters per second.

The MonALISA system is designed as an ensemble of autonomous self-describing agent-based

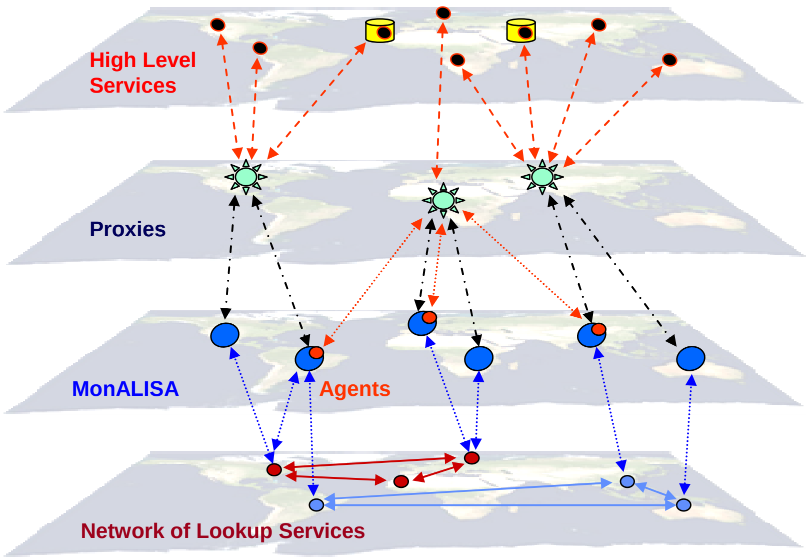


Fig. 1 – The four layers, main services and components of the MonALISA framework

subsystems which are registered as dynamic services. These services are able to collaborate and cooperate in performing a wide range of distributed information-gathering and processing tasks.

An agent-based architecture of this kind is well-adapted to the operation and management of large scale distributed systems, by providing global optimization services capable of orchestrating computing, storage and network resources to support complex workflows. By monitoring the state of LSDS-sites and their network connections end-to-end in real time, the MonALISA services are able to rapidly detect, help diagnose and in many cases mitigate problem conditions, thereby increasing the overall reliability and manageability of the distributed computing systems. The MonALISA architecture, presented in Fig. , is based on four layers of global services. The entire system is developed based on the Java technology.

The network of Lookup Discovery Services (LUS) provides dynamic registration and discovery for all other services and agents. MonALISA services are able to discover each other in the distributed environment, and be discovered by interested clients. The registration uses a lease mechanism. If a service fails to renew its lease, it is removed from the LUSs and a notification is sent to all services or applications that subscribed for such events. Remote event notification is used in this way to get a real overview of this dynamic system.

The second layer represents the network of MonALISA services that host many monitoring tasks through the use of a multithreaded execution engine. The network also hosts a variety of loosely coupled agents that analyse the collected information in real time. These agents are able to process the information locally, and to communicate with other services or agents to perform various global optimization tasks. A service in MonALISA is a component that interacts autonomously with other services, either through dynamic proxies or via agents that use self-describing protocols. By using the network of lookup services, a distributed services registry, and the discovery and notification mechanisms, the services are able to access each other seamlessly. The use of dynamic remote event subscription allows a service to register an interest in a selected set of event types, even in the absence of a notification provider at registration time.

On the third layer MonALISA hosts a series of Proxy services. The layer provides an intelligent multiplexing mechanism for the information requested by the clients or other services, and ensures a reliable communication between agents. It also provides an Access Control Enforcement layer to provide secures access to the collected information.

Higher level services and client access the collected information using the proxy layer of services. A load balancing mechanism is used to allocate these services dynamically to the best proxy service. The clients, other services or agents can get any real-time or historical data by using a predicate mechanism for requesting or subscribing to selected measured values. These predicates are based on regular expressions to match the attribute description of the measured values a client is interested in. They may also be used to impose additional conditions or constraints for selecting the values. The subscription requests create a dedicated priority queue for messages. The communication with the clients is served by a pool of threads. The allocated thread performs the matching tests for all the predicates submitted by a client with the monitoring values in the data flow. The same thread is responsible to send the selected results back to the client as compressed serialized objects. Having an independent thread for clients allows sending the information they need, in a fast and reliable way, and it is not affected by communication errors which may occur with other clients. In case of communication problems these threads will try to re-establish the connection or to clean-up the subscriptions for a client or a service which is no longer active.

3. NETWORK MONITORING AND MANAGEMENT

A large set of MonALISA monitoring modules has been developed to collect specific network information or to interface it with existing monitoring tools, including: SNMP modules for passive traffic measurements and link status; Active network measurements using simple ping-like measurements; Tracepath-like measurements to generate the global topology of a wide area network; Interfaces with the well-known monitoring tools MRTG, RRD [8]; Available Bandwidth measurements using tools like pathload; Active bandwidth measurements using Fast Data Transfer (FDT) [9]; Dedicated modules for TL1 [10] interfaces with CIENA's CD/CIs, optical switches (Glimmerglass and Calient) and GMPLS controllers (Calient) [11, 12].

In the MonALISA framework the overall status of the dispersed systems being monitored is provided by either a GUI client or through specialized web portals. For the dedicated modules and agents used to monitor and control Optical Switches the GUI client of MonALISA provides a dedicated panel. This panel facilitates the interaction between users and the monitored Optical Switches. It offers to the end user a number of features such as complete perspective over the topology of the monitored optical networks or the possibility to monitor the state of the Optical Switches or the possibility to dynamically create new optical paths.

The tremendous interest in optical networks led the Internet Engineering Task Force (IETF) to investigate the use of Generalized MPLS (GMPLS) and related signaling protocols to set up and tear down lightpaths. GMPLS is an extension of MPLS that supports multiple types of switching, including switching based on wavelengths usually referred to as Multi-Protocol Lambda Switching (MPλS). In order to meet the expectations of future network technologies in the prototype system we made the first step towards integrating emerging light path technologies. We implemented the monitoring module and control agent that provide an interface between MonALISA and the Calient's GMPLS-based control plane.The described system, part of MonALISA, is currently used in production to monitor and control a CALIENT Optical Switch located at California Institute of

Technology in USA and another GLIMMERGLASS Optical Switch located at the European Center for Nuclear Research, in Switzerland. The dedicated monitoring modules use the TL1 language to communicate with the switch and they are used to collect specific monitoring information. The state of each link and any change in the system is reported to MonALISA agents. The system is integrated in a reliable and secure way with the end user applications and provides simple shell-like commands to map global connections and to create an optical path / tree on demand for any data transfer application. A schematic view of how the entire system works is shown in Figure 2.

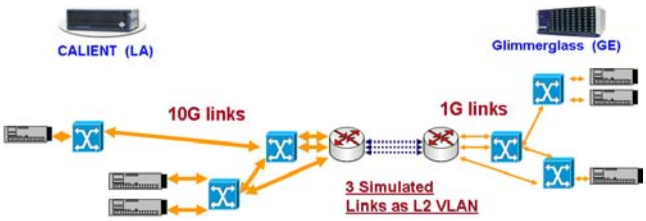


Fig. 2 – The system used to monitor and control Optical Switches and to create on demand optical path used in production

The implemented prototype system is able to create dynamically an end to end light path in less than one second independent of the number of switches involved and their location. It monitors and supervises all the created connections and is able to automatically generate an alternative path in case of connectivity errors. The alternative path is set up rapidly enough to avoid a TCP timeout, and thus to allow the transfer to continue uninterrupted.

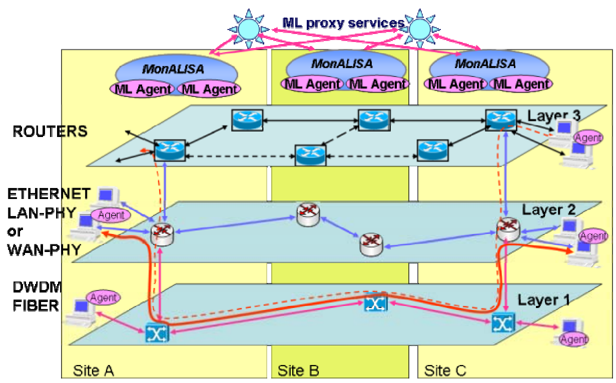


Fig. 3 – A schematic view of the functionality to provide dynamically an efficient end to end path to data intensive applications. The VINCI system is optimizing the path allocation using as much as possible Layer 1 or Layer 2 segments

To satisfy the demands of data intensive applications it is necessary to move to far more synergetic relationships between applications and networks. Currently, even the most complex scientific applications are simply passive users of the existing network infrastructure. The main objective of the VINCI (Virtual Intelligent Networks for Computing Infrastructures) project is to enable users' applications, at the LHC and in other fields of data-intensive science, to effectively use and coordinate shared, hybrid network resources, to correlate them with available processing power in order to dynamically generate optimized workflows in complex distributed system (Figure 3).

VINCI is a multi-agent system for secure light path provisioning based on dynamic discovery of the topology in distributed networks. For this project we are working to provide integrated network services capable to efficiently use and coordinate shared, hybrid networks and to improve the performance and throughput for data intensive applications. This includes services able to dynamically configure routers and to aggregate local traffic on dynamically created optical connections.

The system dynamically estimates and monitors the achievable performance along a set of candidate (shared or dedicated) network paths, and correlates these results with the CPU power and storage available at various sites, to generate optimized workflows for LSDS tasks. The VINCI system is implemented as a dynamic set of collaborating Agents in the MonALISA framework, exploiting MonALISA's ability to access and analyze in-depth monitoring information from a large number of network links and LSDS sites in real-time.

3.1. MONITORING AND REPRESENTATION OF NETWORK TOPOLOGIES AT DIFFERENT OSI LAYERS

We present monitoring and representational services developed considering various network topologies and the differences posed by network equipments operating at various OSI levels. In large-scale networks, such as USLHCNet and UltraLight, we found devices at ever OSI layer.

A. The Physical Network Layer Topology

A set of specialized TL1 modules are used to monitor optical switches (Layer 1 devices) from two major vendors: Glimmerglass and Calient. We were able to monitor the optical power on ports and the state of the cross-connects inside these switches.

Based on the monitoring information an agent is able to detect and to take informed decisions in case of eventual problems with the cross connections inside the switch or loss of light on the connections. The MonALISA framework allows one to securely configure many such devices from a single GUI, to see the state of each link in real time, and to have historical plots for the state and activity on each link. It also allows to easily manually create a path using the GUI. In Figure 4 we present the MonALISA GUI that is used to monitor the topology on the Layer 1 connections and the state and optical power of the links. The same GUI can be used to request an optical path between any two points in the topology. All the topology related information are kept distributed, every MonALISA service having its own view of the network. Every agent computes a shortest path tree based on Dijkstra's algorithm. The convergence in case of problem is very fast, as every agent has the view of the entire topology.

B. Layer 2 Network Topology / Circuits

The USLHCNet transatlantic network has evolved from DOE-funded support and management of international networking between the US and CERN. USLHCNet today consists of a backbone of eight 10 Gbps links interconnecting CERN, MANLAN in New York, and Starlight in Chicago. The core of the USLHCNet network is based on Ciena Core Director CD/CI multiplexers which

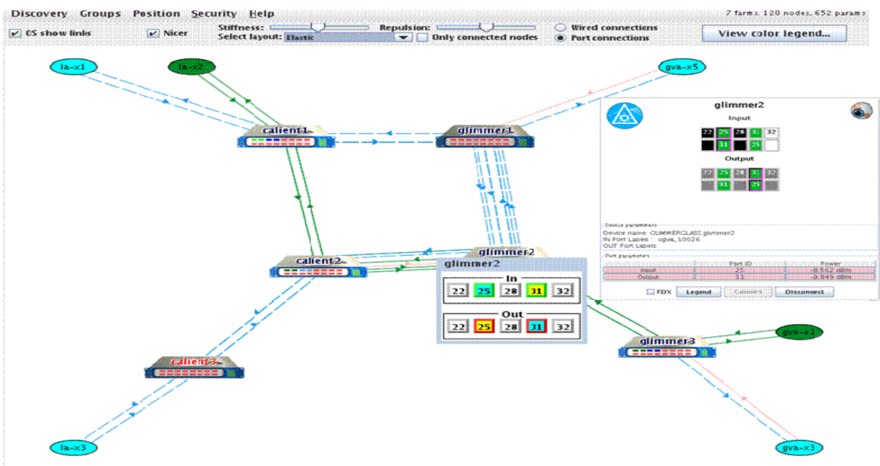


Fig. 4 – Layer 1 topology: Monitoring and autonomous controlling optical switches

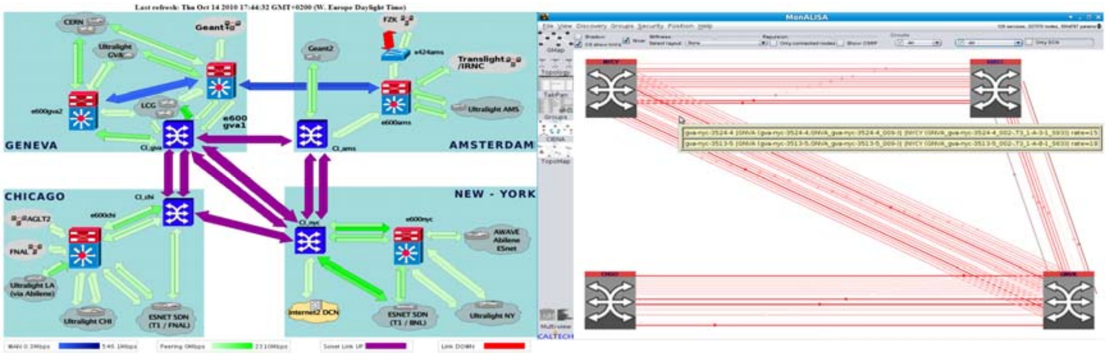


Fig. 5 – A network weathermap (left) and the layer 2 topology for the dynamic circuits (right)

provide stable fallback in case of link outages at Layer 1 (the optical layer), and full support for the GFP/VCAT/LCAS [13] protocol suite.

For the Core Director (CD/CI) we developed modules which monitor the routing protocol (OSRP) which allows us to reconstruct the topology inside the agents, the circuits (VCGs), the state of cross connects, the Ethernet (ETTP/EFLOW) traffic, the allocated time slots on the SONET interfaces and the alarms raised by the CD/CI (see Figure 5).

The operational status for the Force10 ports and all the Ciena CD/CI alarms are recorded by the MonALISA services. They are analyzed and corresponding email notifications can be generated based on different error conditions. We also monitor the services used to collect monitoring information. A global repository for all these alarms is available on the MonALISA servers, which allows one to select and sort the alarms based on different conditions. The link status information is very sensitive information for the SLA (Service Level Agreement) with both the experiments and the link providers. Because of this very strict monitoring requirement the monitoring had to have almost 100% availability. We achieved this monitoring each link at both ends from two different points. The NOCs in Europe, Geneva and Amsterdam, are cross-monitored from both locations, and the same in US. In this way we monitor each link in four points and with special filters this information is directly aggregated in the repository. For redundancy and reliable monitoring we keep at least two instances of repositories running, one in Europe and one in US. For the past two years we manage to have 100% monitoring availability inside USLHCNet.

C. Layer 3 Routed Network Topology

For the routed networks, MonALISA is able to construct the overall topology of a complex wide area network, based on the delay on each network segment determined by tracepath-like measurements from each site to all other sites, as illustrated in Figure 6.

For any LHC experiment such a network topology includes several hundred of routers and tens of Autonomous Systems. Any changes in the global topology are recorded and this information can be easily correlated with traffic patterns. The time evolution of global network topology is shown a dedicated GUI. Changes in the global topology at this level occur quite frequently and even small modifications in the connectivity map may significantly affect the network performance.

3.2. A REAL USE-CASE FOR TOPOLOGY INFORMATION

The Alice Grid infrastructure uses MonALISA framework for both monitoring and controlling. All the resources used by AliEn [14] services: computing and storage resources, central services, networks, jobs are monitored by MonALISA services at every site.

A. Bandwidth measurements between Alice sites

The data transfer service is used by the ALICE experiment to perform bandwidth measurements between all sites, by instructing pairs of site MonALISA instances to perform FDT memory-to-memory data transfers with one or more TCP streams.

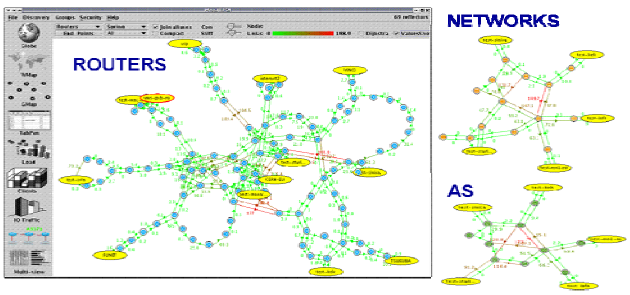


Fig. 6 – MonALISA real time view of a topology. A view of all the routers, or just the network or "autonomous system" identifiers can be shown

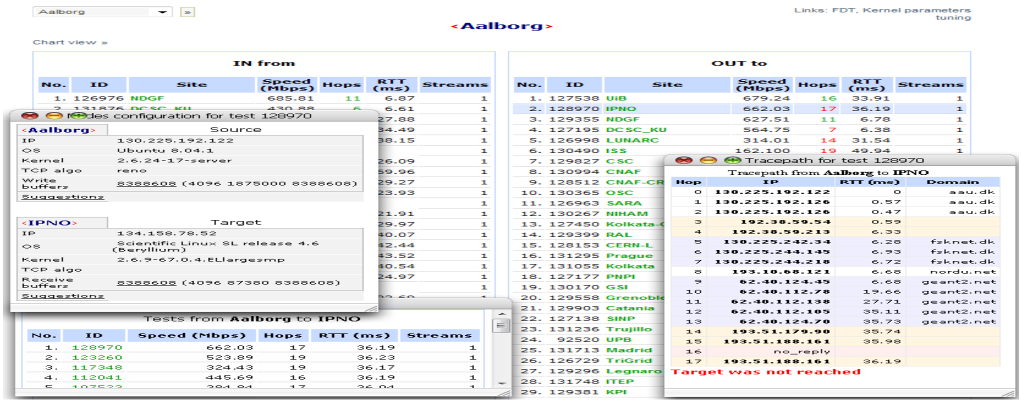


Fig. 7 – Inter-site bandwidth test results. Tracepath is also recorded.

The results are used for detecting network or configuration problems, since with each test the relevant system configuration and the tracepath between the two hosts are recorded as well. The MonALISA services are also used to monitor the end system configuration and automatically notify the user when these systems are not properly configured to support effective data transfers in WAN. In Figure 7 we present the results recorded from one site to all the others.

B. Automatic storage discovery for Alice

Using the monitoring information from trace-like measurements, derived information is computed in the repository, associating the Autonomous System (AS) number to each of the nodes in a network path. The repository also runs other monitoring modules that provide global values and one of them periodically queries AliEn for the list of defined storage elements and their size and usage according to the file catalog. Then periodic functional tests are performed from the central machine to check whether the basic file operations (add, get, remove) are successful. The entire software and network stacks are checked through these tests, thus the outcome should be identical for all clients trying to access the storages.

Aggregating the monitoring and test results, a client-to-storage distance metric is computed and used to sort the list of available storage elements to a particular client. Then the closest working storage elements is selected either to save the data or, in case of reading, sorting the available locations based on this metric, trying to read from the closest location. The algorithm associates to each storage element a list of IP addresses representing known machines from its vicinity.

C. Monitoring modules for dynamic light path provisioning

Given the monitoring part, we present solutions adopted for dynamic and automatic provision of light path based on the monitoring information. For that MonALISA has two monitoring modules that provide information about the optical power on ports and the state of the cross-connect links inside the switch in near real-time. The modules use Transaction Language 1 (TL1) commands to retrieve monitoring information from the optical switch. Based on the monitoring information the agent is able to detect and to take informed decisions in case of eventual problems with the cross connections inside the switch or loss of light on the connections.

For control the Optical Switch Agent is a software agent that is dynamically deployed and runs embedded in a MonALISA service. Its role is to monitor and control an optical switch, to publish and to continuously update its configuration. The configuration consists of the port map, which specifies the devices attached to the switch, state of the ports, optical cross-connects inside the switch and the necessary routing information. The agents use the MonALISA framework to discover each other, publish their configuration, and collaborate to create on-demand and end-to-end optical paths.

The algorithm for dynamic path provisioning is able to establish an end-to-end connection in the shortest possible time. In order to achieve this, every agent in the system has the exact view of the network and adapts very quickly to changes, using the previously described solution. The network topology, implemented as a network graph, has agents as vertices and optical links between switches as edges, every edge having a cost associated with it. The system is modeled using a directed graph. Such an approach makes it possible to have both full-duplex and simplex links between optical switches. Each agent in the graph computes a shortest path tree using a variant of Dijkstra's algorithm. The agents system uses a two-phase commit strategy for creating the optical cross-connects and a lease mechanism to guarantee the reliability in case of partial failures.

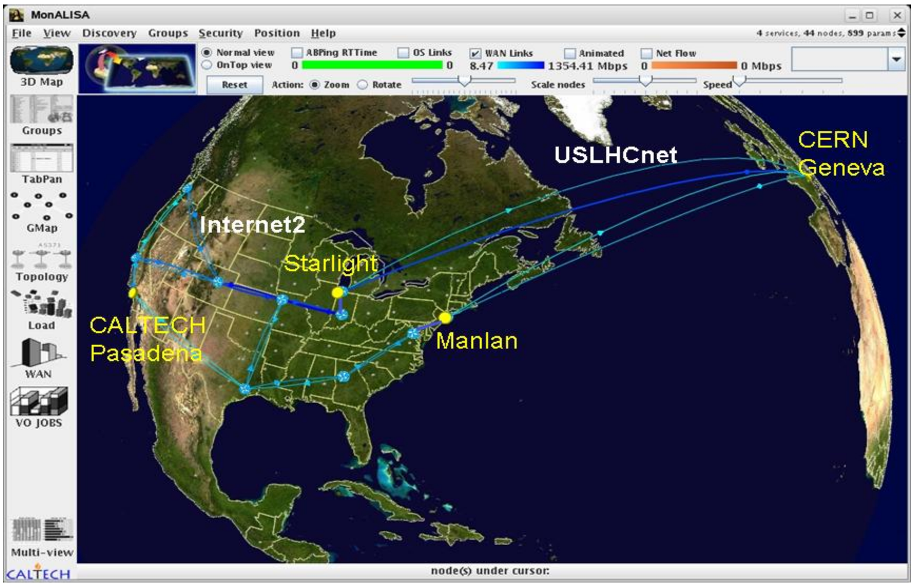


Fig. 8 – The network topology used for creating dynamically, on demand an end to end optical path

An agent that receives a lightpath request determines, based on the local tree that is already built, if the request can be fulfilled or not. If it is possible it also initiates transactions with both the local and remote ports involved in the path. Once the transaction is started, the agent assigns a unique ID for the path, sends the remote cross-connect commands and after that it tries to establish the cross-connects on the local switch. An independent thread is waiting for acknowledgements from the remote agents. Any remote agent which receives such a cross-connect request starts a local transaction only with the ports involved in the cross-connect. If it succeeds in creating the cross-connect, it commits the local transaction and it sends back an "acknowledged" message, otherwise the transaction is rolled-back and a "not acknowledged" message is sent. Based on the received messages the local agent takes the decision whether or not the transaction can be committed or it has to be rolled back. The algorithm described above is reliable and guarantees that the system remains in a consistent state even if a network problem occurs. The newly created lightpath has a lease assigned which must be renewed by all the involved agents and in this way it can provide a viable mechanism for the system to recover from partial failures.

To improve the performance and the response time all the functions executed by an agent are performed in asynchronous sessions using a pool of threads. A task can be a request for a lightpath from a client, or a cross connect request coming from another agent, or a rerouting task triggered by a topology change. The only sequential part of the algorithm described above is in the "pre-commit" phase, and this involves only the ports that are supposed to be in the lightpath. Any request submitted during this phase, which do not involve these ports can be fulfilled in parallel.

Using this information, an agent is able to detect the loss-of-light on fiber, and take specific decisions if the port is part of a lightpath. The agent who detects the problem notifies the initiator, which is responsible to try to reroute the traffic through another path, if this is possible. When the initiator detects a change in topology that affects the lightpath, it forces the shortest path tree to be recalculated. Based on the new tree, the agent is able to take the decision if the light can be rerouted using other path, or it can tear down the entire path. This is very useful, because in case of successful rerouting, the problem will not disturb already established sockets, upper network layers, like TCP, not being able to detect the problem.

The routing algorithm used to establish an end to end lightpath is similar with link-state routing protocols. The work presented here uses an algorithm similar to link-state routing algorithms because they converge faster than distance-vector algorithms. In order to guarantee consistency and reliability of the entire system, a two-phase commit strategy and a lease mechanism were also developed.

We developed dedicated modules for several types of optical switches. The system is currently used to create dynamically on demand optical connections between computers located at CERN (Geneva) and California Institute of Technology (CALTECH) located in Pasadena, CA, using the networking infrastructure of USLHCNet and Internet2 [16, 17].

USLHCNet provides two transatlantic 10 Gb/s optical links between CERN and Starlight (Chicago) and MANLAN (New York). On the Internet2 network, the pure optical connections are simulated using several VLANs to provide direct connections from Chicago and New York to CALTECH. The topology of the network infrastructure used is shown in Figure 8.

The system is able to create dynamically an end to end lightpath in less than one second independent of the number of switches involved and their location. It monitors and supervises all the created connections and is able to automatically generate an alternative path in case of connectivity errors. The alternative path is set up rapidly enough to avoid a TCP timeout, and thus to allow the transfer to continue uninterrupted.

The optical fibers are simulated through two VLANs between the two optical switches. One VLAN is routed through New York and the other one through Chicago. The monitoring module is able to simulate a fiber cut. The optical agent will detect this as a real loss-of-light and will try to reroute the path.

In the example above a disk to disk transfer is presented, using two 4-disk servers, one at Caltech and the other one at CERN in Geneva. During the transfer four fiber cuts were simulated, corresponding to the four drops in the Figure 9.

These fibers cuts simulations were done on the Geneva – Starlight and Geneva – Manlan links and the transfer was rerouted four times between these two links. The "fiber cut" and the reroute are done quick enough that the TCP does not sense the loss in connectivity and the transfer continues. The recovery time differs for various TCP stacks and the round trip time between end points.

Fig. 9 – The total disk to disk throughput between a server at CERN and one at CALTECH. Four "fiber cuts" were simulated during the transfer. The throughput drops when a rerouting is done, but it recovers quickly

In the MonALISA framework the overall status of the dispersed systems being monitored is provided by either a GUI client or through specialized web portals. For the dedicated modules and agents used to monitor and control Optical Switches the GUI client of MonALISA provides a dedicated panel. This panel facilitates the interaction between users and the monitored Optical Switches. It offers to the end user a number of features such as complete perspective over the topology of the monitored optical networks or the possibility to monitor the state of the Optical Switches or the possibility to dynamically create new optical paths.

The main panel is presented in Figure 10. The main aspect of this panel is that it displays in an intuitive way the current topology of the monitored Optical Switches and the links between. For the Optical Switches we use different colors to represent the state of their internal ports and the state of the links between the represented entities. In the panel, besides the Optical Switches a number of other devices (the blue ovals) can also be represented. These devices, equipped with optical network cards, are connected by optical links to the Optical Switches being monitored.

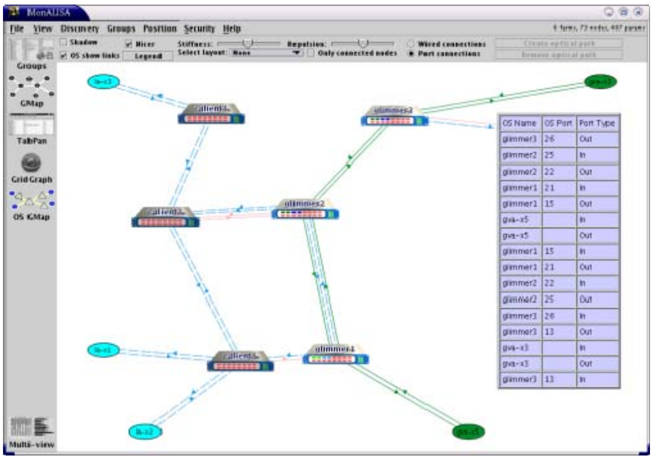


Fig. 10 – Same topology and status on the 3D Map panel

The Optical Switches and the links connecting them are also represented in the 3D Map panel (see Figure 8). This panel locates the MonALISA monitoring services on a 3D view of the world geographical map. It also shows the monitoring WAN links, real-time traffic on them, the capacity of the links, the connectivity between sites, the optical switches controlled and other parameters like sites Load, CPU usage, IO parameters, etc. In this way the user is presented with an easy to use complete visualization tool which represents the global state of the entire monitored systems.

For the optical paths created from this panel (represented in green color in Figure 4) the user is presented with the details of which devices and ports one particular path is crossing (from end to end) together with the components involved in that path (the highlighted devices in Figure 4).

The panel can be also used to create new optical paths or delete existing ones. In order to gain access to these operations the user must present though the necessary credentials. The security layer is implemented using RMI over SSL.

4. MONITORING ALICE DISTRIBUTED COMPUTING ENVIRONMENT

One of the major challenges in designing the monitoring and accounting system in case of LSDS is the heterogeneity of the sites. They may use various resource managers, such as Condor, PBS, Sun Grid Engine, LSF, etc. Such resource managers provide accounting information, but the set of provided parameters (and their measurements units for that matter) differ from one manager to another. While some resource managers record detailed information (such as the amount of memory and disk space used by the jobs, and the amount of network traffic they produce), others only record basic information (such as runtime and CPU time consumed). Therefore, the common set of parameters that can be collected depends on the set of available resource managers.

Another challenge encountered when defining the format of a resource usage record is that there are some differences between LSDS jobs (e.g., between Grid jobs and batch jobs). Therefore, a decision has to be taken regarding which one of the job models should be used for accounting information. For example, when recording the start time for a Grid job, this may have different meanings: the time when the job got submitted to the Grid broker, the time when it entered the batch system queue, or the time when it actually started executing on a computing node. Though the last variant is usually considered at this moment (corresponding to a batch job model), it might be better to use the Grid job model and consider the time needed for brokering, data staging, etc.

There are two ways in which an accounting system can collect the information: 1) in a real-time mode, while the jobs are being executed, or 2) by gathering data from the resource manager logs, after a job completes. The second approach has the advantages of simplicity, and provides more information – so it is sufficient for the accounting purposes. However, a monitoring system is not of much help if it provides information about a job only after it is finished. Users need real-time information, so that they know the status of their jobs while they are being executed – especially since a job can typically run for several hours. To obtain real-time information, a resource manager command that provides the jobs' status must be run periodically, and its output interpreted. This approach has some disadvantages: a negative impact on performance (the commands sometimes take a long time to run, especially when there are thousands of jobs running on the site), and the format of the commands output can change from one version of the resource manager to another. The accounting modules implemented in MonALISA combine both the real-time and the log-based approaches, to deliver accurate information regarding the resource usage.

Resource manager failures are another important aspect that must be addressed by an accounting system. When, for various reasons, the resource manager fails to respond and the accounting system cannot obtain information, the situation should not be interpreted as zero resource usage. There are cases when, even though the queries to the resource manager fail, the jobs are still running correct.

4.1. COLLECTING ACCOUNTING INFORMATION WITH MONALISA

MonALISA provides distributed registration and discovery for services and applications, secured remote administration, and also an agent execution framework that is used to: supervise applications, restart or reconfigure them, and notify other services when certain conditions are detected. Information is provided for: system information for computer nodes and clusters, network information (traffic, flows, connectivity, topology) for WAN and LAN, information regarding the performance of Applications, Jobs or services, and end to end performance measurements. Users may access real time information using a graphical user interfaces, developed with the Java WebStart technology. They can also access history information stored in MonALISA repositories [15].

The accounting modules are a part of the set of MonALISA's monitoring modules, and have the role of collecting information from various available resource managers. These modules are able to work with Condor, PBS, LSF and SGE; if there are multiple queue managers in a cluster, the values obtained from them are combined.

Condor is a workload management system specialized for compute intensive jobs. One of its advantages over other batch queuing systems is the ability to perform opportunistic computing (harnessing CPU power from idle desktop workstations). Also, its ClassAds is a flexible mechanism for matching resource requests with resource offers. PBS, which stands for Portable Batch System, is based on the client-server model, with a client making job execution requests to a batch server and the server handling the execution of the jobs in a cluster by placing them in queues. Among the features that PBS provides are the possibility to set priorities for jobs and to specify interdependencies between them, automatic file staging and multiple scheduling algorithms. SGE (Sun Grid Engine) is a resource management system able to schedule the allocation of various distributed resources, like processors, memory, disk space, and software licenses. Its features include resource reservation, job checkpointing, the implementation of the DRMAA job API and multiple scheduling algorithms. LSF (Load Sharing Facility), a commercial resource management system, has as its core the Platform Enterprise Grid Orchestrator (EGO), which by virtualization and automation provides a way to orchestrate all the enterprise applications into a single cohesive system.

Table 1. Resource managers and their metrics.

Job manager	CPU Time	Run Time	Job Size	Disk Space
CON	Yes	Yes	Yes	Yes
PBS	Yes	Yes	No	No
SGE	Yes	No	Yes	No
LSF	Yes	Yes	Yes	No

The monitoring modules parse the output of specific commands that provide information about the current jobs' status, and provide summarized results for each job. In Table 1 we present the metrics used for each resource manager (where CON means Condor). In case of Condor and PBS, the log files are also considered to obtain additional information. The single-job results are then added to the statistics made per user and per VO; the association between the Unix account from which a job is run and the VO is done on the base of a map file which specifies the corresponding VO for each account.

There are two categories of VO parameters provided by the monitoring module: parameters that represent values obtained in the last time interval (between the previous run of the module and the current one), and parameters that represent rates (calculated as the difference between the current value of a parameter and the value obtained at the previous run, divided by the length of the time interval between runs). Among the parameters in the first category are the number of running/idle/held jobs, the number of submitted and finished jobs, the CPU time consumed, and the total size of the jobs. The parameters in the second category are the rates of submitted jobs, finished jobs, CPU time and wall clock time. The values of these parameters can be viewed with the aid of the MonALISA graphical client, and can also be retrieved by accessing the MonALISA web service. However, a MonALISA service only stores the parameter values for a limited amount of time. For longer periods of time, the values are stored in MonALISA repositories.

As mentioned above, for Condor and PBS the modules can be configured to collect information from the history logs, besides running the job manager commands. Even though this information is not useful for real time monitoring (because the record for a job is written to the log only when the job is finished), there are several reasons why the log information is helpful:

– the log file usually contains the exit status for jobs; knowing whether the jobs were finished successfully is important both for users and site administrators
– there may be some very short jobs which start and end between two consecutive runs of the module; by examining the logs, we can add these jobs to the VO statistics
– with the aid of the logs we can double-check the values for CPU time and runtime that the module collected (the value from the log should be greater than or equal to the value obtained in the last run of the module).

A. Collecting Information from Remote Sites

Normally, the accounting modules collect the information from the local cluster on which MonALISA is running. However, in some situations it is desired to obtain accounting information from remote sites. There are two possibilities of doing that. First, we use the job manager's features. For example, Condor provides an option to query the jobs' status from a remote pool. The MonALISA module can be configured to use this option and to collect information from a remote site (and also from multiple sites). The disadvantage is that in this way, we cannot benefit of the history information as the log files are not on the local machine anymore.

Another possibility to obtain information from remote sites is to run the job manager commands through a SSH connection on the remote hosts. This can be done with any job manager, but it is necessary to configure the remote hosts so that a SSH connection can be opened with the public key authentication method. Another disadvantage is the overhead caused by the SSH communication, especially when there are problems with the network connectivity. This solution has been implemented in a version of the Grid modules that is used in the SEE-Grid project, on LCG middleware.

B. Failure Handling

As mentioned, the accounting system must consider situations when the resource manager fails and stops providing information. A distinction should be made between the case when the manager returns an error message, the case when there is no answer from the job manager, and the case when the job manager works correctly, but there are no running jobs. Otherwise, the accounting system may mistakenly report zero current jobs while there actually are jobs still executing. To avoid this situation, we introduced a set of error codes for the accounting module. When the job manager command returns with error or it fails to answer, we set the appropriate error code, which is also visible from the graphical client.

Another type of failure is the one that affects a single job. Sometimes the resource manager may decide to restart the failed job, and the CPU time counter of the job is reset to zero. We took this case into consideration and the accounting module can be configured for one of the following behaviours: adding the old value of the CPU counter to the VO statistic or neglecting the old value.

C. Processing and Storing Accounting Information in the MonALISA Repositories

MonALISA provides an easy mechanism to create clients able to use the discovery mechanism in JINI and to find all the active services running in a set of targeted communities (groups). Such clients can subscribe to a set of parameters or filter agents to receive selected information from all the services. This offers the possibility to present global views from the dynamic set of services running in a distributed environment to higher level services.

The received values are further stored locally into a relational database, optimized for space and time. The collected monitoring information is further used to create web repositories able to present a synthetic view of how large distributed systems perform. The system allows the development of the required higher level services and components necessary to provide decision support, and eventually some degree of automated decisions, and to help maintain and optimize work-flows through the LSDS.

The repository registers with a set of predicates and stores the received values in the local database. A predicate has the following pattern: *Farm* / *Cluster* / *Node* / *start_time* / *end_time* / *function_list*. These parameters can be dynamically plotted into a large variety of graphical charts, statistics tables, and interactive map views, following the configuration files describing the needed views, and thus offering customized global or specific perspectives. The same mechanism is used to offer access to this information from mobile phones using the Wireless Access Protocol (WAP). The WSDL/SOAP interface is also available so that clients can access information received from several farms in LSDS.

The main components of the repository system are the storage client, responsible for data collection and storage, and the servlet engine, which ensures the translation of user's customized requests from the interface into appropriate queries for the storage client (according to the predicate pattern previously presented). Furthermore, the repository can plot the results in a flexible manner, according to properties set in configuration files. Each chart has a corresponding configuration file with a simple structure that ensures flexibility. Consequently, site administrators can specify custom properties of the plot: the type (bar, series, spider, double axis series, pie, histogram, table, interactive map etc.), the information to be displayed – the predicate(s), the time interval (real time information or maximum length of the history interval), the metrics, the scale, statistics generation, graphical enhancements (series colours, size, names etc.). The same configuration file is used to specify which of these options should be accessible to users from the web interface and the options default values.

This feature stresses two levels of customization permitted by the repository system: user level, at which the user can customize a default view through the interface, and site administration level, at which the super user can decide which monitoring information is made public and how this information is displayed. Furthermore, the flexibility at this level can be increased through integration of new filters and servlets, written by site's administrators and performing specific tasks for the targeted community. We developed such filters for accounting resource usage in several repositories[1]. The MonALISA repository is a Web client that is able to present a synthetic view of how large distributed systems perform. A servlet engine is used to present historical and real time values, statistics and graphical charts in a flexible way. For that, a dedicated module adds a new level of aggregation to raw data stored in the database. The suitable aggregation method and parameters can then be selected from the interface or from the configuration files: sum, minimum/maximum, average, integration over a specified interval, etc.

An important issue in resource usage accounting is the length of the monitored time interval. Usually, this time frame spans over a period of a few years which in conjunction with high parameter collection rates (~2700 parameters/minute for an average Grid/VO community) results in large amounts of monitored data. Such factor size for the repository database (~ 250 GB the average per VO) raises space and access time issues. We therefore optimized the system to achieve consistency, fault tolerance and reliable response times.

First, we allow a precise selection of relevant collected data, as not all received information

[1] For a collection of currently available MonALISA monitoring repositories the user can also consult http://monalisa.cacr.caltech.edu/monalisa__Repositories.htm.

presents interest for a certain community. The system administrator can choose from repository's configuration file which received predicates should be stored in the database, and which should not, and which should only be stored in a temporary memory buffer, but not written to disk (ex: real-time information without history relevance). In the same concern for the database's proportions, the time frame covered is adjustable using a sliding window mechanism.

Also, performing accounting queries for long history periods is a time consuming process. Therefore, an optimized data storage model was needed. We used multiple parameters / series tables for a fast access. Additionally, we designed tables with multiple sampling intervals, so different queries may be served from the appropriate sampling table. For instance, an accounting query for a short history period (1 day, 1 week, 1 month) will use a table with a higher resolution (ex: 1 minute sampling), while queries for long periods (6 months, 1 year) use lower resolution tables (ex: 15 minutes sampling). Also, the sampling method can be customized: write average values for the sampling interval or write directly received data. Further, we use an adaptive memory buffer in order to speed up the response.

Besides being written to the database, the accounting monitoring information is stored in a buffer, so recent data (used for real-time charts) can be quickly accessible without time consuming readings from the disk. The size of this buffer can be set by the system administrator, otherwise is automatically adjusted according to existing memory resources. The time frame of the buffer usually spans from a few hours to a few days according to its memory size and received results rate (~3 hours and ~1.000.000 results for an average-size repository). Besides this buffer, a data cache is used, indexed after servlet queries, which stores the most requested queries and their responses. We designed this complementary cache observing that there are certain requests with the same parameters (all information in the configuration files is translated in servlet parameters), returning the same charts, so a new plot of the same chart was both time consuming and unnecessary.

4.2. CASE STUDY: USING MONALISA FOR ACCOUNTING

The Open Science Grid (OSG) is a consortium formed as a continuation of the Grid3 project, with the purpose of enabling multiple scientist communities to access a common Grid infrastructure. The infrastructure is administered by a set of U.S. universities and national laboratories. One of the main project domains in OSG is nuclear physics, as many of the current OSG applications regard the experiments at the Large Hadron Collider from CERN, Switzerland. Other projects developed within OSG are in astrophysics, biology and gravitational-wave science. The OSG includes an Integration Grid, used for testing of new technologies and applications, and Production Grid, which is a stable environment for executing applications. The OSG middleware is packaged with the Virtual Data Toolkit (VDT), including Globus and Condor as main components, and also the MonALISA framework.

We have been monitoring the OSG group using a global repository for several years, tracking 155.000 parameters from 54 deployed MonALISA services on 26.300 nodes (see Figure 11). The number of finished jobs in this interval was ~ 9.000.000 in 50 Virtual Organizations. The repository has been serving ~ 2.100.000 requests at an average rate of 120 requests/hour, with peaks of 1.500 requests/hour. The average collection rate is ~2.300 results/minute.

Fig. 11 – The OSG Repository

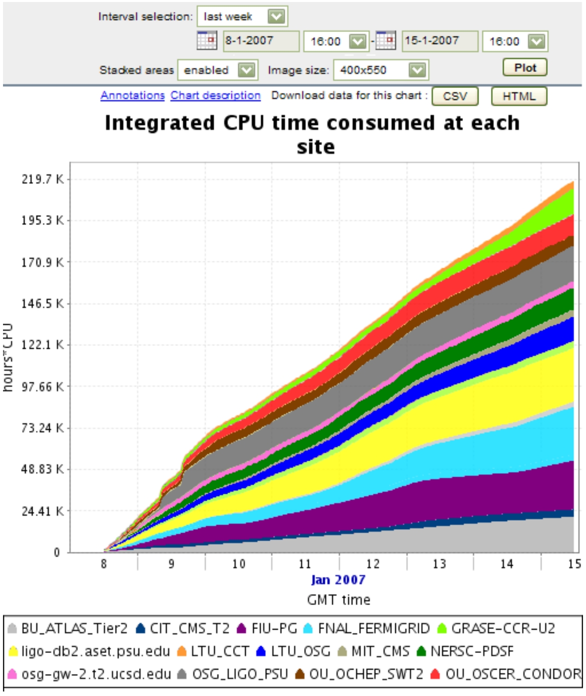


Fig. 12 – Integrated CPU time statistic from the MonALISA repository

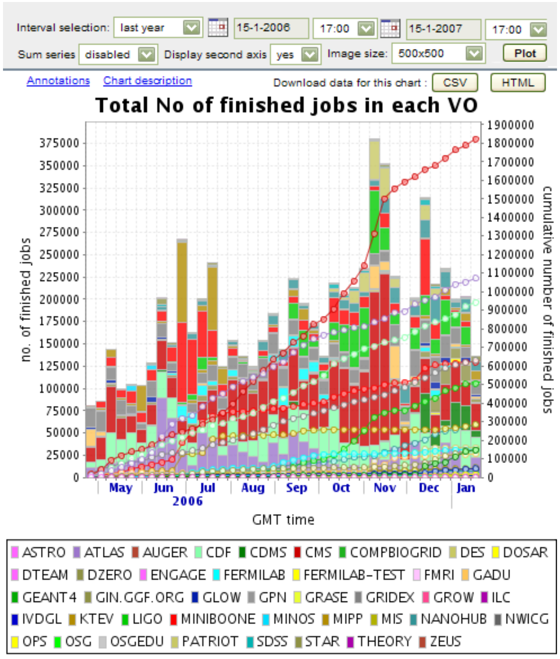


Fig. 13 – Finished jobs statistic from the MonALISA repository

Figure 12 shows an example of accounting resource usage in OSG group with the MonALISA repository. The chart presents the total integrated CPU time consumed at each site in the last week, measured as hours (of CPU time) x number of CPUs. The user can select from the interface the farms which present interest, the time interval for the plot (with predefined periods – last hour, day, week, month, year etc. or specific periods), the representation model (stacked area, series etc.) and size. The chart also has a description and annotations and is available for download in different formats: CSV, HTML.

Fig. 14 – CPU time consumed by the jobs of a virtual organization

In Figure 15 the plotted results represent the number of running and idle jobs for a VO, across different OSG sites. This kind of information, summarized per VO, is stored on a long term in MonALISA repositories.

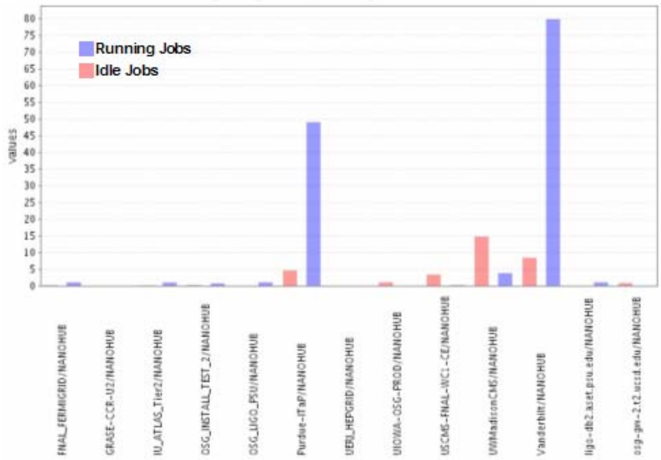


Fig. 15 – Number of running and idle jobs of a virtual organization, across different sites

Another example of accounting resource usage is shown in Figure 13 where a two axes plot presents the number of finished jobs in each Virtual Organization for the last year as well as the cumulative number of finished jobs in each VO, for the last year.

Figures 14 and 15 present information displayed by the MonALISA graphical client. The data was obtained from MonALISA services that are running on OSG sites. In Figure 15 there are the values of CPU time consumed by the jobs belonging to a VO, on a single site. Similar charts are available for the values of wall clock time, jobs size and disk usage (depending on the resource manager running on the site). Such charts are helpful when a user wishes to learn about the status of his/her jobs.

5. CONCLUSION

We have presented a distributed framework for collecting and processing accounting information in LSDS environments. Among the strengths of the framework are: scalability, the possibility of interacting with diverse resource managers, and collecting data both in a real time manner and from logs. As of this writing, more than 360 MonALISA sites are being monitored 24/7 throughout the world. The services monitor more than 60,000 computing servers, and thousands of concurrent jobs. More than 3.5 million parameters are currently monitored in near-real time with an aggregate update rate of approximately 50,000 parameters per second. Such services are mostly deployed by the High Energy Physics community to monitor computing resources, running jobs and applications, different LSDS services and network traffic. The system is used to monitors detailed information on how the jobs are submitted to different systems, the resources consumed, and how the execution is progressing in real-time.

In this paper we presented the capabilities of MonALISA framework towards monitoring and representing large scale networks at different OSI layers. We also present a very useful use case where informed automatic decisions based on monitoring information can improve reliability and increase overall performance of the system. Network monitoring, in particular, is vital to ensure proper network operations over time, and MonALISA was successfully used to provide its monitoring services to control a vast majority of the data intensive processing tasks used by the LHC experiments. In order to build a coherent set of network management services it is very important to collect in near real-time information about the network traffic volume and its quality, and analyze the major flows and the topology of connectivity.

ACKNOWLEDGMENT

This work was supported by project "ERRIC - Empowering Romanian Research on Intelligent Information Technologies/FP7-REGPOT-2010-1", ID: 264207. The work has been cofounded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Romanian Ministry of Labour, Family and Social Protection through the Financial Agreement POSDRU/89/1.5/S/62557.

6. REFERENCES

[1] L. Gaido, A. Guarise, G. Patania, R. Piro, F. Rosso, A. Werbrouck, The Distributed Grid Accounting System (DGAS), Last accessed November 22, 2012, from http://www.to.infn.it/grid/accounting/main.html.

[2] C. Dobre, R. Voicu, I. Legrand, Monitoring large scale network topologies, *Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications* (IDAACS 2011), Prague, Czech Republic (September 2011), pp. 218-222.

[3] MonALISA official website (2012), Last accessed November 24, 2012, from http://monalisa.caltech.edu/.

[4] CMS Experiment official website (2012), Last retrieved November 21, 2012, from http://cms.cern.ch.

[5] ALICE Experiment official website (2012), Last retrieved November 21, 2012, from http://aliweb.cern.ch.

[6] Atlas Experiment official website (2012), Last retrieved November 21, 2012, from http://atlas.web.cern.ch.

[7] OSG official website (2012), Last retrieved November 25, 2012, from http://www.opensciencegrid.org.

[8] RRD official website (2012), Last retrieved November 24, 2012, from http://www.mrtg.org/rrdtool.

[9] FDT official website (2012), Last retrieved November 24, 2012, from http://fdt.cern.ch.

[10] TL1 – Transaction Language 1 Generic Requirements Document GR-831-CORE (2012), Last retrieved November 12, 2012, from http://telecom-info.telcordia.com/site-cgi/ido/docs.cgi?ID=SEARCH&DOCUMENT=GR-831.

[11] Calient Technologies official website (2012), Last retrieved November 23, 2012, from: http://www.calient.net.

[12] GMPLS – General Multi-Protocol Label Switching Architecture RFC3945.

[13] ITU-T Rec. G.7042, Link Capacity Adjustment Scheme (LCAS) for Virtual Concatenated Signals, Feb. 2004.

[14] S. Bagnasco, L. Betev, P. Buncic, *et* al, AliEn: ALICE environment on the grid, in: *J. Phys.: Conf. Ser.* (2007), pp. 119.

[15] I.C. Legrand, H. Newman, R. Voicu, *et al*, MonALISA: An agent based, dynamic service system to monitor, control and optimize distributed systems, In: *Computer Physics Communications*, (180) Issue 12 (December 2009), pp. 2472-2498.

[16] R. Byrom, R. Cordenonsib, L. Cornwall, *et al*,

APEL: An implementation of Grid accounting using R-GMA, *in: UK e-Science All Hands Conference*, Nottingham (September 2005).

[17] A. Cooke, A.J. Gray, W. Nutt, *et al*, The relational grid monitoring architecture: mediating information about the grid, in: *Journal of Grid Computing*, (2) 4 (2004), pp. 323-339.

Ciprian Dobre*, PhD, has scientific and scholarly contributions in the field of large scale distributed systems concerning monitoring (MonALISA), data services (PRO, DataCloud@Work), high-speed networking (VINCI, FDT), large scale application development (EGEE III, SEE-GRID-SCI), evaluation using modeling and simulation (MONARC 2, VNSim). Ciprian Dobre was awarded a PhD scholarship from California Institute of Technology (Caltech, USA), and another one from Oracle. His results received two CENIC Awards, and a Best Paper Award, and were published in 6 books, 10 articles in major international peer-reviewed journal, and over 60 articles in well-established international conferences and workshops (these articles received more than 150 citations). Currently he is local project coordinator for national projects 'CAPIM – Context-Aware Platform using Integrated Mobile Services', and 'TRANSYS – Models and Techniques for Traffic Optimizing in Urban Environments'.*

Ramiro Voicu*, PhD, is Software Engineer at the California Institute of Technology. He has expertise in the design and development of solutions for proficient provisioning of network resources, data transfer mechanisms capable of dynamic bandwidth adjustments capabilities, extensible monitoring infrastructure development, with specific accent on the mechanisms to provide full end-to-end performance data.*

***Iosif Legrand** is Senior Software Engineer at the California Institute of Technology, Division of Physics, Mathematics and Astronomy. He worked on the simulation and modeling of the Data Grid Hierarchy concept and the globally distributed Computing Model adopted by the LHC high energy physics collaborations. He is member of the US-CMS collaboration and is working on distributed network services, monitoring systems and grid related activities.*

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

INTERACTIVE ENVIRONMENT FOR MASSIVE NEUROSCIENCE SIMULATIONS IN GRID

Andrii Salnikov [1,2], Oleksandr Sudakov [1,2], Roman Levchenko [2], Ievgen Sliusar [1], Anton Savchenko [1]

[1] Information and Computer Centre, National Taras Shevchenko University of Kyiv,
4D Glushkova avenue, Kyiv, Ukraine, e-mail: cluster@cluster.kiev.ua, http://grid.org.ua
[2] National Scientific Centre for Medical and Biotechnical Research, National Academy of Sciences of Ukraine,
54 Volodymyrska str., room 232, Kyiv, Ukraine, e-mail: biomed@nas.gov.ua, http://biomed.kiev.ua/

Abstract: *End-user oriented system for massive computations in grid is proposed and implemented. The system provides support of user interfaces for input and output data staging, asynchronous jobs submission and control, tasks status and results monitoring. The main system components include web-portal, authentication components and jobs submitter that interact with grid infrastructure. The main advantages of described grid-portal are flexibility in computations back-ends support and possibility to interactively handle thousands of jobs. The proposed integrated environment was implemented in Ukrainian National Grid (UNG) infrastructure for massive simulations of non-linear dynamics in neuroscience.*

Keywords: *Grid, portal, neuroscience, massive simulation.*

1. INTRODUCTION

Grid [1] is one of the most popular tools for large scale high-throughput computing. Ukrainian grid-infrastructure was established in 2006 as Ukrainian Academic Grid (UAG) [2]. Since 2006 number of UAG application for scientific researches increases and leads to evolving to Ukrainian National Grid (UNG). New problems that could not be efficiently solved before now are able to utilize computing power and storage elements of the UNG. One of such new application is non-linear dynamics problems concerned with biological neurons. In 2010 the virtual organization “networkdynamics” [3] has been created specially for these tasks under the initiative of Laboratory for mathematical modelling of nonlinear processes of National Scientific Centre for Medical and Biotechnical Research, National Academy of Sciences of Ukraine (NSCMBR) in cooperation with Laboratory for parallel computing, Information and Computer Centre and Medical Radiophysics Department, Radiophysics Faculty National Taras Shevchenko University of Kyiv (KNU).

Analysis of neuronal networks is one of the leading trends in modern science aimed to understand mechanisms of human brain functions like memory, cognition, etc or nervous pathologies like Epilepsy, Parkinsonism etc. The main difficulty in such simulations is a large number of neurons (>10^3-10^5) and large number of parameters to be taken into account. Simulation requires consideration of 10^3-10^5 connected neurons and solution of 10^3-10^5 non-linear differential equations. Investigation of neuronal network behaviour requires computing of 10^2-10^3 trajectories, each of 10^6-10^7 steps. Computing time of this task is 3-6 months on the one modern CPU. Size of the compressed data file for each trajectory is 0.1−1 Gigabytes. Different dynamics trajectories are not coupled so may by computed in parallel on different resources in Grid.

The main problem of Grid application is the large number of jobs that should be handled interactively. When number of jobs grows up to hundreds or thousands automation is required to accomplish the research task. Automation is also required for jobs monitoring and aggregation of jobs results. The manual operation requires a lot of knowledge beyond the subject of researcher’s science area, like internals of grid operation, job description languages, command line client tools usage for job submission, monitoring, management and data staging. Human factor is another disadvantage of the manual operation. One can easily mistype the input data or lose the job identifier. Thus we can conclude that without automation it is almost impossible to perform research that requires massive distributed computing.

Many software tools available for biological neurons simulations, but authors found no such tool designed for batch procession in grid. Thus special parallel software for neurons dynamics modelling was developed by authors of this paper [4]. This software was deployed for grid-computing with integrated environment for handling massive job submission. Despite several implementations of grid portals frameworks exist [5], [6] we implemented our own approach [7] that overcome shortcomings of thousands jobs handling present in the mentioned frameworks. In present works this approach is used for building of grid-portal for nonlinear dynamics simulations in neuroscience.

2. HANDLING OF COMPUTATIONAL JOBS IN GRID ENVIRONMENT

Developed system treats a grid job as a set of executables and data specified by job description. Job description contains information about executable itself, location of input and output data and requirements for execution: processor count, system memory, local storage capacity, execution wall-time, etc. Job description is required to allow the grid-scheduler to find computing element that fulfils job resource needs. There are two common description semantics used: JSDL – Job Submitting Description Language and xRSL – eXtended Resource Specification Language. [8]

Job passes various states in grid environment:

1. Preparing the job input files, executable parameters specification and writing the job description. Requirements to computing and storage elements need to be chosen. Wall-time can be computed taking into account algorithm complexity and job parameters (number of elements, etc).
2. Job submission and scheduling. Based on the job description grid scheduler choose appropriate computing element. Information about available processors, disk space and resource load published in common grid information system and available for scheduler. There are two approaches of scheduler implementation in middleware: separate service (for example, Workload Management System (WMS) in gLite) and integration of brokering into client tools (like Advanced Resource Connector [9] clients). Passing to separate service minimizes user interface (UI) tools execution time, but job additionally has to wait in service queue and single point of failure exists. Choosing computing element directly from UI tools requires retrieving resource specification from information system and thus it takes more time to proceed but it passes job to computing element immediately. Both approaches, depending on the number of resources and their response times, waste from dozens of seconds to couple of minutes before submitting to a target computing element (CE).
3. Preparing input files on CE. Depending on middleware implementation, input files can be uploaded to a computing element bundled with a job, or downloaded by CE from specified URI. In turn, file downloading can be performed on gateway node or, after the submission to Local Resource Management System (LRMS), on worker node.
4. Pending state. When all information about job including input files has been retrieved, job is waiting for submission to LRMS. Due to CE queue limits and resources available a significant time can be elapsed before pending job become submitted.
5. Submission to LRMS. Computing element reads the job description, locates job input files and parameters. Based on requirements from the job description, job is passed to the LRMS. Each cluster have own LRMS. For end users it doesn't matter how grid job is scheduled locally.
6. In LRMS queue. Job is processed by LRMS scheduler, gets passed to selected queue and waiting for resources to be available for actual execution.
7. Running. At this stage the desired execution of program on selected worker node finally takes place. During this process some additional commands can be executed before and after job computation. These actions are produced on demand of job script itself and to ensure correct middleware operation.
8. Finishing. Execution of specified program finished and output data needs to be handled. There are several possibilities to handle data: leave it on the CE to be called for retrieval on client or upload it to specified URI on grid Storage Element (SE). The first method is less demanding – client retrieval is always available. Second method requires SE protocols support, frequently outbound internet access on Worker Node (WN) and valid user delegation available (see below).
9. Finished. CE finished output files handling and job operation is almost complete.
10. Job information deleted. After configured amount of time, information about the job removed from grid information system.

After submission to the scheduler (or to a CE directly) unique identifier is assigned to the job for further operations. Information about job state and parameters gets published and continuously updated in the grid information system.

Delegation is the process of transferring some limited rights and privileges to another party, primarily grid service. Use of delegation techniques is a common requirement for a wide range of grid applications [10]. Integrated environment, like any other grid-service, needs to obtain user delegation for further job submission and handling.

The mechanism of delegation commonly used in grid – transferring of the user proxy certificate. Proxy certificate is a short lived certificate signed by user's personal long-term certificate. Usually proxy certificate is valid for 12 hours that is less than job life cycle time. Often, the user proxy expires while the job is still running (or even waiting in a queue).

When the job with expired proxy tries to upload output files to SE – data stage-out will fail [11]. To avoid this situation delegation renewal is required. Delegation renewal can be accomplished via client tools (such as arcrenew for ARC middleware) or via MyProxy service. Like output files uploading, using client tools is the most robust way, which is independent on remote CE deployment. Interaction with MyProxy needs to be configured both on remote CE and MyProxy server.

3. INTERACTIVE PREPARATION OF MASSIVE JOBS

Composition of thousands of input files without automation is complicated. However, researches that require massive computations in most cases focused on enumeration of some parameters. Structure of input files with predominant number of parameters left the same, while changing initial conditions.

Set of jobs with enumeration of several accessible parameters handled as one project we called a jobset.

Jobset require methods, to specify all enumeration once a time. Proposed approach designed to bring special symbols that indicate parameter enumeration:

- To specify several parameter values the syntax: *{p1,p2,…,pN}* is used;
- Parameter numerical values range can be specified as: $\{P_{start}:P_{step}:P_{end}\}$. For example, specification *{0.1:0.05:0.3}* is equivalent to *{0.1,0.15,0.2,0.25,0.3}*.

Integrated environment needs to parse provided jobset files looking for defined semantics and generate set of input files for each job. The good practice is to include exact parameter value on every job in jobset into job name published to information system.

As mentioned above submission of job requires significantly long time. For example, UNG consolidate 24 clusters, and average job submission time in this segment is about 100 seconds. This submission time is provided by client tools available in ARC middleware installed in UNG [2].

Using serial submission of 1000 jobs requires more that twenty-four hours: 100*1000/3600=27.7. Submission of 12000 jobs consume a two weeks. Even if submission time can be reduced with blacklisting of some "bad" clusters, and by aggregating jobs submit (several jobs per submit) submission of thousands jobs may take hours or days.

Existing implementations of grid portals and frameworks are not suitable for massive submission, because of using interactive submission from user interface [5], [6]. Integrated environment needs to separate the process of input data preparation from actual grid job submission to accomplish the goal.

We suggested the following methodology for massive submission with integrated environment:

- User creates a jobset by means of UI;
- UI passes jobset to the portal server along with user identity;
- Server stores information about jobset in a database and notify user about submission via integrated environment;
- Batch server backend checks database on regular basis and looks for new jobs;
- Server retrieves user delegation and submits jobs from jobset non-interactively in background.

4. NETWORKDYNAMICS WEB PORTAL

To investigate neuron networks behaviour and determine which set of input parameters lead to synchronization it is necessary to recompute enumerations of data. Massive distributed grid computing is the efficient way for that researches, so integrated environment requires for end-user scientists.

On demand of networkdynamics VO, integrated environment has been implemented. User interface to solution has been built using Adobe Flex technology to be implemented as a cross-platform web-based solution – portal for non-linear networks investigations.

Backend implements described methods to support massive computing and analysis. Backend is written in the PHP [12] and provides the JSON RPC for interaction with the UI. Backend separation provides an ability to completely change UI implementation or to use more than one different interfaces (including non web-based).

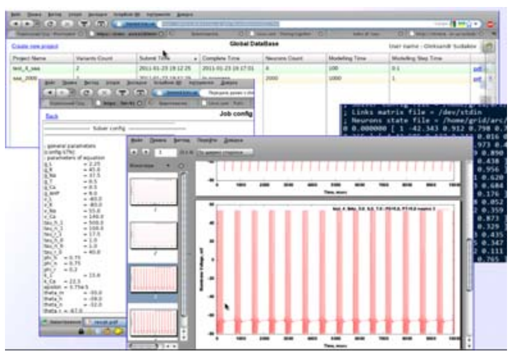


Fig. 1 – Web portal screenshot

Portal is available at the web site https://chimera.biomed.kiev.ua for VO members only due to authentication restrictions.

User authentication on the backend uses HTTPS client certificate authentication method and require PKCS12 user certificate to be imported into the web browser. User certificate Distinguished Name (DN) serves as unique identity to all user-dependent operations on the backend.

If HTTPS authentication has successfully passed, VO authentication is performed next. Integrated environment connects to VOMS server via SOAP interface [13] (PHP-SOAP is used for this purpose) and checks membership of authenticated user.

Networkdynamics VO uses PHP VOMS-Admin 0.6 software with membership database multi-master replication enabled: two instances at NSCMBR and KNU. Thus backend involves use of several VOMS servers for authentication to achieve fault tolerance.

Backend has the database of jobs under control of the integrated environment. MySQL backend is utilized for this purpose, and several database schemas have been tested to optimize performance. Every jobset contain thousands of jobs and when number of jobsets grows, backend must able to handle millions of jobsets.

Saving parameters and input file links in relational database is more processor and time intensive operation, compared to storing it as serialized arrays within the same jobs table. Database access operations in networkdynamics implementation do not require searching for every parameter, so indexes are available only for several fields: job and jobset ids, authors, searchable parameters (separate fields of job table) and job status. Future system enhancements will change this behaviour to more universal.

Monitor script selects jobs having transient status (already finished or failed jobs don't get queued, because nothing has to be done for final status). The querying of grid LDAP-based information system is performed. Querying the data also has the specific features. Efficient querying applies request-time filtering techniques by jobid to eliminate continuous interactions with LDAP servers. In the system with thousands of jobs filter size grows, and LDAP cannot handle megabytes of filter specifications. Filter data requires separation to manageable pieces (4KB in general).

LDAP response contains information actual job status for every jobid. This information is used for updating the database. Monitor script is executed on regular basis by means of CRON UNIX subsystem. To prevent concurrent script running, when CRON interval become smaller then LDAP query time locking mechanism has been implemented as well.

As mentioned above, every grid operation requires delegation from user. Networkdynamics portal implements transparent delegation retrieval from MyProxy server. MyProxy supports "authorized retrievers" policy that describes subjects able to retrieve user delegation without password providing service SSL credentials.

To allow transparent delegation, user need to upload proxy certificate to KNU MyProxy server (px.grid.org.ua) that supports NSCMBR portal certificate as authorized retriever.

Job submission also relies on CRON. Prepared jobs have the initial state in database, that can be queried and job will be submitted. Locking mechanism becomes more important for submission, because of long submission times. Input files are generated and passed to remote CE at submit time, while statically linked programs are available for download from specified URL. This approach use CE caching mechanisms [11], which prevent clusters from making thousands of code copies.

Unfortunately, due to different systematic-less configuration of clusters in UNG, automatic results uploading to SE on every CE become impossible. So we forced to stick on manual results retrieval. Retrieving process, like submission and monitoring, operates the same way by querying finished jobs from database and retrieving results using client tools. Third party transfer allows storing space-consuming results on SE.

Job script contains a code for visualizing results – plotter that stores images in PDF file. PDF files are stored on portal file backend locally, and are available for download from the UI for the first step analysis.

Aggregation of jobset PDF files is also supported, so users can simply review the results of the whole jobset.

5. USING ARC1 CLIENTS IN GRID-PORTAL

A new generation of ARC middleware client tools (starting from version 1.0.0) supports multiple endpoints to submit job as well as multiple sources of information about available VO resources.

Endpoints supported by ARC A-REX computing element are: GridFTP (legacy interface that rely on Globus Toolkit and compatible with ARC 0.x clients), xBES – extended OGSA BES interface implementation and a new-one EMI-ES interface that is now under development in the EMI project.

ARC clients are capable of submitting jobs not only to A-REX interfaces, but also to gLite CREAM CE or UNICORE/X execution service. The future development of portal will cover this way of submission to other infrastructures.

Information sources supported by ARC clients are LDAP resource information systems (including own Nordugrid LDAP schema and Glue2.0 schema), WSRF XML resource information endpoints, LDAP-based EGIIS indexing service and EMI Registry indexes.

Compared to the old clients (which were initially used in the first versions of grid-portal) where grid job ID was the ultimate source of information, a new clients require additional info to operate with jobs (like the exact URI of endpoint where job was submitted and the information source). This additional information is stored in a database local to ARC client (in current implementation file jobs.xml is used). Database contains every required (or even optional, like human-readable job name) parameters associated with every grid job ID.

So, unlike old implementation, where only grid job ID had to be stored in the portal database, with a new clients it is required to preserve jobs.xml file.

Common jobs.xml is not efficient for massive computations – there are performance issues with parsing a huge XML document and there are many different users that access the portal simultaneously.

General scalable approach is to save separate jobs.xml file for every job submitted in portal database. Networkdynamics web portal is project-oriented and all operations are performed in terms of jobsets instead of independent jobs including status updates. With a new ARC clients (starting from 2.0.0 version) it is possible to perform batch operations and retrieve information about every job in jobs.xml with a single command.

Taking into account all this considerations, it was decided and implemented in the current version of portal to save separate jobs.xml files for every jobset in the internal database and substitute it for every ARC client command invoked from shell wrappers.

UNG now contains many A-REX instances with different endpoints – legacy GridFTP available on every cluster, xBES and EMI-ES are supported on several installations. Networkdynamics web-portal is now ready to submit to EMI-ES transparently.

6. UTILIZING STORAGE INFRASTRUCTURE OF UNG

ARC 1.x comes with built-in support for accessing Storage Resource Manager (SRM) compatiple storage elements and LCG File Catalog (LFC) data catalogue services, which are de-facto standards in the global grid infrastructures like EGI and WLCG.

Clusters that support netowrkdynamics VO deploy ARC 1.x and higher and hence support data staging using SRM and LFC as well as GridFTP.

Portal was extended to automatically stage-out jobset results to the storage infrastructure of the VO, which consists of storage elements and central redundant data catalogue deployed at KNU.

EMI StoRM SRM implementation was deployed on CHIMERA cluster as a primary storage for networkdynamics computations. It provides dedicated disk storage resources for the VO accessible via SRM and raw GridFTP protocols.

LFC catalogue is used to track replicas of files as well as access permissions. Portal uses LFC references when producing job description which allows off-loading data staging from the portal to the accepting computing element. After job completion at the target CE, it automatically stages out data to the CHIMERA SE and registers file location in the central LFC catalogue.

7. GRID-PORTAL API

A test version of new grid-portal API is developed based on the experience in creation and applications of networkdynamics web-portal. A new API includes three main parts: job monitor, job submit system, results access system. Grid-portal API contains software components that simplify creation of end-user web interfaces to grid jobs. *JavaScript* components of the dynamic user-interface communicate with server (section 3) using *JSON-RPC* protocol. For data parsing and representation components *jQuery*, *dataTable* and *jsTree* are utilized. To optimize server access times for large number of jobs and large data files HTML5 *localStorage* objects are used if available in client browser. AJAX library is used for asynchronous communications between server and client if *localStorage* is unavailable.

Monitoring system periodically communicates with server using AJAX library to get, renew or change status of running tasks. Minimum information is transferred over the network and only if task status changes occur.

Job submitting interface receives existing task profiles from server, stores task profile on server and submits jobs based on task profiles specified by user. Task profiles include set of input and output jobs data that may be edited by user (section 3). Profile data is sent and received by the same methods as in monitoring interface. Development of job workflow support is now in progress.

Visualization interface provides visual representations and aggregation of job results as plots, pictures, diagrams, animations etc. Downloading of job results data files and building of data aggregation maps for multiple jobs are implemented now.

8. APPLICATION RESULTS

Application of proposed system was performed for investigation of condition when the network of 2000 neurons transfers from chaotic (healthy) to synchronized (Parkinsonism disease) state. For this realistic simulation Rubin-Terman model [14] was used and 640 trajectories of 10 seconds dynamics on 2 clusters of UNG were computed.

Rubin-Terman model is one of the most realistic models for neurons responsible for certain diseases, like Parkinsonism. It involves six nonlinear differential equations per neuron that describes different electrochemical parameters. Neurons are coupled together by one dynamic variable. Simulation requires consideration of 10^3 connected neurons and in turn solution of system of non-linear differential equations. Investigation of neuronal network behavior requires computing of 10^3 trajectories, each of 10^6 steps. Computing time of this task is about 4 months on the one modern CPU. Total size of the compressed data files for simulation is about 1 Terabyte. About 100 CPUs were used and it took about 15 days that was about 50 times faster then on supercomputer in Juelich where 32 CPUs were available for such jobs [4]. The main scientific result was that network can be transferred from healthy to pathological state only when the links number and strengthens reduced.

Another application of proposed system is investigation neuronal networks described by Kuramoto-Sakaguchi model. Kuramoto models [15] treats each neuron as phase oscillator. Each oscillator is described by one nonlinear differential equation. Set of such oscillators are coupled. Physical meaning of phase is position of neurons membrane potential pulses in time. Investigation of hyper-chaos and synchronization regions in parameters space by Lyapunov exponents method requires obtaining of 10^{6-7} trajectories with 10^{5-6} steps. Computing time of this task corresponds to 1-3 months on single modern CPU. Simulation of 10^6 trajectories of 10^5 steps on 3 clusters (115 CPUs) took about 3 days. The main scientific results were determination of initial conditions and parameters ranges where chaotic and synchronized behavior can exist.

Some examples of massive jobs results representations are depicted in Fig. 2-Fig 5 [16]. Fig. 2 describes an example of aggregated parameters map. Each pixel of this map corresponds to a single trajectory for 1000 neurons simulated with certain parameters. Vertical and horizontal axes correspond to coupling radius and initial phase. Pixel colour describes number of frequency clusters in the network. This plot is one of the possible representations of bifurcation diagram.

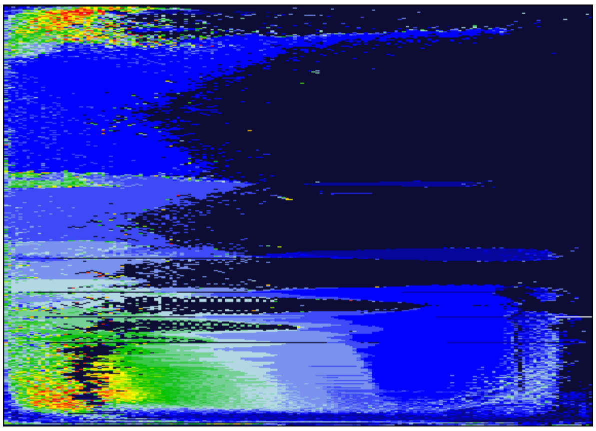


Fig. 2 – Aggregated parameters map (79000 trajectories)

Clicking at appropriate place in map one can see all data available for trajectory, like animations of trajectory dynamics in time (Fig. 3, Fig. 4), phase space diagrams (Fig. 5), parameters values etc. Animations may be easily compared by visual inspection. Parameters sets may by easily imported into other software for data analysis.

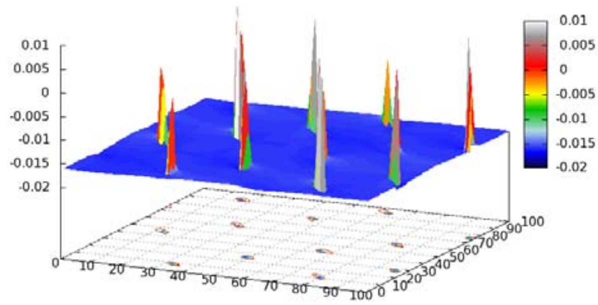


Fig. 3 – Dynamics of neurons frequencies (2d network 100x100 neurons)

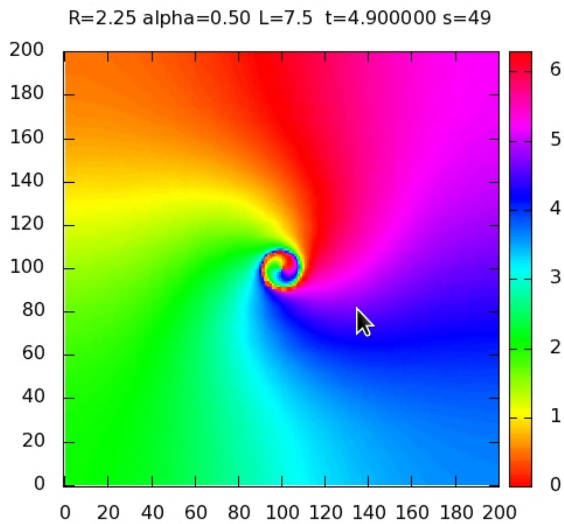


Fig. 4 – Dynamics of neurons phases (2d network 200x200 neurons)

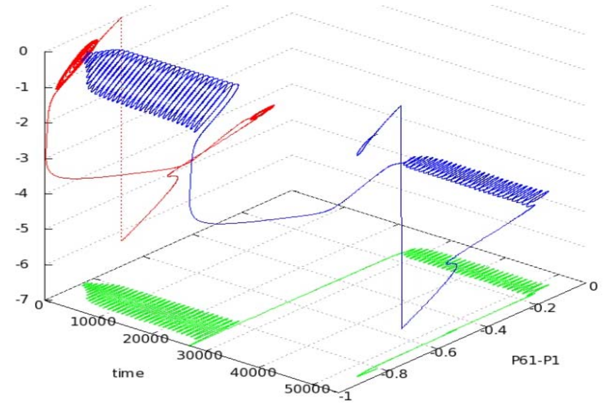


Fig. 5 – Phase space diagram for two neurons

9. CONCLUSIONS

Developed job management system allows handling thousands of grid jobs form a single web-based user interface and provide a framework for a complete automation of grid-computing cycle: from input parameters preparation, submitting and managing jobs in background to staging-out a job results to the storage infrastructure.

Backend implementation of the latest framework build on the top of Nordugrid ARC1 clients that allows a transparent usage of different information sources (including gLite Top-BDII, ARC EGIIS and EMI EMIR) as well as job management endpoints, making the whole system GLUE2 and EMI-ES ready.

Data storage infrastructure used involves SRM-storages and LFC file catalogue, to automatically stage-out data for further processing.

Proposed framework provides an open RPC API for easy extension with other interfaces that can be used for completely different projects.

First applications of the grid-portal has been devoted to brain structures simulations during the Parkinsonism disease and obtaining a new results in the field of neuroscience and non-linear dynamics using Kuramoto-Sakaguchi phenomenological model for phase oscillators and Hodgkin-Huxley-Katz realistic neuron models.

Proposed solution provides the way of research automation in the grid infrastructures to efficiently utilize computing resources.

10. ACKNOWLEDGEMENTS

All computations were performed in Ukrainian National Grid Infrastructure. Research and developments were held using computing clusters of the Information and Computer Centre of National Taras Shevchenko University of Kyiv and National Scientific Centre for Medical and Biotechnical Research, National Academy of Sciences of Ukraine. Funds were provided in the framework of The Ukrainian State Scientific and Technical Programme on Development and Application of Grid Technologies in 2009–2013.

11. REFERENCES

[1] I. Foster and C. Kesselman, *The Grid: Blueprint for a New Computing Infrastructure,* Morgan Kaufmann, 1999.

[2] M. Zynovyev, S. Svistunov, Y. Boyko, and O. Sudakov, Ukrainian grid infrastructure: Practical experience, *4-th IEEE Workshop IDAACS'2007*, (September 6-8, 2007, Dortmund, Germany, pp. 165-169.

[3] Virtual organization membership service of Ukrainian National Grid (UNG), National Taras Shevchenko University of Kyiv, 2011. [Online]. Available: http://grid.org.ua/voms/

[4] R. Levchenko, O. Sudakov, and Y. Maistrenko, Parallel software for modeling complex dynamics of large neuronal networks, *17th International Workshop on Nonlinear Dynamics of Electronic Systems*, June 2009, Rapperswille, Switzerland, pp. 34-37.

[5] Lunarc Application Portal – User's guide, University of Lund, 2006. [Online]. Available: http://laportal.sourceforge.net/docs/users_guide.pdf

[6] P-GRADE Grid Portal, Sztaki, 2005. [Online]. Available: http://portal.p-grade.hu/

[7] A. Salnikov, I. Sliusar, O. Sudakov, O. Savytskyi, and A. Kornelyuk, Moldyngrid virtual laboratory as a part of Ukrainian academic grid infrastructure, *Proc. IEEE International Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, 21-23 September 2009, Rende (Cosenza), Italy, pp. 237-240. [Online]. Available: http://moldyngrid.org

[8] The NorduGrid Collaboration, Web site. [Online]. Available: http://www.nordugrid.org

[9] M. Ellert et al., Advanced resource connector middleware for lightweight computational grids, *Future Gener. Comput. Syst*., (23) 1 (2007), pp. 219-240.

[10] GridSiteWiki, Grid Security for the Web Web platforms for Grids, 2007. [Online]. Available: http://www.gridsite.org/wiki/Delegation_protocol

[11] ARC Clients: User's Manual, Nordugrid, 2011. [Online]. Available: http://www.nordugrid.org/documents/arc-ui.pdf

[12] T. Converse and J. Park, *PHP 4 Bible*, New York, NY, USA: John Wiley & Sons, Inc., 2000.

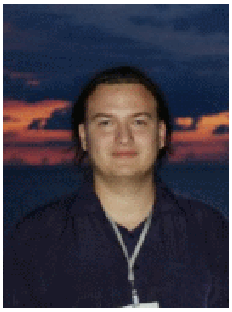
[13] R. Alfieri et al., From gridmap-file to VOMS: managing authorization in a grid environment,

Future Gener. Comput. Syst., (21) 4 (2005), pp. 549-558.

[14] D. Terman, J. Rubin, A. Yew, and C. Wilson, Activity patterns in a model for the subthalamopallidal network of the basal ganglia, *J. Neurosci.*, vol. 2, 2002, pp. 2963-2976.

[15] O.E. Omel'chenko, M. Wolfrum, S. Yanchuk, Y.L. Maistrenko, O. Sudakov, Stationary patterns of coherence and incoherence in two-dimensional arrays of non-locally-coupled phase oscillators, *Phys. Rev. E 85*, 036210 (2012).

[16] A. Salnikov, R. Levchenko, O. Sudakov, Integrated grid environment for massive distributed computing in neuroscience, Proc. *6-th IEEE International Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications,* 15-17 October 2011, Prague, Chech Republic, – pp. 198-202.



Andrii O. Salnikov, *Master of physical and mathematical sciencies, Engineer of Parallel Computing Laboratory at Information and Computer Center of National Taras Shevchenko University of Kyiv.*

Scientific interests: grid and high performance computing

Oleksandr O. Sudakov, *Candidate of physical and mathematical sciencies (Ph.D.). Associate Professor of Medical Radiophysics Department, Head of Parallel Computing Laboratory at Information and computer Center National Taras Shevchenko University of Kyiv. Graduated from Radiophysics Faculty Taras Shevchenko Kyiv University in 1996. Ph.D. thesis in Procession of magnetic resonance tomography signals in 2002.*

Scientific interests: high performance computing, physical processes in biological systems.

Roman I. Levchenko, *Candidate of technical sciences (Ph.D.), Engineer of National Scientific Center for Medical and Biotechnical Research, NAS of Ukraine. Ph.D. thesis in automatic dynamic parallelizing of calculations for heterogeneous multiprocessing computers in 2011.*

Research Interests: Numerical methods and nonlinear dynamic, high performance computing systems and information technologies in physic, dynamic parallelizing for heterogeneous computer systems.

Ievgen A. Sliusar, *Master of physical and mathematical sciences, Engineer of Parallel Computing Laboratory at Information and Computer Center of National Taras Shevchenko University of Kyiv.*

Scientific interests: grid and high performance computing.

Anton I. Savchenko, *National Taras Shevchenko University of Kyiv, Faculty of radiophysics, Quantum radiophysics department, 4-th year bachelor student.*

Scientific interests: computer science, distributed computing, front-ends development.

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

NOVEL CHATTERBOT SYSTEM OF ESTIMATING CURRENT USER INTERESTS BY MEANS OF WEB INFORMATION

Miki Ueno, Naoki Mori, Keinosuke Matsumoto

Department of Computer and Systems Sciences, Graduate school of Engineering, Osaka Prefecture University
1-1 Gakuencho, Nakaku, Sakai, Osaka 599-8531, Japan
e-mail: ueno@ss.cs.osakafu-u.ac.jp, mori@cs.osakafu-u.ac.jp, matsu@cs.osakafu-u.ac.jp
http://zope.ss.cs.osakafu-u.ac.jp/

Abstract: *Human like conversation systems are one of the most important target of computer engineering. To achieve natural conversation, estimating current user interests is the essential issue. In this paper, we proposed the novel chatterbot which can estimate current user interests by means of Web information to solve above problem. In proposed chatterbot, interests are represented by interest vectors that were created by Bulletin Board System (BBS) data. To show the effectiveness of the proposed method, the computational experiments are carried out taking several BBS data as examples.*

Keywords: *chatterbot, estimating current user's interest, web information.*

1. INTRODUCTION

Attempting to create an intelligent conversation system [1-4] is one of the most important and interesting themes in computer engineering. However, approaches that use natural language processing and artificial intelligence techniques have not yet been able to create an enjoyable experience for users.

In conversation systems, one of the most important issue is how to estimate current user interests [5, 6]. In this paper, we propose the novel chatterbot that estimates user interests by using Web information [7]. In this chatterbot, interests are represented by interest vectors that are created by Bulletin Board System (BBS) called "2channel" (2ch) [8]. Although lots of interest vectors can be obtained by our method, we have not shown the generality of interest vectors of 2ch for various user inputs. We show the effectiveness and generality of interest vectors of proposed chatterbot by computer simulation taking several BBS data as pseudo user inputs.

We first present the constitution of the proposed chatterbot in section 2. We propose a novel chatterbot in section 3. Computer experiments are described in section 4. We proposed new method to estimate current user's interests in section 5. In section 6, we had computer experiments to confirm effectiveness of our method, while section 7 introduces possible applications of the proposed chatterbot. Finally, in section 8, we conclude this study.

2. CONSTITUTION OF PROPOSED CHATTERBOT

In this study, the proposed chatterbot is constituted in the following manner.

Interpretation

The chatterbot receives an input sentence and formats this input for the following processes. The first step of interpretation is morphological analysis of the input. Here, we utilize Sen [9], which is one of the leading pure Java morphological analysis libraries for Japanese.

Replying

The chatterbot replies to the user with an appropriate expression. We adopt short-term memory for reasonable conversation and a user logging system for retrieving information on the specific user. The proposed chatterbot also checks Wikipedia [10] to formulate an appropriate response to unknown keywords.

Learning

The chatterbot can memorize new statements and revise its memory. If the chatterbot fails to supply an appropriate response using its memory, it will ask the user about the user's input sentence or any unknown keywords. The user can teach the chatterbot the meaning of new words, or force the chatterbot to forget a specific part of its memory.

Personality

Since the chatterbot matures through conversation with users, the personality of the chatterbot is crucial for forging an emotional bond between the users and the chatterbot. The proposed chatterbot maintains a self-portrait and introduces unique topics of conversation.

3. UTILIZING WEB INFORMATION

3.1 BASIC CONCEPT

We propose a novel chatterbot that uses Web information. A simple approach to utilize Web information is to extract the sentences from Wikipedia [10] or from search engine results. In this study, we propose a novel method for making the appropriate replies with estimating the current user interests. In this paper, we focus on the estimating current user interests and do not show the detail of making replies. Since estimating the user interests is very important to achieve interesting conversation, this study is essential to construct our chatterbot.

We use the data of Bulletin Board System (BBS) to estimate user interests because BBS data is already categorized into typical fields.

3.2 TARGET BBS

We selected 2ch [8] as the target BBS because 2ch is the most comprehensive forum in Japan and covers diverse fields of interest. The top level unit is called “category”. Several boards belong to a “category”. It has more than 600 active boards including “Social News”, “Computers”, and “Cooking”. Each board usually has many active threads that have main topics for discussion.

3.3 UTILIZING BBS INFORMATION

The following 2 approaches are adopted to use the information from the BBS.

Approach1: If the chatterbot knows the user’s interests before the session, the chatterbot will try to use words that appear frequently on the board related to the user’s interests.

Approach2: The chatterbot determines the user’s interests automatically by using statistical information from the user’s conversation log.

3.4 DISTANCE BETWEEN BOARDS

3.4.1 DEFINITION OF DISTANCE

In this study, we define the distance between two boards in the 2ch BBS as a simple Euclidean distance. If the similarity of two boards is high, the distance between those 2 boards will be low.

The words set throughout the entire BBS is defined as W, and the i-th word is denoted as w_i. We set $|W| = M$. Then the feature vectors of board x and y, $\hat{\mathbf{x}}$ and $\hat{\mathbf{y}}$ respectively, are defined as follows.

$$x = \begin{pmatrix} N^x_{w_1} \\ \vdots \\ N^x_{w_i} \\ \vdots \\ N^x_{w_M} \end{pmatrix}, \quad y = \begin{pmatrix} N^y_{w_1} \\ \vdots \\ N^y_{w_i} \\ \vdots \\ N^y_{w_M} \end{pmatrix}$$

N^{x,w_i}: *The number of words w_i in board x*

N^{y,w_i}: *The number of words w_i in board y*

$$\hat{\mathbf{x}} = \frac{\mathbf{x}}{|\mathbf{x}|}, \quad \hat{\mathbf{y}} = \frac{\mathbf{y}}{|\mathbf{y}|}$$

Then, the distance between boards x and y is defined as follows.

$$D(x, y) = \sqrt{\sum_{i=1}^{M} (\hat{x}_i - \hat{y}_i)^2}$$

3.4.2 STOP WORDS REDUCTION

We aim to find the typical relationship between words and the particular board. Therefore extremely common words such as “I” or “you” are not suitable for this purpose. To solve this problem, words which appear in N boards are regarded as stop words and removed, where N is the number obtained by multiplying the total number of boards and parameter γ. We also removed “user name”, “date and time” and inappropriate no good words by pattern matching.

3.5 ALGORITHM OF SIMPLE REPLYING

We show the algorithm of simple replying as following. To confirm the efficiency of using user's interest, we performed simple experiment based on this algorithm in Section **4**.

[Simple Replying]:

1. Save all sentences on board i from the Web to set S_i.
2. Let the number of all boards from which sentences are saved be n. Define $S = \bigcup_{i=1}^{n} S_i (\neq \varphi)$ as the total set for n boards.
3. Set the probability of using the positive set p.
4. Let the first noun in the sentence be k. Set the positive set as

$S^{\text{true}} = \{x | x \in S, x$ is the sentence which contains word $k\}$.
Let $S^{\text{false}}=S \setminus S^{\text{true}}$.

5. Select a sentence randomly from S^{true} with probability p, or from S^{false} with probability of $1-p$, and output this sentence after the formatting procedure. If $S^{\text{true}}=\varphi$ or $S^{\text{false}}=\varphi$, a sentence is selected from S.

4. COMPUTER EXPERIMENTS 1

We evaluate whether the board's distance can be practically used to detect user interests. This experiments shows the effectiveness of Approach1 in **3.3**.

4.1 EXPERIMENTAL SETUP AND RESULTS

In this study, we selected 2ch [8] for the computer experiments because it is one of the largest BBSs in Japan and its BBS topics are categorized well (Top → Category → Board → Thread). First, we selected five boards: Math, Physics, Literature, Beauty (topics about cosmetics), and Jobs (topics about employment). We only focus on nouns when analyzing target words. Replying of chatterbot is generated by algorithm shown in **3.5**.

Table 1 shows the top 10 most frequently used words on each board. Table 2 shows the distance between each pair of boards.

Table 1. Top 10 words on each board (γ = 0.6)

Mathematics	Physics	Literature	Beauty	Jobs
mathematics	time	smile	face	informal decision
proof	existence	novel	male	company
book	physics	work of art	female	enterprise
definition	light	book	eye	work
1	universe	novelist	hair	interview
number	understanding	literature	skin	university
understanding	explanation	love	love	age
case	human	human	nose	activity
existence	earth	Japan	beautiful	recruit
you	case	age	effect	day
Note: Japanese results translated into English.				

Table 2. Distance between boards in 2ch BBS (γ = 0.6)

	Math	Physics	Literature	Beauty	Jobs	Norm
Math	0	0.87	1.04	1.18	1.12	26975.91
Physics	0.87	0	1.02	1.17	1.13	28850.04
Literature	1.04	1.02	0	1.03	1.06	37687.74
Beauty	1.18	1.17	1.03	0	1.10	34642.16
Jobs	1.12	1.13	1.06	1.10	0	31950.71
Note: rounded to two decimal places						

To investigate the effects of applying BBS information to determine user interests, we conducted the following questionnaire survey of users. Specifically, we evaluated the extent to which the conversational quality of the proposed chatterbot improved. The procedure for the experiment is presented below. We set the number of user inputs of each trial to 10 times.

BBS Experiment

1. The target user converses with the original chatterbot freely without BBS Information.
2. The target user then selects one board of interest. In this step, we set n=1 in replying algorithm in **3.5** and set selected board as S_1.
3. We adjust the chatterbot settings to use sentences from the board selected in Step 2.
4. The target user converses with the chatterbot that is using board information.
5. Repeat Step 1 – Step 4 five times and count the number of trials that user could be satisfied the chatterbot outputs from the view point of their interests in conversations of Step 1 and Step 4.

The results of the questionnaire survey are shown in Table 3, where the words after user name (Math, Fashion, TV Game) were user's interests. n/5 represents that user could be satisfied chatterbot outputs n times in 5 trials of BBS Experiment.

Table 3. Evaluation of chatterbots before and after utilization of BBS information

	No BBS Info	Use BBS Info
User1(Math)	1/5	5/5
User2(Fashion)	2/5	4/5
User3(TV Game)	2/5	4/5

4.2 DISCUSSION

The results shown in Table 2 indicate that the distance between Math and Physics is smaller than the distance between Math and Beauty. Since Math and Physics have several top 10 words in common in Table 1, it is natural that the distance between Math and Physics is small. On the other hand, since Math and Beauty have no words in common in Table 1 the distance between Math and Beauty is large. The results in Table 1 and Table 2 are reasonable, and appropriate values were obtained by checking the similarity of the different boards.

Table 3 shows that utilizing board information is effective for satisfying the user's interests.

5. ESTIMATING CURRENT USER INTERESTS

We proposed method and showed effectiveness of Approach1 in **3.3** by Experiment 1 shown in section **4**. However, Approach2 in **3.3** is more important for chatterbot system.

In this section, we proposed method of estimating user interests automatically by user's conversational log as Approach2 in **3.3**.

Generally, user interests are changing during conversation. If the chatterbot uses all logs equality, it is difficult to estimate current topics. To solve this problem, we propose the following method which estimate current user's interests by emphasizing the current user input.

The proposed chatterbot has a user a's interest vector $\boldsymbol{c}^a$ which represents user's internal state. Each vector element of $\boldsymbol{c}^a$ ($0 \leq \boldsymbol{c}^{a,j} \leq 1$) relates to category j of stored BBS board information. If the degree of user interests in related board is maximum, the value of vector element becomes 1. On the other hand, use has no interest in that board, the value becomes 0.

The proposed chatterbot tries to answer based on the topic of board of larger $\boldsymbol{c}^{a,j}$. However, $\boldsymbol{c}^a$ is made by all logs, there is problem that the proposed chatterbot fails to understand current topics. To avoid this, the proposed chatterbot decides the topic of answer as follows:

We define the latest input in time step T as S_T. Old inputs are represented by S_{T-1}, S_{T-2}, ..., S_1. We also define the changing topic vector $\boldsymbol{\sigma}_{S_T}$ as follows:

$$\{\boldsymbol{y}_{S_T}\}_j = \sum_{i=1}^{W} N_i R_i^j \tag{1}$$

where N_i is the frequency of word $_i$ in S_T and R^j_i is the frequency word i in board j.

Next, the topic vector $\boldsymbol{t}^\alpha$ which i-th element represents the current significance of board i is defined.

We set the default value of all elements of $\boldsymbol{t}^\alpha$ to 0. The proposed chatterbot calculates $\boldsymbol{t}^\alpha$ as follows whenever the proposed chatterbot obtains the newest input S_T.

$$\boldsymbol{t}^\alpha = \sum_{i=1}^{T} \gamma^{i-1} \boldsymbol{y}_{S_{T-i+1}} \tag{2}$$

where γ, $0 \leqq \gamma \leqq 1$, is the discount rate. As γ decreases, the influence of past inputs decreases. We define normalized unit vector of $\boldsymbol{t}^\alpha$ as $\hat{x}^a$ $\hat{t}^a$.

Since we assume that user interests are constant in short term, we consider that the weight of past inputs and that of current inputs are the same.

Therefore $\boldsymbol{c}^a$ is obtained by $\boldsymbol{t}^\alpha_{\gamma=1}$ for $\gamma = 1$ as follows:

$$\mathbf{t}^\alpha_{\gamma=1} = \sum_{i=1}^{T} \boldsymbol{\sigma}_{S_{T-i+1}}, \mathbf{c}^a = \hat{\mathbf{t}}^a_{\gamma=1} \tag{3}$$

The proposed chatterbot decides the board to use by referring to $\boldsymbol{c}^a$ and $\hat{t}^a$. We define board deciding vector $\boldsymbol{b}$ as follows:

$$\mathbf{b} = \eta \mathbf{c}^a + (1-\eta)\hat{\mathbf{t}}^a \tag{4}$$

where $0 \leq \eta \leq 1$. The proposed chatterbot selects board i in proportion to $\boldsymbol{b}_i$.

6. COMPUTER EXPERIMENT 2

6.1 EXPERIMENT 2-1

To evaluate the algorithm for estimating user's in-terest, we did a statistical experiment using texts of boards from 2ch which are already categorized.

In this section, we performed computer experiments in order to confirm our method of estimating user's interest based on the distance of boards shown in section **5**.

To prepare the experiment, we applied the follow-ing processing to 2ch data.

1. Combine continuous nouns into one word.
2. Remove stop-words from test data.

We would like to obtained statistical results, lots of user inputs of a certain interests are required.

However, to get such a large data is difficult, we utilized randomly selected sentences from a board of 2ch as pseudo user inputs. We regarded the category of selected board as the interests of those inputs.

6.1.1. SETTING OF EXPERIMENT

1. Select 3 boards "Math", "Physics" and "Beauty" from 2ch for target boards.
2. The experiment is carried out in following 3 combination of board A and board B.
3. These 3 patterns are selected based on the result of Table 2.
   (a) board A: Math, board B: Physics
   The example of distance between boards is small.
   (b) board A: Math, board B: Beauty
   The example of distance between boards is large.
   (c) board A: Beauty, board B: Math
   Same pairs of boards as (b), but board A and B is opposite order.

4. Top 10,000 frequent words of board A and board B on Jun. 23rd, 2009 are defined as the group of words for estimating user interest. These words are the same as words obtained in experiment 1 in section **4**.
5. Text data of board A and board B posted from Nov. 10th, 2012 to Nov. 16th, 2012 were separated into sentences and put each boards' sentences into U_A and U_B respectively. Those sentences are used as pseudo user inputs in the following experiment. We select n sentences from U_A and m sentences from U_B randomly. In experiment, n sentences from U_A are used first and then m sentences from U_B are used after finishing U_A sentences. Finally, $n + m$ inputs are evaluated.
6. Each element of board define vector ***b*** in Eq. (4) shows the level of interests of the corresponding board. In this experiment, board define vector has two elements corresponding to board A and board B. The variation of each element is observed in order to check the tendency of 2ch boards and definition of boards define vector.

Table 4 displays conditions of experiment. We set η = 0.2. η is the parameter controlling the sensitivity of latest input. 100 results of board define vector of different random seeds are obtained.

Table 4. Experimental conditions

Number of sentences sampled from board A : n	10
Number of sentences sampled from board B : m	10
Number of sentences per log : $n + m$	20
Times	100
Coefficient η	0.2
Discount rate γ	0.2

To make the effectiveness of board define vector ***b*** in Eq. (4) clear, we did a t-test(two-sided test) every step between 100 trials of the first element of ***b*** as interest level of board A and that of the second element of ***b*** as interest level of board B.

6.1.2. CONSIDERATION AND RESULTS

In this section, the x-axis shows the input step and the y-axis shows the average of ***b*** element in 100 trials. First element of ***b*** represents the interest level of board A and Second element of ***b*** represents that of board B. In Figs.1-3, the source of pseudo input is changed from U_A sentences to U_B sentences on input step 11. Figs. 1-3 show the variation of level of interests of board A and that of board B are shown as 2 lines.

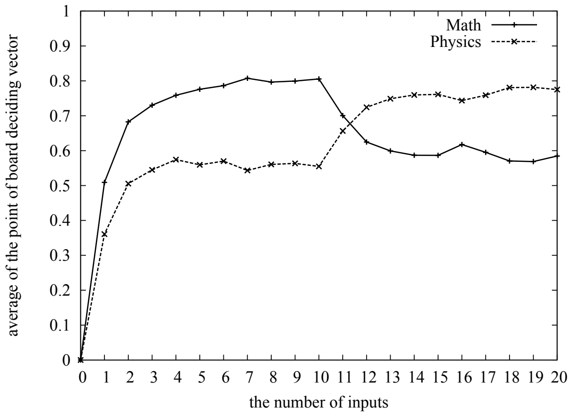


Fig. 1 – Experiment 2-1 (a)
(board A: Math, board B:Physics)

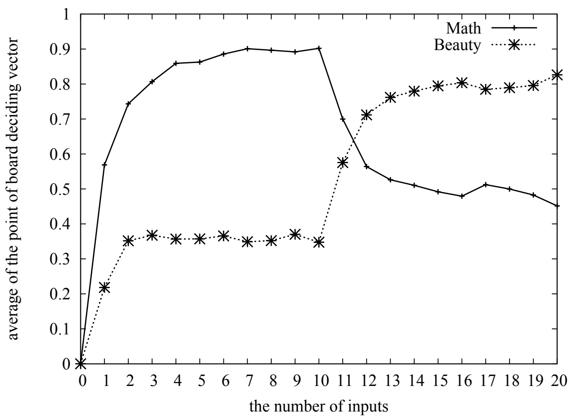


Fig. 2 – Experiment 2-1 (b)
(board A: Math, board B: Beauty)

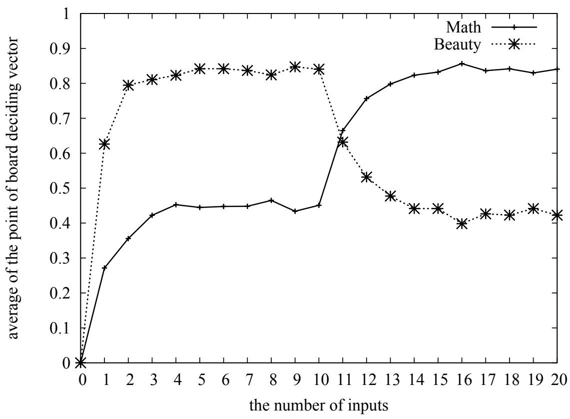


Fig. 3 – Experiment 2-1 (c)
(board A: Beauty, board B: Math)

(a) Math-Physics

Fig.1 shows the results of experiment 2-1 (a).

From input step 7 to input step 10, there exists significant difference at the significance level 1%.

Value of interest level of board A gradually increases from step 1 to step 10. On the other hand, from step 1 to step 6 and step 11 to step 20, there was no significant difference. Value of interest level of board B is increasing after input step 11.

(b) Math-Beauty

Fig.2 shows the results of experiment 2-1 (b).

From step 1 to step 10 and from step 14 to 20, there exist significant difference at the significance level 1%. In experiment 2-1 (a), significant difference is observed only 4 input steps 7, 8, 9 and 10, while significant difference is observed 17 input steps in experiment 2-1 (b). The difference between interests level of board A and that of board B of Fig. 2 is larger than that of Fig. 1.

This is because difference between math and beauty is larger than difference between math and physics. This result is reasonable because of result of Table 2 which shows the distance between math and beauty is larger than the distance between math and physics. The result of Table 1 also supports this results.

(c) Beauty-Math

Fig.3 shows the results of experiment 2-1 (c). In experiment 2-1 (b), first 10 inputs are selected from "Math" board next inputs are selected from "Beauty", while “Math” and “Beauty” is opposite order in experiment 2-1 (c). From step 1 to step 10 and from step 13 to step 20, there exists significant difference at the significance level 1%. This result is the almost same as result in experiment 2-1 (b). Comparison result between Fig.1 and Fig.3 is similar that of Fig.1 and Fig.2, so the result is not affected by order of “Math” and "Beauty". This result show the maximum element of board define vector ***b*** represents user interests well.

6.2 EXPERIMENT 2-2

There exists small difference between the graph shape of Fig.2 and Fig.3. This is because the meaning of inputing “Math” sentences and “Beauty” sentences are different.

The results of experiment 2-1(b) and 2-1(c) show that the difference between values of interest level of “Math” and that of “Beauty” become large when input sentences is from "Math" board.

The increases of interest level of "Beauty" under using "Math" input is smaller than that of "Math" under using "Beauty" input.

We can make a following assumption by this fact.

6.2.1 ASSUMPTION

In board math, there are lots of specific words such as technical term. On the other hand, in beauty board, there are not so specific words.

The ratio of specific words such as technical term of “Math” board is larger than that of “Beauty”.

6.2.2 SETTING OF EXPERIMENT

To investigate above assumption, we performed computer experiment under condition of setting $\eta = 0$, $\gamma = 0$, $n = 10$, $m = 10$ in order to compare "Math" board and "Beauty" board on every step.

We checked error rate in following board setting:

(1) board A: Math, board B: Beauty

(2) board A: Beauty, board B: Math

Error rate of board A is the ratio of input steps that the interest level of board B is higher than that of board A even if input sentences are selected from board A. We calculated the error rate by using results of 100 trials in case of (1) and (2).

6.2.3 RESULTS

We obtained following results:

(1) Board A: Math, Board B: Beauty(using same sentences in experiment 2-1(b))
Error rate of "Math" : 126(12.6 %)
Error rate of "Beauty" : 173(17.3 %)

(2) Board A: Beauty, Board B: Math(using same sentences in experiment 2-1(c))
Error rate of “Math” : 123(12.3 %)
Error rate of “Beauty” : 183(18. 3 %)

The error rate of “Beauty” is always higher than that of “Math”.

This results support that our assumption is true.

We may utilize this error rate for reliability of category of user interests. Lower error rate categories have high reliability in detecting user interests.

7. APPLICATION

We developed three types of applications for the proposed chatterbot. Since our chatterbot engine is independent part, we can easily apply the proposed chatterbot to other applications.

7.1 STANDALONE APPLICATION

This is a local application with a GUI [7]. Although it is possible to obtain Web information from Wikipedia or a BBS simultaneously via a network, this application also can be executed without a network by using a local dictionary. The GUI handles displaying characters, obtaining user input and printing responses of the chatterbot. Fig. 4 shows the look of our standalone chatterbot.

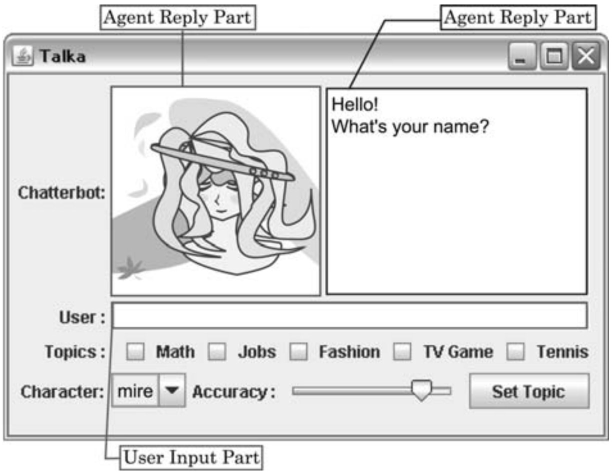


Fig. 4 – GUI of standalone chatterbot

7.2 TWITTER BOT

Twitter is a popular social network based communication service that enables its users to send, receive and view short messages known as tweets. Tweets are text-based posts of up to 140 characters that are displayed on the author's profile page and delivered to the author's subscribers, who are known as followers. We applied the proposed chatterbot as a Twitter bot using the Java-based Twitter API called Twitter4J. We have asked several testers to try our chatterbot in Twitter, and obtained positive opinions.

7.3 PICTGENT

We have proposed novel variation of our chatterbot by introducing picture information called "Picture Information Shared Conversation Agent" (Pictgent) [11] which can share picture information with user to create common topics of conversation easily. Pictgent can be applied to the field of e-Learning.

The advantage of Pictgent becomes obvious when we apply it to education of children in single age because lots of children are bored with chatting by only text. Pictgent solves this problem by showing picture and realizing conversation with sympathy of user.

8. CONCLUSION

In this paper, we proposed the novel chatterbot that estimates user interests and showed the effectiveness and generality of interest vectors of proposed chatterbot.

The results of computer simulations taking several BBS data represented that proposed interest vectors can be applied for estimating general user inputs and follow the topic change immediately. We also showed the our proposed applications, such as "Picture Information Shared Conversation Agent " (Pictgent).

The following objectives will be studied in future research.

1. Making interest vectors of various fields.
2. Introducing proposed estimating user interest method into Pictgent.
3. Applying proposed chatterbot to human users.
4. Estimating not only user interests but user emotions from user inputs.

9. ACKNOWLEDGMENTS

This research was supported in part by a Grant-in-Aid for Scientific Research (C), 22500208, 2010-2014 from the Ministry of Education, Culture, Sports, Science and Technology.

10. REFERENCES

[1] J. Weizenbaum, Eliza – a computer program for the study of natural language communication between man and machine, *Communications of the ACM*, (9), (1966).
[2] W. Chamberlain, *The Policeman's Beard is Half Constructed*, Warner Books, (1984).
[3] G. Guzeldere and S. Franchi, Dialogues with colorful personalities of early AI, *Stanford Humanities Review*, (4) 2 (1995).
[4] D. Vrajitoru, J. Ratkiewicz, Evolutionary sentence combination for chatterbots, *International Conference on Artificial Intelligence and Applications (AIA 2004)*, ACTA Press, pp. 287-292, (2004).
[5] J. Kleinberg, Bursty and hierarchical structure in streams, *Data Mining and Knowledge Discovery*, vol. 7, 2003, pp. 373-397.
[6] T. Fujiki, T. Nanno, Y. Suzuki, and M. Okumura, Identification of bursts in a document stream, *In First International Workshop on Knowledge Discovery in Data Streams*, 2004, pp. 55-64.
[7] M. Ueno, N. Mori, K. Matsumoto, Novel chatterbot system utilizing web information for estimating current user interests, *Proceedings of the 6th IEEE International Conference on IDAACS*, Vol. 2, 2011, pp. 656-659.
[8] 2 channel, http://www.2ch.net/
[9] Sen, https://sen.dev.java.net/
[10] Wikipedia, http://wikipedia.org/
[11] M. Ueno, N. Mori, K. Matsumoto, Picture information shared conversation agent: pictgent, distributed computing and artificial intelligence advances in intelligent and soft computing, *Springer*, Vol. 151, 2012, pp. 91-94.

Miki Ueno, *received her master degree of engineering from Osaka Prefecture University in 2012. She has been a student of Graduate School of Computer Science and Intelligent Systems, Osaka Prefecture University. Her research interests include dialogue system and affective engineering.*

Naoki Mori, *completed the M.E. and doctoral programs at Kyoto University in 1994 and 1997, and joined the faculty of Osaka Prefecture University as a research associate.*
He is now an associate professor in the Department of Computer Science and Intelligent Systems at Osaka Prefecture University. His research interests are genetic algorithms, artificial market and dialogue system. He received an ISCIE Paper Award in 1999. He holds a D.Eng. degree

Keinosuke Matsumoto, *is a professor in the Department of Computer Science and Intelligent Systems at Osaka Prefecture University. He received his B.S. and M.S. degrees in mechanics from Kyoto University in 1976 and 1978 respectively. He worked for Mitsubishi Electric Corporation as a researcher from 1978 to 1996. He received his Ph.D. in electrical engineering from Kyoto University for his work on a knowledge-based approach to power system restoration. His research interests include software engineering, object-oriented technologies, and intelligent systems.*

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

FUSION OF RECIRCULATION NEURAL NETWORKS FOR REAL-TIME NETWORK INTRUSION DETECTION AND RECOGNITION

Pavel Kachurka, Vladimir Golovko

Brest State Technical University
Moskovskaya str. 267, 224017, Brest, Republic of Belarus
e-mail: paulermo@gmail.com, gva@bstu.by
http://www.bstu.by

Abstract: *Intrusion detection system is one of the essential security tools of modern information systems. Continuous development of new types of attacks requires the development of intelligent approaches for intrusion detection capable to detect newest attacks. We present recirculation neural network based approach which lets to detect previously unseen attack types in real-time mode and to further correct recognition of this types. In this paper we use recirculation neural networks as an anomaly detector as well as a misuse detector, ensemble of anomaly and misuse detectors, fusion of several detectors for correct detection and recognition of attack types. The experiments held on both KDD'99 data and real network traffic data show promising results.*

Keywords: *Intrusion detection, classification, artificial neural networks.*

1. INTRODUCTION

An increasing role of network information technologies in human activities leads to a rising level of attention to such technologies from evildoers. The average level of expenses of legitimate users in case of successful attack increases too. Every second organization has been attacked during 2009-2010 years and 45% of them were victims of targeted attacks [1]. The global damage from computer attacks in 2011 is expected to be higher than $250 billion [2].

In popular proprietary or open source intrusion detection systems (IDS) mostly signature search and rule-based analysis [3–6] is used. Its shortcoming is the insufficient flexibility at detection of the modified and unknown attacks. A large number of methods for analyzing network activity by means of various technologies of data mining exist. Researchers widely use decision trees [7], Bayesian networks [8], hidden Markov models [9], fuzzy logic [10], artificial immune systems [11], support vector machines [12] and other techniques.

One of the technologies with promising results bases on the use of artificial neural networks (ANNs). ANNs have been declared alternatively to components of the statistical analysis of systems of anomaly detection. Neural networks have been specially suggested to identify typical characteristics of users of system and statistically significant deviations from the established operating mode of the user. Many different ANN architectures can be used to detect and classify the intrusions. Comparative studies [13–14] researchers conclude that every architecture has its own advantages and disadvantages but Adaptive Resonance Theory (ART) networks and Multi-layer Perceptrons (MLP) show better results most often. Recent researches try to utilize classic NN architectures [15] or PCA neural networks [16–17], to create hierarchical ANN-based IDS [18–22], to combine different ANNs with other approaches [23–24], incl. flow traffic analysis [25].

Different approaches are compared using wide known KDD'99 database [26] from processed DARPA 1998 Intrusion detection evaluation database. It contains more than 4 million records describing TCP-connections. The given data base includes normal connections and the attacks of 22 types belonging to four classes: DOS – «denial-of-service» – refusal in service, for example, a Syn-flood; U2R – not authorized access with root privileges on the given system, for example, various attacks of buffer overflow; R2L – not authorized access from the remote system, for example, password selection; Probe – analysis of the topology of a network, services accessible to attack, carrying out search of vulnerabilities on network hosts.

Table 1 shows that mentioned techniques show good results as in detection of known attacks. But during the detection of new attacks the FNR and FPR can raise up to 30-50% [24]. The quality of attack class recognition is shown in Table 2. You can see that ANN-based approaches operate better than others.

Table 1. Best Results In Attack Detection

Approach	FNR, %	FPR, %
Flexible Neural Tree [17]	1,2	0,3
MLP [22]	5,8	0,8
Clasterisation[12]	7	10
K-NN [12]	9	8
SVM [12]	2	10

Table 2. Best Results In Attack Recognition

Approach	dos, %	probe, %	r2l, %	u2r, %
Gaussian classifier	82,4	90,2	9,6	22,8
K-NN	97,3	87,6	6,4	29,8
Decision Trees [18]	99,8	50,0	33,3	50,0
Bayesian Networks [18]	99,7	52,6	46,2	25,0
Flexible Neural Tree [17]	98,8	99,3	98,8	99,9
Fuzzy NN [19]	100,0	100,0	99,8	40,0
MLP [18]	99,9	48,1	93,2	83,3
RBF [20]	98,8	98,0	97,2	–
Hierarchy of PCA Networks [21]	100,0	100,0	97,2	–
PCA Networks & SOM [21]	99,0	75,2	77,0	–
Hierarchy of SOM [20]	96,9	81,3	0,0	1,1

Most of IDS techniques use only anomaly detection or only misuse detection. The combination of this approaches can show better results than the systems using them separately. The goal of this study is to build IDS capable to 1) detect and recognize known attacks with the accuracy comparable to the best shown above; 2) detect previously unseen attacks with low false positive and negative rates; 3) combine anomaly and misuse detection in one technique.

In this paper the neural network based approach to anomaly and misuse detection on the basis of the analysis of the network traffic is described. The algorithm of IDS functioning is discussed and the building of working prototype is described.

The paper is organized as follows. The anomaly detectors based on recircular neural networks (RNNs) are described in the section 2. The misuse detectors are described in the Section 3. The joint functioning of anomaly and misuse detectors in one ensemble is discussed in the Section 4. Section 5 presents the fusion classifier bsed on previously discussed detectors. Test results of presented approaches on KDD'99 dataset are presented in Section 6. The structure of IDS prototype and its testing on real data are presented in Section 7. The conclusion is made in Section 8.

2. RNN-BASED ANOMALY DETECTORS

There are two technologies in intrusion detection: anomaly detection and misuse detection. Their basic difference consists that at use of the first the normal behavior of the subject is known and deviations from this behavior are searched while at use of the second attacks which are searched and distinguished among normal behavior. Both techniques eliminate each other's defects, owing to what the best results of detection can be reached only applying them simultaneously, within the limits of different IDS subsystems or with use of the combined detection methods.

It is proved [27], what the best results at classification (even a question – «attack or not?» is definition of an accessory to a class of attacks or a class of normal connections; not speaking already about definition of a class of attack) give classifiers independent from each other. There are much more abilities for construction of a cumulative estimation of the general classifier at use of independent detectors of the identical nature.

Recirculation neural networks (see Figure 1) differ from others ANNs that on the input information in the same kind is reconstructed on an output. They are applied to compression and restoration of the information (direct and return distribution of the information in the networks «with a narrow throat»), for definition of outliers on a background of the general file of entrance data.

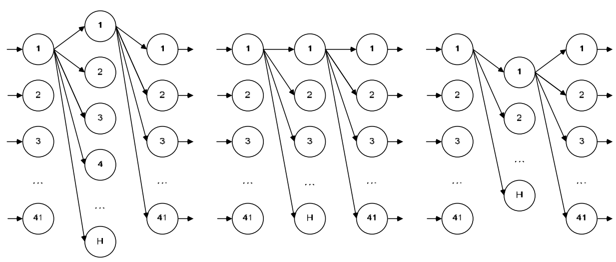


Fig. 1 – 3-layered RNN Architecture

Nonlinear RNNs have shown good results as the detector of anomalies: training RNN is made on normal connections so that input vectors on an output were reconstructed in themselves, thus the connection is more similar on normal, the less reconstruction error is:

$$E^k = \sum_j (\bar{X}_j^k - X_j^k)^2, \tag{1}$$

where X_j^k – j-th element of k-th input vector, $\overline{X}_j^k$ – j-th element k-th output vector. Whether $E^k > T$, where T – certain threshold for given RNN connection admits anomaly, or attack, differently – normal connection (see Figure 2). Thus there is a problem of a threshold T value determination, providing the most qualitative detection of abnormal connections. It is possible to get threshold value minimizing the sum of false positive (FP) and false negative (FN) errors, basing on cost characteristics of the given errors – FN error seems to be more expensive, than FP error, and its cost should be higher.

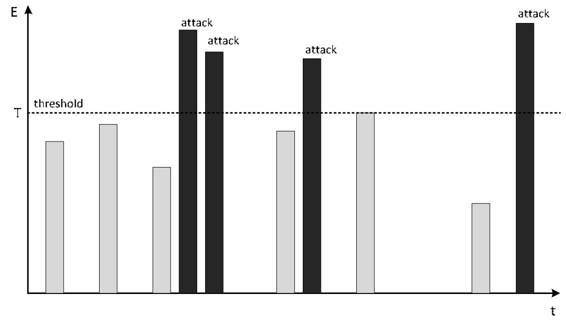


Fig. 2 – RNN-based anomaly detection

3. RNN-BASED MISUSE DETECTORS

The described technique of definition of an input vector accessory to one of two classes – "normal" or "attacks", that is "not-normal" – it is possible to use in opposite way. If at training the detector of anomalies we used normal vectors which were restored in itself, and the conclusion about their accessory to a class "normal" was made, training the detector on vectors-attacks which should be restored in itself, it is possible to do a conclusion about their accessory to a class of "attack". Thus, if during functioning of this detector the reconstruction error (1) exceeds the certain threshold, given connection it is possible to carry to a class "not-attacks", that is normal connections. As training is conducted on vectors-attacks the given approach realizes technology of misuse detection, and its use together with previous technique is righteous.

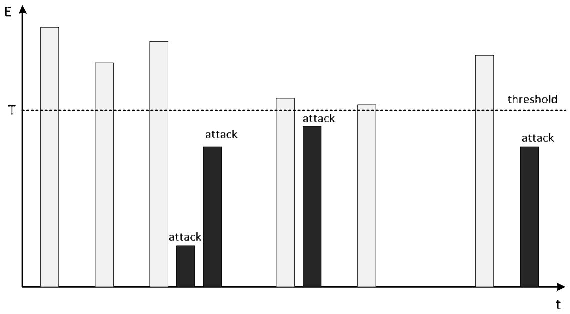


Fig. 3 – RNN-based misuse detection

Thus, one RNN can be applied to definition of an accessory of input vector to one of two classes – to on what it was trained or to the second class, to which outliers correspond.

4. ENSEMBLE OF RNN-BASED ANOMALY AND MISUSE DETECTORS

As it was mentioned above anomaly detectors can function with high False Positive Rate while the misuse detectors can skip targets not belonging to training database. The use of two approaches within one system helps to avoid the disadvantages of each technology without losing their dignity. This will reduce I-type and II-type errors increasing accuracy of prediction.

If anomaly and misuse detectors base on different approaches then the problem of the complexity of final decision exists. The biggest problem in such approach is to make decision when the attack was detected only by one detector.

Ensemble made of two RNN-based detectors – anomaly detector and misuse detector described above – lets to analyze not only binary vectors of their decisions but to construct the decision basing on their output data. In the terms of RNN-based detectors it means that we can compare reconstruction errors of anomaly and misuse detectors (see Figure 4):

$$\begin{cases} X \in A_N, & если \quad E_A \le E_3, \\ X \in A_P, & если \quad E_A > E_3, \end{cases} \tag{2}$$

where E_A – reconstruction error on the anomaly detector, E_3 – reconstruction error on the misuse detector, A_N – normal connections (negative), A_P – attacks (positive).

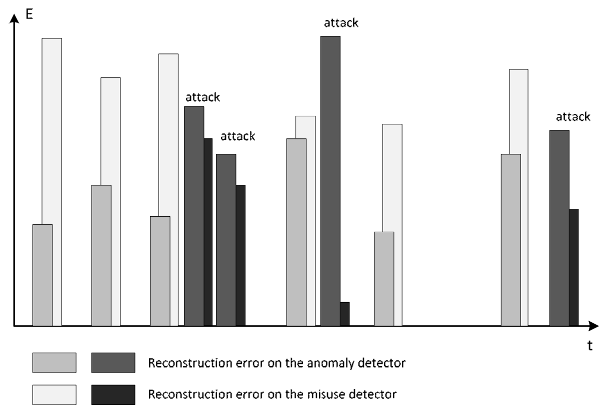


Fig. 4 – RNN ensemble-based intrusion detection

This approach requires equal quantity of synaptic connections in the detectors and equal MSE achieved during the training phase. Opposite reconstruction errors can become incomparable that leads to decision making basing on the private decisions of every detector.

5. FUSION OF RNN-BASED CLASSIFIERS

As it was told above the best classification results can be achieved using several independent classifiers of the identical nature because construction of the general estimation from private can be made by greater number of methods. We shall unite the private detectors trained in the previous section in one general.

The main idea of this approach is that every new detector can be trained using the data samples not recognized by the operating detectors. In such a way general classifier can grow from one normal detector to many parallel neural detectors (see Figure 5).

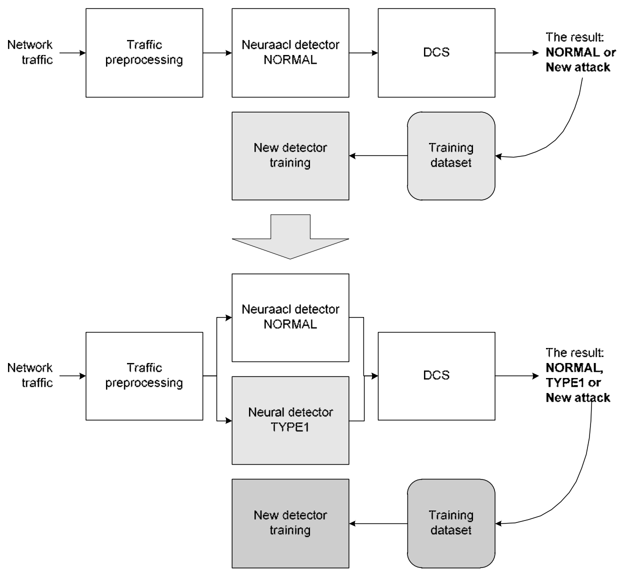


Fig. 5 – General Classifier Generation

The general classifier consists from N private detectors, each of which has a threshold T. To make estimation values comparable it is enough to scale reconstruction error on a threshold to get the relative reconstruction error:

$$\delta_i^k = \frac{E_i^k}{T_i}. \quad (3)$$

Thus, than less δ_i^k is, the probability of accessory of an input image X^k to a class A_i is higher.

6. RNN-BASED APPROACH TESTING ON KDD'99 DATASET

KDD'99 dataset [26] contains almost 5 million connection records and only 20% of them represent normal network traffic. As for the main test dataset ("ALL") we shall use 10%-sample of KDD database. It contains 494020 connections including attacks of 22 types.

For validation of the possibility to detect unknown attacks we shall add test dataset "ALL-NEW" made of records from the KDD'99 testing data set. It includes 32 types of attacks and normal connections which are absent in the KDD'99 training dataset.

RNNs will be trained using layered training method using training data sets described in Table 3.

Table 3. Datasets description

Dataset	*P* No. of attacks	*N* No. of normal	No. of connection types: *K* Total	No. of connection types: No. of attack types
Testing data sets				
ALL	396743	97277	23	22
ALL-NEW	250436	60592	33	32
Training data sets				
Normal connections	*0*	500	1	0
Attacks	4400	0	22	22

To train anomaly detectors on the normal traffic 500 random normal connections are selected as well as to train misuse detectors – 200 random connections for each attack type are selected.

The training and testing phases where made on several 3-layer and 5-layer RNNs with different count of neurons in hidden layer. Test results show that the architecture of the neural networks does not affect the accuracy of prediction almost. In the Table 4 the test results of the 3-layer RNNs with 41 input and output neurons and 25 neurons in hidden layer are shown.

Table 4. Attack detection results on the KDD dataset

	FPR, %	FNR, %	ACC, %
ALL data set			
Anomaly	10,88	0,10	**97,78**
Misuse	0,10	2,73	**97,79**
Ensemble	0,03	1,83	**98,52**
ALL-NEW data set			
Anomaly	7,43	19,56	**82,80**
Misuse	0,17	19,56	**84,22**
Ensemble	0,00	12,33	**90,07**

As it can be seen from the Table 4, (1) the RNN ensemble-based approach detects attacks on benchmark KDD dataset with high accuracy; (2) ensemble performs better than every detector separately; (3) ensemble can detect unknown attacks.

Let's test the ability of the fusion of RNN-based classifiers to correctly detect and recognize attacks. The results are shown in the Table 5.

The results show that 97% of attack can be correctly recognized by the fusion of RNN detectors. The accuracy of prediction of such an approach is high enough.

Table 5. Results of attack detection and recognition by RNN-fusion on the KDD dataset

FPR, %	FNR, %	ACC, %	CR, %
12,50	0,01	97,53	97,41
dos, %	**probe, %**	**r2l, %**	**u2r, %**
99,87	96,76	99,73	98,08

7. RNN-BASED IDS TESTING ON THE REAL NETWORK DATA

Our IDS prototype is implemented for the operating system GNU/Linux using open source software BroIDS, mawk, bash, tee, gcc. For the training and testing purposes we have conducted the attacks of the following types: (1) *tcpscan* – the attack of Probe class, scans the open ports of the victim using TCP-connections; (2) *synflood* – DoS-attack, tries to flood the victim with the SYN packets of TCP connections; (3) *udpflood* – DoS-attack, floods the victim with UDP packets. The training datasets contain 500 collected connections for each class.

Data Preprocessing. IDS receives a records of all network connections formed with the help of Bro IDS from host's traffic. Bro is an open source intrusion detection system which performs a modified script for obtaining records of the connections which include the following fields: timestamp, duration of connection in seconds; source's and destination's IP-address; name of the service used; port numbers; the number of bytes transferred; the result flag of the connection.

Bro consistently generates connection strings which are piped to the pre-processing module (see Figure 6). Further, the obtained connection lines are handled consistently by several scripts in awk, which form the records similar to KDD database [26] records, encode categorical parameters and normalize input data. The resulting row of numbers is used as the input vector to RNN-based detectors.

```
61.674526 192.168.2.20 74.125.10.225 http 51450
80 tcp 989 20105 SF X ShADadfFR
↓
61 tcp http 989 20105 SF 0 0 0 1 0 0 0 1 1 1
↓
61 1 20 989 20105 1 0 0 0 1 0 0 0 1 1 1
↓
0.85635375 0.50000109 0.78600832 0.95235664
0.98665665 0.50000109 0.0066928509 0.0066928509
0.0066928509 0.50000109 0.0066928509
0.0066928509 0.0066928509 0.50000109 0.50000109
0.50000109
```

Fig. 6 – Data Preprocessing

Neural Detectors' Training. Each particular detector is a nonlinear recirculation neural network with one hidden layer. Learning algorithm and the functioning of RNN is implemented in C and as a result IDS has speed adequate to assess the functioning of the prototype system in real time.

RNNs are trained using the method of layer-learning. Then the initial threshold value for a particular detector is set equal to the value at which 5% of the images of the training sample gives a reconstruction error above the threshold. After this threshold adjustment neural detector is able to determine the membership of its class with up to 95% in real time mode.

Time and quality of training depends on the number of images in the training set. Table 6 shows the results of thresholds setting for the detectors of the three classes when applied to the input detector images of the training sample.

Table 6. Threshold Adjustment Results

Class A_i name	DR_i, %	Threshold T_i
Normal	94,6	0.819415
tcpscan	94,8	0.835775
synflood	94,8	0.785963

Private Detectors Functioning and Generation. Trained and configured neural detectors calculate the relative reconstruction error and conclude probability of belonging of the input image to the class.

The result of the private detector is a string containing a timestamp to identify a specific connection; the name of the class, which is responsible for this detector; the absolute error of reconstruction of input images; the relative error of reconstruction of the input image, which will be used to decide to witch class image belongs. If the relative error of reconstruction is greater than 1, then the image is saved for possible future participation in new detector training.

Table 7 shows the results of the analysis of three classes by private detectors. Every connection was fed to the detectors of two classes to which this connection does not belong. The successful decision in this case is result more than 1 on every detector. It shows that this algorithm can be successfully used for anomaly and unknown attack detection.

Table 7. Anomaly Detection Quality

Real / Predicted	normal	tcpscan	synflood
normal		100,00%	31,00%
tcpscan	98,20%		84,00%
synflood	99,40%	94,40%	

At the beginning of its operation IDS has only one source of data: normal network traffic. Neural detector trained on this traffic begins to detect anomalies in network connections. For example, all tcpscan connections were correctly identified as an anomaly (see Table 8), and saved for new detector training like a training sample.

As seen from Table 5 quality of detection of synflood images as anomalies at the normal-detector is quite low – only 31%. But in the opposite synflood- detector detects anomalies in normal connections with an accuracy of 99.4%. By combining these detectors into a single system in accordance with Section 3, we can obtain a significant increase in quality of recognition.

Nevertheless, we can conclude that the quality of anomaly detection and therefore – detection of unknown attacks by private normal-detector is high enough.

In case none of detectors operating in the IDS predicted input image as belonging to its class IDS accumulates image for a training of new detector.

Attack Recognition. This module accumulates the results of analysis of input image by all currently functioning private detectors. It is worth noting that the detectors operate in parallel mode. If all the relative errors are greater than 1 it is concluded that the connection may not belong to either of these classes. Mode of recognition of a new class can be turned off and then even among relative errors greater than 1 the smallest one will be chosen.

Table 8 and 9 show the quality of attack detection and recognition on the training datasets and in the real-time testing.

Table 8. Attack Detection and Recognition on the Training Datasets

	W/out new class gen.			With new class gen.		
	FN_K,%	FN_U,%	FP,%	FN_K,%	FN_U,%	FP,%
normal tcpscan	0,40	87,60	1,60	0,00	63,00	2,40
normal synflood	0,00	90,80	0,60	0,00	0,00	40,20
normal synflood tcpscan	0,04		1,80	**0,00**		**8,60**

Table 9 Attack Detection and Recognition in Real-Time Mode

	W/out new class gen.			With new class gen.		
	FN_K,%	FN_U,%	FP,%	FN_K,%	FN_U,%	FP,%
normal					7,68	1,22
normal tcpscan	0,20	100,0	0,98	0,28	10,70	1,22
normal synflood	14,72	33,32	0,73	4,72	0,10	7,82
normal synflood tcpscan	1,09	48,44	1,22	**1,09**	**0,01**	**8,81**

8. CONCLUSION

The results of experiments presented in Section 6 and Section 7 let us to make the following conclusions.

RNN-based anomaly and misuse detectors separately perform with good accuracy but the best accuracy can be achieved when used both of them. The use of RNN-based ensemble of anomaly and misuse detector allows to detect known attacks with superior accuracy 98% and to detect previously unseen attaks with good accuracy 90%.

The fusion of RNN-based classifiers is the evolution of the ensemble. Fusion classifier allows not only to detect but also to recognize the attack. Like an ensemble it can detect and recognize network intrusions previously seen in the training dataset (see Figure 7) and totally unknown and the quality of recognition is high enough. Unlike an ensemble where the decision is made by the absolute reconstruction error in the fusion classifier decision is made by the relative reconstruction error. It allows to tune classifier’s accuracy using methods of threshold selection.

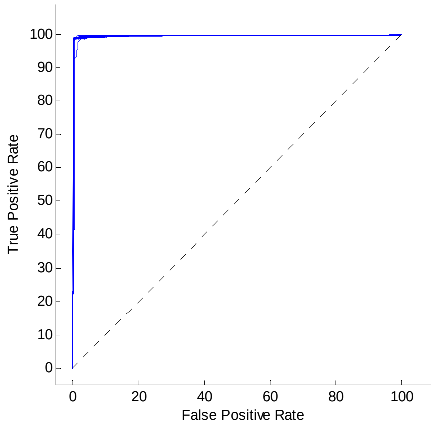


Fig. 7 – ROC of Known Attack Detection Using RNN-based Ensemble

Tests on the real network data prove that this technique can be used for building real-time intrusion detection systems. The main promising result of presented technique is that both anomaly and misuse detection simultaneously can successfully detect known and previously unseen network intrusions.

9. REFERENCES

[1] CSI Computer Crime and Security Survey 2010 [Electronic resource] Mode of access: http://gocsi.com/survey. – Date of access: 11.01.2011.

[2] Proposal for a Regulation of the European Parliament and Council concerning the European Network and Information Security Agency (ENISA) [Electronic resource] Mode of access: http://ec.europa.eu/governance/impact/ia_carried_out/docs/ia_2010/sec_2010_1126_en.pdf. – Date of access: 11.01.2011.

[3] J. Beale and Caswell. *Snort 2.1. Intrusion Detection*. – 2-nd ed. – Syngress Publishing, Inc. 2004.

[4] Prelude SIEM. [Electronic resource] Mode of

access: http://www.prelude-technologies.com/en/welcome/index.html. – Date of access: 12.01.2011.

[5] Cisco Intrusion Detection [Electronic resource] Mode of access: http://www.cisco.com/warp/public/cc/pd/sqsw/sqidsz/index.shtml. Date of access: 12.01.2011.

[6] Bro Intrusion Detection System [Electronic resource] Mode of access: http://www.bro-ids.org/. Date of access: 12.01.2011.

[7] J. Frank, Artificial intelligence and intrusion detection: Current and future directions, The 17th National Computer Security Conference, Baltimore, MD, 1999 / National Institute of Standards and Technology (NIST). – 1999.

[8] C. Srilatha, A. Ajith, Th. Johnson, Feature deduction and ensemble design of intrusion detection systems, *Computers & Security*, (24) (2005), pp. 295-307.

[9] T.D. Lane, *Machine Learning Techniques for the Computer Security Domain of Anomaly Detection,* Ph. D. Thesis, Purdue Univ., West Lafayette, IN, 2000.

[10] J.E. Dickerson, J.A. Dickerson, Fuzzy intrusion detection, *IFSA World Congress and 20th North American Fuzzy Information Processing Society (NAFIPS) International Conf.: proceedings*, Vancouver, Canada, July, 2001. – North American Fuzzy Information Processing Society (NAFIPS), (Vol. 3), (2001), pp. 1506-1510.

[11] S.A. Hofmeyr, S. Fo, Immunizing computer networks: Getting all the machines in your network to fight the hacker disease, The 1999 IEEE Symp. on Security and Privacy: proceedings, Oakland, CA, 1999. – IEEE Computer Society Press, 1999.

[12] E. Eskin, A geometric framework for unsupervised anomaly detection: Detecting intrusions in unlabeled data, *Data Mining for Security Applications*; Eds.: D. Barbar, S. Jajodia, Boston, Kluwer Academic Publishers, 2002.

[13] A. Iftikhar, A. Azween, A. Alghamdi, Towards the selection of best neural network system for intrusion detection, *International Journal of the Physical Sciences*, (5) 12 (2010), pp. 1830-1839.

[14] A. Ali, A. Saleh, T. Badawy, Intelligent adaptive intrusion detection systems using neural networks (comparative study), *International Journal of Video & Image Processing and Network Security*, (10) 1 (2010).

[15] M. Pradhan, S.K. Pradhan, S.K. Sahu, Anomaly detection using artificial neural network, *International Journal of Engineering Sciences & Emerging Technologies,* (2) 1 (2012), pp. 29-36.

[16] Kh. Al-Nafjan, M.A. Al-Hussein, A.S. Alghamdi, M. Amanul Haque, and I. Ahmad, Intrusion detection using PCA based modular neural network, *International Journal of Machine Learning and Computing*, (2) 5 (2012), pp. 583-587.

[17] A. Jahanbani, H. Karimi, A new Approach for detecting intrusions based on the PCA neural networks, *Journal of Basic and Applied Scientific Research*, (2) 1 (2012), pp. 672-679.

[18] G. Liu, Z. Yi, S. Yang, A hierarchical intrusion detection model based on the PCA neural networks, *Neurocomputing*, 2007.

[19] L.O. Anyanwu, L. Keengwe, G.A. Arome, Scalable intrusion detection with recurrent neural networks, *International Journal of Multimedia and Ubiquitos Engineering*, (6) 1 (2011).

[20] H.G. Kayacik, A.N. Zincir-Heywood, M. Heywood, A hierarchical SOM-based intrusion detection system, *Engineering Applications of Artificial Intelligence*, 9 (2006), pp. 439-451.

[23] G. Liu, Z. Yi, S. Yang, A hierarchical intrusion detection model based on the PCA neural networks, *Neurocomputing*, 2007, pp. 1561-1568.

[24] T. Novosad, J. Platos, V. Snasel, A. Ajith, Fast intrusion detection system based on flexible neural tree, *proceedings of Sixth International Conference on Information Assurance and Security (IAS)*, USA, 2010, pp. 142-147.

[25] G. Wang, J. Hao, J. Ma, L. Huang, A new approach to intrusion detection using Artificial Neural Networks and fuzzy clastering, *Expert Systems with Applications*, (2) (2010).

[26] M.J. Muna, M. Mehrotra, Design network intrusion detection system usin hybrid fuzzy-neural network, *International Journal of Computer Science and Security*, (4) 3 (2010), pp. 258-294.

[27] A. Yousef, Z. Jovanovic, Flow-based anomaly intrusion detection system using neural network, *Proceedings of International Conference on Internet Computing, Informatics in E-Business and applied Computing (ICIEACS 2012)*, Bur Dubai, UAE, 2012.

[28] KDD Cup'99 Competition, 1999, http://kdd.ics.uci.edu/databases/kddcup99/kddcup99.html

[29] G. Giacinto, F. Roli, L. Didaci, Fusion of multiple classifiers for intrusion detection in computer networks, *Pattern Recognition Letters*, 24, 2003, pp. 1795-180.

[30] S. Saravanakumar, Umamahchwari, D. Jayalakshmi, R. Sugumar, Development and

implementation of artificial neural networks for intrusion detection in computer network, *International Journal of Computer Science and Network Security*, (10) 7 (2010).

[31] P. Kachurka, V. Golovko, Neural network approach to real-time network intrusion detection and recognition, *Proceedings of The 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, (15-17 September 2011), Prague, 2011, pp. 393-397.

***Pavel Kachurka** was born in Belarus in 1982. He received PhD degree in 2012 from the Belarusian State University of Informatics and Radio-electronics. At present he works as an assistant professor at the Department of Intelligent Informational Technologies, Brest State Technical University (Belarus). His research interests include computer network security, data-mining, artificial intelligence and neural networks, networking and operating systems.*

***Prof. Vladimir Golovko** was born in Belarus in 1960. He received M.E. degree in Computer Engineering in 1984 from the Moscow Bauman State Technical University. In 1990 he received PhD degree from the Belarus State Technical University and in 2003 he received doctor science degree in Computer Science from the United Institute of Informatics problems national Academy of Sciences (Belarus). At present he work as a head of Intelligence Information Technologies Department and Laboratory of Artificial Neural Networks of the Brest State Technical University. His research interests include Artificial Intelligence, neural networks, autonomous learning robot, signal processing, chaotic processes, intrusion and epilepsy detection. He has published more than 200 scientific papers, including books and chapters of books.*

computing@computingonline.net
www.computingonline.net

ISSN 1727-6209
International Journal of Computing

MODIFIED PROBABILISTIC NEURO-FUZZY NETWORK FOR TEXT DOCUMENTS PROCESSING

Yevgeniy Bodyanskiy, Irina Pliss, Valentyna Volkova

Dept. of Artificial Intelligence, Kharkiv National University of Radio Electronics
Lenina av. 14, 255, Kharkiv, Ukraine, 61166
e-mail: bodya@kture.kharkov.ua, pliss@kture.kharkov.ua, volkova@kture.kharkov.ua
www.kture.kharkov.ua

Abstract: *We consider the problem of text processing (classification problem) using the modification of the probabilistic neural network proposed by D. Specht. Since classes often overlap during texts processing, there were introduced the modification that implements a procedure of fuzzy inference. For this into the network were introduced two additional layers. The results of the outputs of the network are levels of belonging each text document to each of the possible classes.*

Keywords: *Text document processing, probabilistic neuro-fuzzy network, multilayer architecture.*

1. INTRODUCTION

Data classification is key problem of data mining, and solving this problem is important for effective knowledge accumulation on the basis of observational analysis. One of the popular techniques of data classification is the probabilistic neural network (PNN) proposed by D.F. Specht [1,2]. This network is effectively applied to various problems of classification, diagnosis, pattern recognition etc. [3-5]. However, the conventional PNN solves the classification problem according to the traditional “crisp” approach when every observation is assigned to only one class. But in practice the problems with overlapping classes are common, when the classified observations can belong to several classes simultaneously with certain degrees of membership. To solve such problems the methods based on the fuzzy approach to clustering, classification and pattern recognition are used [6,7].

The fuzzy situations often arise in text document processing task. Such a process is called semantic metadata processing [9] and consists of three main components: ontology, text corpus, and the method of constructing a classifier for text mining.

There is a set of standard solutions that are proposed to describe the metadata and to generate semantic annotations, such as the standard Dublin Core [10]. However, given a sets of tags for describing text documents do not reflect the information that may be relevant to the current ontology and often contain only general information. It should be noted that the creation of semantic annotations manually is quite time consuming and requires large costs. This has led to the development of methods for semi-automatic text processing, which in turn has several disadvantages, such as using templates or a priori defined rules. Therefore, the actual task is to develop models and methods for on-line semantic annotation of text documents.

2. PROBLEM STATEMENT

The process of text processing can be regarded as a classification problem, and the automation can be achieved by applying different data mining technique. The main challenge in this case is to build a classifier based on an ontology O and the reference data sample X for the text object projection on the domain ontology. In this case “projection” should understand as the assignment of a text object to the ontological class as an instance of this concept.

It should be observed that artificial neural networks (ANN) have good reputation in the present modern developments using intelligent technologies, so it seems appropriate to use the neural network approach for semantic annotation of text documents [11-14]. In addition, the using of ANN makes it possible to build a classifier, regardless of the semantic annotation level (the level of words, sentences, paragraphs, documents) for the formation of the text documents’ metadata. In this case, it is allowed to use different ways of presenting the original text data in vector space of attributes that are not reflected in the quality of data processing.

The formal representation of semantic annotation of text documents can be obtained from the standpoint of the classification problem as follows. For the given domain ontology O the set of the concepts (classes) are defined as $C = (c(1), c(2), ..., c(N_1))$, where $c(i)$ – i-th concept from O. The set of text objects for the concerned text corpus are represented as $X = (x(1), x(2), ..., x(j), ..., x(N_2))$, where $x(j)$ – j-th text object presented in the vector form as a set of relevant features, N_1 and N_2 – number of ontological concepts (classes) and the power of the original text objects sample respectively.

Then the semantic annotation – labeling or the set of metadata for considered text document – on the basis of the given ontology will be defined as $L = \{l_i \mid \exists c_j \in C \wedge l_i = c_j\}$ where L – the unique set for each text document, consisting of concepts (classes) of the domain ontology, obtained by projections of textual objects belonging to each document to a given ontology using techniques based on ANN. It should be pointed out that under this approach does not exclude membership of one text object $x(k)$ to several classes (fuzzy situation), namely, the output of the classifier is determined by the membership to each given class of ontology O for input pattern. It is possible to include an object to a number of potentially possible concepts of the ontology by setting a threshold that is determined based on the membership difference. The received labeling can then be presented in tabular form for the formation of RDF-descriptions and its further using by various software tools.

3. MODIFIED PROBABILISTIC NEURO-FUZZY NETWORK

In the general case the probabilistic neural networks which solve the problem of Bayesian classification [15] via the recovery of unknown probability distributions by means of the Parzen kernels [15,16], belong to the feed forward architectures and are closely related to the radial-basis function networks [17] and generalized regression neural networks [18].

The modified probabilistic neuro-fuzzy network (MPNFN) has three-layer structure shown in Fig. 1 and is the modification of neuro-fuzzy systems introduced in [19,20].

The source information for the synthesis of network is the training set of patterns formed as a "packet" of n-dimensional vectors $x(1), ..., x(i), ..., x(N), x(N+1), ..., x(N+M)$, $x(j) = (x_1(j), ..., x_i(j), ..., x_n(j))^T$. The order of patterns in the packet is not significant. It is assumed that the crisp classification (the membership to one of m clusters) is known for each of the training patterns $x(j)$, and the representatives of all the possible clusters must be present in the dataset. That is, if N_l observations from the training set belong to the l-th class, then

$$\sum_{l=1}^{m} N_l = N. \qquad (1)$$

The input layer (number 0) receives an n-dimensional vector patterns $x(k), k > N+M$ that are transferred to the hidden layers for further processing.

The first hidden layer (the prototype layer) contains N neurons with the bell-shaped (usually Gaussian) activation functions and their synaptic weights are determined by the components of the training patterns, i.e.

$$w_{ji} = x_i(j), \qquad (2)$$

$i = 1, 2, ..., n,\ j = 1, 2, ..., N,$ or in a vector form

$$w_j = x(j) = (x_1(j), ..., x_i(j), ..., x_n(j))^T.$$

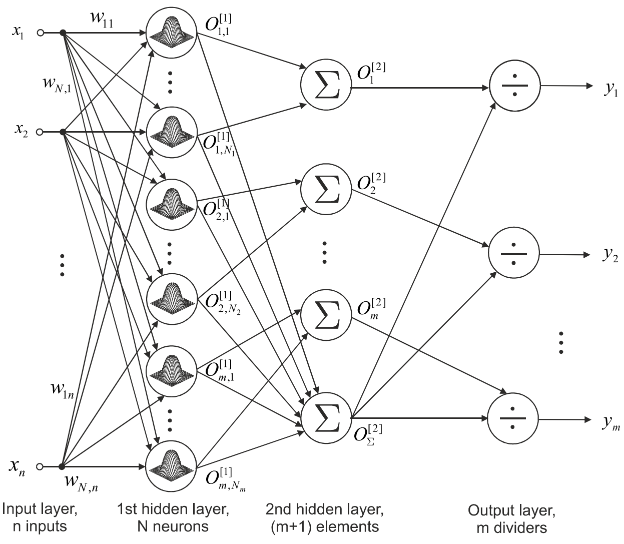


Fig. 1 – Modified probabilistic neuro-fuzzy network

For the convenience of notation, all the neurons in the prototype layer are divided into m groups with N_l nodes in each, corresponding to its class.

The vector of weights of the p-th neuron in the l-th group will be denoted as $w_{l,p} = w_{l+p-1}$, $l = 1,2,...,m,\ p = 1,2,...,N_l$.

It is obvious that the training of the synaptic weights in this case is reduced to their one-time setting that is very simple.

When the vector $x(k)$ is fed to the 0-th layer the neurons of the 1-st layer produce the signals

$$o_{l,p}^{[1]}(k) = \Phi_{l,p}(x(k), \sigma_l) = \\ = \exp\left(-\frac{\left\|x(k) - w_{l,p}\right\|^2}{2\sigma_l^2}\right), \quad (4)$$

$l = 1,...,m;\ p = 1,...,N_l;\ k > N + M$, (where σ_l^2 is the width parameter of the activation function).

If all the input vectors are pre-normalized so that $\|x\| = 1$, the expression (4) assumes the following simple form

$$o_{l,p}^{[1]}(k) = \exp\left(-\frac{1 - x^T(k)w_{l,p}}{\sigma_l^2}\right). \quad (5)$$

It is also obvious that $\left\|w_{l,p}\right\| = 1$.

Since it holds

$$-1 \le x^T(k)w_{l,p} \le 1, \quad (6)$$

the outputs of the neurons of the first layer can vary only within the interval

$$\exp(-2\sigma_l^{-2}) \le o_{l,p}^{[1]} \le 1 \quad (7)$$

as is shown in Fig. 2.

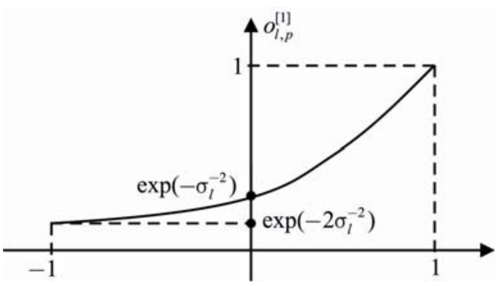


Fig. 2 – Activation function of neurons in the first layer

At the level of the first layer it is also possible to determine the diameters of the classes formed by the training data as

$$\begin{cases} D_l^2 = \max\limits_{p,q=1,...,N_l} \left\|w_{l,p} - w_{l,q}\right\|^2 = \\ = \max\limits_{p,q=1,...,N_l} 2(1 - w_{l,p}^T w_{l,q}), \\ 0 \le D_l = \sqrt{\max 2(1 - w_{l,p}^T w_{l,q})} \le 2, \end{cases} \quad (8)$$

and to roughly estimate how much the overlap.

The second hidden layer is formed by $m+1$ elementary summing units with first m of them receiving the outputs of the prototype layer so that

$$o_l^{[2]}(k) = \sum_{p=1}^{N_l} o_{l,p}^{[1]}(k), \quad (9)$$

And the output of the $(m+1)$-th summing unit calculates the total sum

$$o_\Sigma^{[2]}(k) = \sum_{l=1}^{m}\sum_{p=1}^{N_l} o_{l,p}^{[1]}(k). \quad (10)$$

It can be readily seen that the sums (9) are Parzen approximations [5,6] of the unknown data distributions in the classes.

Finally the output of normalization layer formed by m dividers calculates the vector of degrees of membership $y(k) = (y_1(k),..., y_l(k),..., y_m(k))^T$ of the processed observation as

$$0 \le y_l(k) = \frac{o_l^{[2]}}{o_\Sigma^{[2]}} \le 1, \sum_{l=1}^{m} y_l(k) = 1. \quad (11)$$

It is easy to see that the described network is a combination of the probabilistic and generalized regression neural networks and is capable of data classification on the basis of fuzzy decision on membership of a particular observation to a certain class.

It is also evident that the first two layers of this network are essentially a standard radial basis function architecture with fixed synaptic weights $w_{lj}^{RBF} \equiv 1$ and centers $c_j^{RBF} \equiv w_j$.

Undetermined are only the cluster width parameters σ_l^2 which significantly affect the classification accuracy and are usually chosen empirically [5].

Therefore it is advisable to introduce the learning capabilities into the proposed network.

The learning algorithm adjusts the width parameters σ_l^2 to provide more accurate approximation of the data belonging to the l-th class from the observations $x(u)$, $u = N+1,...,N+M$ in the training set and their crisp classification $d(u)$.

4. LEARNING ALGORITHM

Let introduce the one-step learning criterion (error function)

$$E(u) = \sum_{h=1}^{m} E_h(u) = \frac{1}{2}\|e(u)\|^2, \qquad (12)$$

(where $e(u) = (e_1(u),...,e_h(u),...,e_m(u))^T$, $E_h(u) = \frac{1}{2}e_h^2(u) = \frac{1}{2}(d_h(u) - y_h(u))^2$, $d_h(u)$ is the training signal equal to 1 if the vector $x(u)$, $u - N+1,...,N+M$ belongs to the h-th class and 0 otherwise). The derivative of the error function with respect to the tunable parameters will be

$$\begin{cases} \dfrac{\partial E_l(u)}{\partial \sigma_l^2} = -e_l(u)\dfrac{1-y_l(u)}{o_\Sigma^{[2]}(u)}\displaystyle\sum_{p=1}^{N_l}\dfrac{\partial o_{l,p}^{[1]}(u)}{\partial \sigma_l^2}, \\ \dfrac{\partial E_h(u)}{\partial \sigma_l^2} = e_h(u)\dfrac{y_h(u)}{o_\Sigma^{[2]}(u)}\displaystyle\sum_{p=1}^{N_l}\dfrac{\partial o_{l,p}^{[1]}(u)}{\partial \sigma_l^2}, h \neq l, \end{cases} \qquad (13)$$

or

$$\frac{\partial E_h(u)}{\partial \sigma_l^2} = e_h(u)\frac{y_h(u) - \delta_{hl}}{o_\Sigma^{[2]}(u)}\sum_{p=1}^{N_l}\frac{\partial o_{l,p}^{[1]}(u)}{\partial \sigma_l^2}, \qquad (14)$$
$$h = 1,2,...,m,$$

where $\delta_{hl} = \begin{cases} 1, & if\ h = l, \\ 0, & otherwise. \end{cases}$

It can be readily seen that

$$\frac{\partial E(u)}{\partial \sigma_l^2} = \frac{1}{o_\Sigma^{[2]}(u)}\sum_{p=1}^{N_l}\frac{\partial o_{l,p}^{[1]}(u)}{\partial \sigma_l^2} \cdot \sum_{h=1}^{m}(y_h(u) - \delta_{hl})e_h(u), \qquad (15)$$

and since for the Gaussian membership function

$$\frac{\partial o_{l,p}^{[1]}(u)}{\partial \sigma_l^2} = \frac{\|x(u) - w_{l,p}\|^2}{\sigma_l^4} \cdot \exp\left(-\frac{\|x(u) - w_{l,p}\|^2}{2\sigma_l^2}\right), \qquad (16)$$

the expression (15) can be rewritten in the form

$$\frac{\partial E(u)}{\partial \sigma_l^2} = \frac{1}{2\sigma_l^4 o_\Sigma^{[2]}(u)}\sum_{h=1}^{m}(y_h(u) - \delta_{hl})e_h(u) \cdot \sum_{p=1}^{N_l}\|x(u) - w_{l,p}\|^2 \exp\left(-\frac{\|x(u) - w_{l,p}\|^2}{2\sigma_l^2}\right). \qquad (17)$$

Minimizing (12) with the gradient-based procedure

$$\sigma_l^2(q+1) = \sigma_l^2(u) - \eta(u)\frac{\partial E(u)}{\partial \sigma_l^2}, \qquad (18)$$

we can finally write the learning algorithm of the probabilistic neuro-fuzzy network

$$\sigma_l^2(q+1) = \sigma_l^2(u) - \eta(u)\frac{1}{2\sigma_l^4(u)o_\Sigma^{[2]}(u)} \cdot \sum_{p=1}^{N_l}\|x(u) - w_{l,p}\|^2 \exp\left(-\frac{\|x(u) - w_{l,p}\|^2}{2\sigma_l^2(u)}\right) \cdot \sum_{h=1}^{m}(y_h(u) - \delta_{hl})e_h(u), \qquad (19)$$

or taking into account (5)

$$\sigma_l^2(q+1) = \sigma_l^2(u) - \eta(u)\frac{1}{\sigma_l^4(u)o_\Sigma^{[2]}(u)} \cdot \sum_{p=1}^{N_l}\|1 - x^T(u)w_{l,p}\|^2 \exp\left(-\frac{1 - x^T(u)w_{l,p}}{\sigma_l^2(u)}\right) \cdot \sum_{h=1}^{m}(y_h(u) - \delta_{hl})e_h(u), \qquad (20)$$

where $\eta(u)$ is the scalar learning rate parameter.

When the learning is finished the values $\sigma_l^2(N+M+1)$, $l = 1,2,...,m$ are used as estimates of the activation function parameters (4), (5) in the classification of objects $x(k), k > N+M$ with unknown membership.

5. THE RESULTS OF EXPERIMENT

The processing semantic annotation procedure for text documents, which is based on MPNFN, was tested on sample texts belonging to different ontological classes (50 features, 100 objects). The initial data was considered as a corpus “20

Newsgroups DataSet" (comp.graphics, comp.os.ms-windows.misc, comp.sys.ibm.pc.hardware classes), and text information is treated from highly specialized subject area. Initial taxonomy (ontology) for "20 Newsgroups DataSet" is considered on Fig. 3.

comp.graphics
comp.os.ms-windows.misc
comp.sys.ibm.pc.hardware
comp.sys.mac.hardware
comp.windows.xrec.autos
rec.motorcycles
rec.sport.baseball
rec.sport.hockeysci.crypt
sci.electronics
sci.med
sci.spacemisc.forsaletalk.politics.misc
talk.politics.guns
talk.politics.mideasttalk.religion.misc
alt.atheism
soc.religion.christian

Fig. 3 – Initial taxonomy for "20 Newsgroups DataSet"

Converting text corpus in the vector space based on statistical evaluation of TF-IDF using WordNet 2.0 (for the attributes formation was considered only nouns, stop words were removed). The experiment was considered, first of all, to estimate quality of MPNFN processing [13]. Table 1 shows the results of the processing. It is indicated for an input text object that the operation generates a set of the membership values to several classes, which are considered as classes of domain ontology.

Table 1. Examples of the program work

Input text object number	Membership values to each classes		
	comp.graphics	***comp.os.ms windows.misc***	***comp.sys.ibm.pc. hardware***
10157	0,99964	0,00010032	0,00025828
10158	0,67091	0,094663	0,23443
10159	0,02427	0,95577	0,019964
10160	0,092507	0,88085	0,02664
10161	0,32385	0,62807	0,048079
10162	0,13043	0,84376	0,025803
10163	0,061536	0,91668	0,021786
10164	0,25684	0,37909	0,36406
10165	0,10571	0,033676	0,86061
10166	0,0044423	0,00086429	0,99469

Thus it becomes possible to get semantic annotations on the basis of proposed method. Example of the semantic annotation for the text document № 10159 from the "20 Newsgroups DataSet" is shown in Fig. 4. In this case semantic annotation includes some tags from Dublin Core (title, author) and the other obtained by modified probabilistic neural network.


```xml
<!-- http://www.semanticweb.org/ontologies/2011/4/Ontology1304595614765.owl#Document10159-->
  <owl:NamedIndividual rdf:about="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#Document10159">
     <rdf:type rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#Document"/>
     <dcterms:title xml:lang="en-US">WfWorkgroups server goes deaf</dcterms:title>
     <dcterms:publisher rdf:resource="http://people.csail.mit.edu/~jrennie/20Newsgroups/"/>
     <dcterms:modified>2010-05-15</dcterms:modified>
     <creation_date rdf:datatype="&xsd;dateTime">2003-03-18</creation_date>
     <from rdf:datatype="&xsd;string">taso@munnari.OZ.AU (Taso Hatzi)</from>
     <organization rdf:datatype="&xsd;string">Comp Sci, Univ Melbourne, AU</organization>
     <X-Newsreader rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#TIN"/>
     <belongs_to rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#CP10159_1"/>
     <belongs_to rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#CP10159_2"/>
     <belongs_to rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#CP10159_3"/>
     <X-Newsreader rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#TIN"/>
  </owl:NamedIndividual>
  <owl:NamedIndividual rdf:about="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#CP10159_1">
     <rdf:type rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#ComplexProbability"/>
     <probability rdf:datatype="&xsd;double">0,02427</probability>
     <class_label rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#comp.graphics"/>
  </owl:NamedIndividual>
  <owl:NamedIndividual rdf:about="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#CP10159_2">
     <rdf:type rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#ComplexProbability"/>
     <probability rdf:datatype="&xsd;double">0,95577</probability>
     <class_label rdf:resource="http://www.semanticweb.org/ontologies/2011/4/
Ontology1304595614765.owl#comp.os.ms-windows.misc"/>
  </owl:NamedIndividual>
```


Fig. 4 – Example of text document semantic annotation

6. SUMMARY

In this paper a method for semantic annotation based on modified probabilistic neuro-fuzzy network, which is a hybrid of the probabilistic neural network, a general regression neural network and neuro-fuzzy systems is described. Due to this, it becomes possible to determine the memberships for an incoming text object to each of the potentially possible classes of ontology. This method provides the ability to process information as it becomes available in sequential on-line mode, characterized by simplicity of implementation and speed of information processing.

6. REFERENCES

[1] D.F. Specht, Probabilistic neural networks, Neural Networks, (1) 3 (1990), pp. 109-118.

[2] D.F. Specht, Probabilistic neural networks and polynomial adaline as complementary techniques for classification, *IEEE Trans. on Neural Networks*, (1) 1 (1990), pp. 111-121.

[3] C.M. Bishop, *Neural Networks for Pattern Recognition,* Clarendon Press, Oxford, 1995, 482 p.

[4] C. Looney, *Pattern Recognition Using Neural Networks: Theory and Algorithms for Engineers and Scientists,* Oxford University Press, N.Y., 1997, 480 p.

[5] R. Callan, *The Essence of Neural Networks,* Prentice Hall Europe, London, 1999, 288 p.

[6] J.C. Bezdek, *Pattern Recognition with Fuzzy Objective Function Algorithms,* Plenum Press, N.Y., 1981, 272 p.

[7] F. Höppner, F. Klawonn, R. Kruse, *Fuzzy Cluster-Analyse,* Vieweg, Braunschweig, 1999, 289 p.

[8] J.-S. R. Jang, C.-T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing – Computational Approach to Learning and Machine Intelligence,* Prentice Hall, Upper Saddle River, 1997, 640 p.

[9] V. Uren, Ph. Cimiano, J. Iria, S. Handschuh, M. Vargas-Vera, E. Motta, F. Ciravegna, Semantic annotation for knowledge management: Requirements and a survey of the state of the art, *Web Semantics: Science, Services and Agents on the World Wide Web*, (1) 4 (2006), pp. 14-28.

[10] Dublin Core: Metadata Initiative (http://www.dublincore.org [last accessed 22/02/2011]).

[11] Ye. Bodyanskiy, O. Shubkina, Semantic annotation of text documents using hierarchical radial basis function neural network, *Eastern-European Journal of Enterprise Technologies*, (48) 6/3 (2010), pp. 72-77.

[12] Ye. Bodyanskiy, O. Shubkina, Semantic annotation of text documents using evolving neural network based on principle "Neurons at Data Points", *4th Int. Workshop on Inductive Modeling "IWIM 2011"*, Kyiv, Ukraine (2011), pp. 31-37.

[13] Ye. Bodyanskiy, O. Shubkina, Semantic annotation of text documents using modified probabilistic neural network, *6th IEEE Int. Conf. on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, Prague, Czech Republic (2011), pp. 328-331.

[14] O. Shubkina, I. Pliss, Ye. Bodyanskiy, Using of competitive probabilistic network in the text information processing tasks, *Bulletin of NU "Lvivska Politechnika", Computer Science and Information Technologies*, 710 (2011), pp. 175-181.

[15] K. Fukunaga, *Intruduction to Statical Pattern Recognition.* Academic Press, New York and London, 1972, 368 p.

[16] E. Parzen, On the estimation of a probability density function and the mode, *Ann. Math. Statist*., 38 (1962), pp. 1065-1076.

[17] J. Moody, C.J. Darken, Fast learning in networks of locally-tuned processing units. *Neural Computing*, 1 (1989), pp. 281-299.

[18] D.F. Specht, A general regression neural network, *IEEE Transactions on Neural Networks*, (2) 6 (1991), pp. 568-576.

[19] Ye. Bodyanskiy, Ye. Gorshkov, V. Kolodyazhniy, J. Wernstedt, A learning probabilistic neural network with fuzzy inference, Proc. *6th Int. Conf. on Artificial Neural Nets and Genetic Algorithms "ICANNGA 2003"*, Roanne, France, Springer-Verlag, Wien (2003), pp. 13-17.

[20] Ye. Bodyanskiy, Ye. Gorshkov, V. Kolodyazhniy, J. Wernstedt, *Probabilistic neuro-fuzzy network with non-conventional activation functions*, in: Lecture Notes in Artificial Intelligence, v. 2773, Springer, Berlin-Heidelberg-New York, 2003, pp. 973-979.

Yevgeniy Bodyanskiy, *in 1971 graduated with honour Kharkiv National University of Radio Electronics. In 1980 has defended the candidate thesis. In 1984 has taken academic title Senior Reseacher. In 1990 defended the doctor thesis (Dr.habil.sci.ing.). Since 1974 he has been working at Kharkiv National University of Radio Electronics. Since 1992 professor of Artificial Intelligence Department KhNURE, scientific head of Control Systems Research Laboratory KhNURE. He has more then 500 scientific publications including 40 inventions and 10 monographs. Research interests include hybrid systems of computational intelligence: adaptive, neuro-, wavelet-, neo-fuzzy-, real-time systems including problems connected with control, identification, forecasting, clustering, diagnostics.*

Iryna Pliss, *In 1970 received her Engineer-electrician degree in "Automatic and Remote Control" from Kharkiv National University of Radio Electronics, Ukraine. She became Candidate of technical Sciences in 1979 on "Technical Cybernetics and Information Theory", and Senior Researcher in 1984 on "Technical Cybernetics and Information Theory". She is currently a Leading Researcher of the Control Systems Research Laboratory. She is a member of the IEEE Signal Processing Society and the Neural Network Society. She has more than 150 scientific publications and five inventions. Her current research interests are neuro-fuzzy hybrid systems for forecasting, identification and diagnostics.*

Valentyna Volkova, *in 2005 graduated from Kharkiv National University of Radio Electronics by specialty "Intelligent Decision Making Systems", 2005-2006 rese-archer, 2006-2009 post-graduate study in Artificial Intelligence Department, has defended the PhD thesis in 2011. Her major field of research is fuzzy clustering of multi-topic text documents. After post-graduate study works in Artificial Intelligence Department at Kharkiv National University of Radio Electronics. She has more than 20 publications. Research interests are computational intelligence, data mining: fuzzy clustering algorithms based on neuro-fuzzy models.*

Dorian Gorgan, Victor Bacu, Danut Mihon, Denisa Rodila, Teodor Stefanut, Karim Abbaspour, Pierluigi Cau, Gregory Giuliani, Nicolas Ray, Anthony Lehmann

SPATIAL DATA PROCESSING TOOLS AND APPLICATIONS FOR BLACK SEA CATCHMENT REGION

The enviroGRIDS project has developed and provides through the BSC-OS portal a set of tools, applications and platforms concerning with the processing of huge spatial data for the Black Sea catchment region. The paper highlights the main issues of interoperability between Geospatial and Grid infrastructures, and between different platforms supporting the Earth Science oriented tools and applications. The BSC-OS portal provides end user applications for spatial data management, hydrological model calibration, environmental scenario development and execution, workflow based satellite image processing, data reporting and scenarios visualization, and development of Earth Science oriented training materials.

Yuriy P. Kondratenko, Sylvia B. Encheva, Ievgen V. Sidenko

SYNTHESIS OF MODULAR-STRUCTURED SYSTEMS FOR AUTOMATIZATION OF DECISION-MAKING PROCESSES IN TRANSPORT LOGISTICS

The ranging analysis of transport logistics problems and decision-making methods were held in the paper. The problems, which are represented as subsystems of DSS (Decision Support System) module type, were considered. One of which, in particular, evaluation of the quality of transport services to select cargo shipping company, was considered in details.

Tomasz Owczarek

COMPETITION BETWEEN HETEROGENEOUS AGENTS IN COMPLEX ENVIRONMENT

The article applies complexity theory to study heterogeneous organizations in an environment filled with their competitors and complementors. An agent-based simulation model is used to analyze effects of interactions in an environment with different level of complexity. Agents, differing in size and adaptability, try to adapt to fitness landscape they are placed in (which is based on Kauffman's NK model) in order to increase their fitness level. Results of conducted simulations are presented and analyzed.

Ciprian Dobre, Ramiro Voicu, Iosif C. Legrand

MONALISA: A MONITORING FRAMEWORK FOR LARGE SCALE COMPUTING SYSTEMS

The MonALISA (Monitoring Agents in A Large Integrated Services Architecture) framework provides a set of distributed services for monitoring, control, management and global optimization for large scale distributed systems. It is based on an ensemble of autonomous, multi-threaded, agent-based subsystems which are registered as dynamic services. They can be automatically discovered and used by other services or clients. The distributed agents can collaborate and cooperate in performing a wide range of management, control and global optimization tasks (such as network monitoring, resource accounting) using real time monitoring information. MonALISA includes a coherent set of network management services to collect in near real-time information about the network topology, the main data flows, traffic volume and the quality of connectivity. A set of dedicated modules were developed in the MonALISA framework to periodically perform network measurements tests between all sites. We developed global services to present in near real-time the entire network topology used by a community. The time evolution of global network topology is shown in a dedicated GUI. Changes in the global topology at this level occur quite frequently and even small modifications in the connectivity map may significantly affect the network performance. The global topology graphs are correlated with active end-to-end network performance measurements, done using the Fast Data Transfer application, between all sites. Access to both real-time and historical data, as provided by MonALISA, is also important for developing services able to predict the usage pattern, to aid in efficiently allocating resources globally. For resource accounting, MonALISA collects information regarding the amounts of resources consumed by the users, which represent virtual organizations in a large scale distributed system. Besides providing statistical information, an accounting system can also be the base for managing distributed resources upon an economic model. In the MonALISA monitoring framework we developed modules that provide accounting facilities, collecting information from cluster managers like Condor, PBS, LSF and SGE. The usage statistics is used for an intelligent management of the resources.

Andrii Salnikov, Oleksandr Sudakov, Roman Levchenko, Ievgen Sliusar, Anton Savchenko

INTERACTIVE ENVIRONMENT FOR MASSIVE NEUROSCIENCE SIMULATIONS IN GRID

End-user oriented system for massive computations in grid is proposed and implemented. The system provides support of user interfaces for input and output data staging, asynchronous jobs submission and control, tasks status and results monitoring. The main system components include web-portal, authentication components and jobs submitter that interact with grid infrastructure. The main advantages of described grid-portal are flexibility in computations back-ends support and possibility to interactively handle thousands of jobs. The proposed integrated environment was implemented in Ukrainian National Grid (UNG) infrastructure for massive simulations of non-linear dynamics in neuroscience.

Miki Ueno, Naoki Mori, Keinosuke Matsumoto

NOVEL CHATTERBOT SYSTEM OF ESTIMATING CURRENT USER INTERESTS BY MEANS OF WEB INFORMATION

Human like conversation systems are one of the most important target of computer engineering. To achieve natural conversation, estimating current user interests is the essential issue. In this paper, we proposed the novel chatterbot which can estimate current user interests by means of Web information to solve above problem. In proposed chatterbot, interests are represented by interest vectors that were created by Bulletin Board System (BBS) data. To show the effectiveness of the proposed method, the computational experiments are carried out taking several BBS data as examples.

Pavel Kachurka, Vladimir Golovko

FUSION OF RECIRCULATION NEURAL NETWORKS FOR REAL-TIME NETWORK INTRUSION DETECTION AND RECOGNITION

Intrusion detection system is one of the essential security tools of modern information systems. Continuous development of new types of attacks requires the development of intelligent approaches for intrusion detection capable to detect newest attacks. We present recirculation neural network based approach which lets to detect previously unseen attack types in real-time mode and to further correct recognition of this types. In this paper we use recirculation neural networks as an anomaly detector as well as a misuse detector, ensemble of anomaly and misuse detectors, fusion of several detectors for correct detection and recognition of attack types. The experiments held on both KDD’99 data and real network traffic data show promising results.

Yevgeniy Bodyanskiy, Irina Pliss, Valentyna Volkova

MODIFIED PROBABILISTIC NEURO-FUZZY NETWORK FOR TEXT DOCUMENTS PROCESSING

We consider the problem of text processing (classification problem) using the modification of the probabilistic neural network proposed by D. Specht. Since classes often overlap during texts processing, there were introduced the modification that implements a procedure of fuzzy inference. For this into the network were introduced two additional layers. The results of the outputs of the network are levels of belonging each text document to each of the possible classes.

Dorian Gorgan, Victor Bacu, Danut Mihon, Denisa Rodila, Teodor Stefanut, Karim Abbaspour, Pierluigi Cau, Gregory Giuliani, Nicolas Ray, Anthony Lehmann

ІНСТРУМЕНТИ І ДОДАТКИ ПРОСТОРОВОЇ ОБРОБКИ ДАНИХ ДЛЯ РЕГІОНУ ВОДОЗБОРУ ЧОРНОГО МОРЯ

У проекті enviroGRIDS розроблено і забезпечено (через портал BSC-OS) набір інструментів, додатків і платформ, для обробки величезних просторових даних в регіоні водозбору Чорного моря. У статті розглядаються основні питання взаємодії між картографічними та грід-інфраструктурами, а також між різними платформами підтримки інструментів і додатків, орієнтованих на науку про Землю. BSC-OS портал надає кінцевим користувачам додатки для управління просторовими даними, моделі гідрологічного калібрування, екологічні сценарії розвитку і виконання робочих процесів на основі обробки супутникових зображень, додатки подання даних та сценаріїв візуалізації, а також додатки для створення навчальних матеріалів науки про Землю.

Юрій Кондратенко, Сільвія Енчева, Євген Сіденко

СИНТЕЗ МОДУЛЬНО-СТРУКТУРОВАНИХ СИСТЕМ ДЛЯ АВТОМАТИЗАЦІЇ ПРОЦЕСІВ ПРИЙНЯТТЯ РІШЕНЬ В ЗАДАЧАХ ТРАНСПОРТНОЇ ЛОГІСТИКИ

В статті проведено класифікаційний аналіз задач транспортної логістики та методів прийняття рішень. Розглянуті задачі представлені у вигляді підсистем СППР модульного типу. Одна з яких, зокрема, оцінка якості транспортного обслуговування для вибору компанії-перевізника вантажу, розглянута детально.

Tomasz Owczarek

КОНКУРЕНЦІЯ МІЖ ГЕТЕРОГЕННИМИ АГЕНТАМИ В СКЛАДНИХ СЕРЕДОВИЩАХ

У статті застосовується теорія складності для вивчення гетерогенних організацій в середовищі, наповненому конкурентами та доповнювачами. Імітаційна модель на агентній основі використовується для аналізу ефектів взаємодії в середовищі з різним рівнем складності. Агенти, що відрізняються за розміром і пристосованістю, намагаються адаптуватися до умов, де вони розміщаються (на основі NK моделі Кауфмана) з метою підвищення їх рівня пристосування. Представлені та проаналізовані результати проведеного моделювання.

Ciprian Dobre, Ramiro Voicu, Iosif C. Legrand

MONALISA: СТРУКТУРА МОНІТОРИНГУ ДЛЯ ВЕЛИКОМАСШТАБНИХ ОБЧИСЛЮВАЛЬНИХ СИСТЕМ

Структура MonALISA (Monitoring Agents in A Large Integrated Services Architecture) надає набір розподілених сервісів для моніторингу, контролю, управління та глобальної оптимізації для великомасштабних розподілених систем. Вона заснована на ансамблі автономних, багатопотокових підсистем на основі агентів, що зареєстровані як динамічні сервіси. Вони можуть бути автоматично виявлені та використані іншими службами або клієнтами. Розподілені агенти можуть взаємодіяти і співпрацювати у виконанні широкого спектру завдань з управління, контролю і глобальних завдань оптимізації (наприклад, моніторинг мережі, облік ресурсів), використовуючи інформацію моніторингу в режимі реального часу. MonALISA включає в себе узгоджений набір послуг з управління мережею для збору в режимі реального часу інформації про топологію мережі, основні потоки даних, обсяг трафіку та якість зв'язку. В структурі MonALISA було розроблено набір спеціалізованих модулів для періодичного виконання мережевих вимірювальних тестів між усіма сайтами. Ми розробили глобальні сервіси для представлення в режимі мажде реального часу вхідної топології мережі, що використовується користувачами. Час еволюції глобальної мережевої топології показано в спеціальному графічному користувацькому інтерфейсі. Зміни в глобальній топології на цьому рівні відбуваються досить часто, і навіть невеликі зміни в карті з'єднання можуть суттєво вплинути на продуктивність мережі. Глобальні графіки топології корелюють з активним наскрізним вимірюванням продуктивності мережі, виконаного за допомогою швидкої передачі даних додатків між усіма сайтами. Доступ як до даних в режимі реального часу, так і до історичних даних, як це передбачено Monalisa, є також важливим для розробки служб передбачення використання мережі, щоб допомогти в ефективному розподілі ресурсів у глобальному масштабі. Для обліку ресурсів, MonALISA збирає інформацію про кількість ресурсів використаних користувачами, що представляють віртуальні організації у великомасштабній розподіленій системі. Крім надання статистичної інформації, системи обліку також можуть бути базою для управління розподіленими

ресурсами на основі економічної моделі. В рамках моніторингу MonALISA ми розробили модулі, які забезпечують облік об'єктів, збір інформації від менеджерів кластерів, як Condor, PBS, LSF і SGE. Також статистика використовується для інтелектуального управління ресурсами.

Андрій Сальніков, Олександр Судаков, Роман Левченко, Євген Слюсар, Антон Савченко
ІНТЕРАКТИВНЕ СЕРЕДОВИЩЕ ДЛЯ МАСИВНОГО МОДЕЛЮВАННЯ НЕЙРОДИНАМІКИ В ГРІД

Запропоновано і розроблено систему автоматизації великих об'ємів розрахунків в грід, яка орієнтована на кінцевого користувача. Система забезпечує підтримку інтерфейсів користувача для створення вхідних та отримання вихідних даних, асинхронний запуск завдань і керування ними, моніторинг і візуалізацію результатів розрахунків. Основні компоненти системи включають Веб-портал, засоби аутентифікації і систему запуску задач, які взаємодіють з грід-інфраструктурою. Головними перевагами описаного грід-порталу є гнучкість в підтримці різних засобів розрахунків і можливість інтерактивно керувати тисячами задач. Запропоноване інтегроване середовище було впроваджене в Українській національній грід інфраструктурі (УНГ) для масивного моделювання нелінійної динаміки для задач нейрології.

Miki Ueno, Naoki Mori, Keinosuke Matsumoto
НОВІТНЯ СИСТЕМА ЧАТТЕРБОТ ДЛЯ ОЦІНКИ ПОТОЧНИХ ІНТЕРЕСІВ КОРИСТУВАЧА ЗА ДОПОМОГОЮ ВЕБ-ІНФОРМАЦІЇ

Системи, що імітують людську розмову, є однією з найважливіших цілей комп'ютерного проектування. Для того, щоб досягнути рівня природного спілкування комп'ютер-людина, важливим питанням є оцінювання поточних інтересів користувачів. У цій статті ми запропонували новий чаттер-бот, що може оцінити поточні інтереси користувача за допомогою веб-інформації для вирішення поставленого завдання. У пропонованому чаттер-боті, інтереси представлені вектором інтересів, були створені за допомогою даних Bulletin Board System (BBS). Щоб показати ефективність запропонованого методу, обчислювальні експерименти проводилися на даних декількох BBS в якості прикладів.

Павло Качурка, Володимир Головко
ОБ'ЄДНАННЯ РЕЦИРКУЛЯЦІЙНИХ НЕЙРОННИХ МЕРЕЖ ДЛЯ ВИЯВЛЕННЯ І РОЗПІЗНАВАННЯ МЕРЕЖНИХ АТАК В РЕАЛЬНОМУ ЧАСІ

Система виявлення вторгнень є одним з найважливіших інструментів безпеки сучасних інформаційних систем. Безперервна розробка нових типів атак вимагає розробки та інтелектуальних підходів до виявлення вторгнень, здатних виявляти новітні атаки. Ми пропонуємо підхід на основі рециркуляційних нейронних мереж, який дозволяє виявити не відомі раніше типи атак в режимі реального часу з подальшим коректним розпізнаванням цього типу. У даній роботі ми використовуємо рециркуляційні нейронні мережі в якості детекторів аномалій та детекторів зловживань, ансамбль з детекторів аномалій та зловживань і об'єднання декількох детекторів для правильного виявлення та розпізнавання типів атак. Експерименти, проведені на базі даних KDD'99 і реальних даних мережевого трафіку, показують багатообіцяючі результати.

Євген Бодянський, Ірина Плісс, Валентина Волкова
МОДИФІКОВАНА ЙМОВІРНІСНА НЕЙРО-ФАЗЗІ МЕРЕЖА ДЛЯ ОБРОБКИ ТЕКСТОВИХ ДОКУМЕНТІВ

Розглядається проблема обробки текстової інформації (задача класифікації) за допомогою модифікації ймовірнісної нейронної мережі Д.Шпехта. Оскільки при обробці текстів класи достатньо часто перекриваються, введена модифікація реалізує процедуру нечіткого виведення, для чого в мережу додатково введено два шари. Результатом на виходах мережі є рівні належності кожного текстового документу до кожного з можливих класів.

Dorian Gorgan, Victor Bacu, Danut Mihon, Denisa Rodila, Teodor Stefanut, Karim Abbaspour, Pierluigi Cau, Gregory Giuliani, Nicolas Ray, Anthony Lehmann
ИНСТРУМЕНТЫ И ПРИЛОЖЕНИЯ ПРОСТРАНСТВЕННОЙ ОБРАБОТКИ ДАННЫХ ДЛЯ РЕГИОНА ВОДОСБОРА ЧЕРНОГО МОРЯ

В проекте enviroGRIDS разработан и обеспечен (через портал BSC-OS) набор инструментов, приложений и платформ, для обработки огромных пространственных данных в регионе водосбора Черного моря. В статье рассматриваются основные вопросы взаимодействия между картографическими и грид-инфраструктурами, а также между различными платформами поддержки инструментов и приложений, ориентированных на науку о Земле. BSC-OS портал предоставляет конечным пользователям приложения для управления пространственными данными, модели гидрологической калибровки, экологические сценарии развития и выполнения рабочих процессов на основе обработки спутниковых изображений, приложения представления данных и сценариев визуализации, а также приложения для создания учебных материалов науки о Земле.

Юрий Кондратенко, Сильвия Енчева, Евгений Сиденко
СИНТЕЗ МОДУЛЬНО-СТРУКТУРИРОВАННЫХ СИСТЕМ ДЛЯ АВТОМАТИЗАЦИИ ПРОЦЕССОВ ПРИНЯТИЯ РЕШЕНИЙ В ЗАДАЧАХ ТРАНСПОРТНОЙ ЛОГИСТИКИ

В статье проведен классификационный анализ задач транспортной логистики и методов принятия решений. Рассмотренные задачи представлены в виде подсистем СППР модульного типа. Одна из них, в частности, оценка качества транспортного обслуживания для выбора компании-перевозчика груза, рассмотрена детально.

Tomasz Owczarek
КОНКУРЕНЦИЯ МЕЖДУ ГЕТЕРОГЕННЫМИ АГЕНТАМИ В СЛОЖНЫХ СРЕДАХ

В статье применяется теория сложности для изучения гетерогенных организаций в среде, наполненной конкурентами и дополнителями. Имитационная модель на агентной основе используется для анализа эффектов взаимодействия в среде с разным уровнем сложности. Агенты, отличающиеся размером и приспособленностью, пытаются адаптироваться к условиям, где они размещаются (на основе NK модели Кауфмана) с целью повышения их уровня приспособления. Представлены и проанализированы результаты проведенного моделирования.

Ciprian Dobre, Ramiro Voicu, Iosif C. Legrand
MONALISA: СТРУКТУРА МОНИТОРИНГА КРУПНОМАСШТАБНЫХ ВЫЧИСЛИТЕЛЬНЫХ СИСТЕМ

Структура MonALISA (Monitoring Agents in A Large Integrated Services Architecture) предоставляет набор распределенных сервисов для мониторинга, контроля, управления и глобальной оптимизации для крупномасштабных распределенных систем. Она основана на ансамбле автономных, многопоточных подсистем на основе агентов, зарегистрированных как динамические сервисы. Они могут быть автоматически обнаружены и использованы другими службами или клиентами. Распределенные агенты могут взаимодействовать и сотрудничать в выполнении широкого спектра задач по управлению, контролю и глобальным задачам оптимизации (например, мониторинг сети, учет ресурсов), используя информацию мониторинга в режиме реального времени. MonALISA включает в себя согласованный набор услуг по управлению сетью для сбора в режиме реального времени информации о топологии сети, основным потокам данных, объеме трафика и качестве связи. В структуре MonALISA был разработан набор специализированных модулей для периодического выполнения сетевых измерительных тестов между всеми сайтами. Мы разработали глобальные сервисы для представления в режиме почти реального времени входной топологии сети, используемой пользователями. Время эволюции глобальной сетевой топологии показано в специальном графическом пользовательском интерфейсе. Изменения в глобальной топологии на этом уровне происходят довольно часто, и даже небольшие изменения в карте соединения могут существенно повлиять на производительность сети. Глобальные графики топологии коррелируют с активным сквозным измерением производительности сети, выполненного с помощью быстрой передачи данных приложений между всеми сайтами. Доступ как к данным в режиме реального времени, так и историческим сведениям, как это предусмотрено MonaLISA, является важным для разработки служб предусмотрения использования сети, чтобы помочь в эффективном распределении ресурсов в глобальном масштабе. Для учета ресурсов, MonALISA собирает информацию о количестве ресурсов, использованных пользователями, представляющим виртуальные организации в крупномасштабной распределенной системе. Помимо предоставления статистической информации, системы учета также могут быть базой для управления распределенными ресурсами на основе экономической модели. В рамках мониторинга MonALISA мы разработали модули, обеспечивающие учет объектов, сбор информации от менеджеров кластеров, таких как Condor, PBS, LSF и SGE. Также статистика используется для интеллектуального управления ресурсами.

Андрей Сальников, Александр Судаков, Роман Левченко, Евгений Слюсар, Антон Савченко

ИНТЕРАКТИВНАЯ СЕРЕДА ДЛЯ МАССИВНОГО МОДЕЛИРОВАНИЯ НЕЙРОДИНАМИКИ В ГРИД

Предложена и реализована система автоматизации больших объемов расчетов в грид, ориентированная на конечного пользователя. Система обеспечивает поддержку пользовательских интерфейсов для создания исходных и получения результирующих данных, асинхронный запуск задач и управление ими, мониторинг и визуализацию результатов расчетов. Основные компоненты системы включают Веб-портал, компоненты аутентификации и систему запуска задач, которые взаимодействуют с грид-инфраструктурой. Главными преимуществами описанного грид-портала является гибкость в поддержке различных средств моделирования и возможность интерактивного управления тысячами задач. Предложенная интегрированная среда была внедрена в Украинской национальной грид инфраструктуре (УНГ) для масивного моделирования нелинейной динамики в задачах нейрологии.

Miki Ueno, Naoki Mori, Keinosuke Matsumoto

НОВЕЙШАЯ СИСТЕМА ЧАТТЕРБОТ ДЛЯ ОЦЕНКИ ТЕКУЩИХ ИНТЕРЕСОВ ПОЛЬЗОВАТЕЛЯ С ПОМОЩЬЮ ВЕБ-ИНФОРМАЦИИ

Системы, имитирующие человеческий разговор, является одной из важнейших целей компьютерного проектирования. Для того, чтобы достичь уровня естественного общения компьютер-человек, важным вопросом является оценка текущих интересов пользователей. В этой статье мы предложили новый чаттер-бот, который может оценить текущие интересы пользователя с помощью веб-информации для решения поставленной задачи. В предлагаемом чаттер-боте, интересы представлены вектором интересов, были созданы с помощью данных Bulletin Board System (BBS). Чтобы показать эффективность предложенного метода, проводились вычислительные эксперименты на данных нескольких BBS в качестве примеров.

Павел Качурка, Владимир Головко

ОБЪЕДИНЕНИЕ РЕЦИРКУЛЯЦИОННЫХ НЕЙРОННЫХ СЕТЕЙ ДЛЯ ОБНАРУЖЕНИЯ И РАСПОЗНАВАНИЯ СЕТЕВЫХ АТАК В РЕАЛЬНОМ ВРЕМЕНИ

Система обнаружения вторжений является одним из важнейших инструментов безопасности современных информационных систем. Непрерывная разработка новых типов атак требует разработки и интеллектуальных подходов к обнаружению вторжений, способных обнаруживать новейшие атаки. Мы предлагаем подход на основе рециркуляционных нейронных сетей, который позволяет обнаружить не известные ранее типы атак в режиме реального времени с последующим корректным распознаванием этого типа. В данной работе мы используем рециркуляционные нейронные сети в качестве детекторов аномалий и детекторов злоупотреблений, ансамбль из детекторов аномалий и злоупотреблений и объединение нескольких детекторов для правильного обнаружения и распознавания типов атак. Эксперименты, проведенные на базе данных KDD'99 и реальных данных с сетевого трафика, показывают многообещающие результаты.

Евгений Бодянский, Ирина Плисс, Валентина Волкова

МОДИФИЦИРОВАННАЯ ВЕРОЯТНОСТНАЯ НЕЙРО-ФАЗЗИ СЕТЬ ДЛЯ ОБРАБОТКИ ТЕКСТОВЫХ ДОКУМЕНТОВ

Рассматривается проблема обработки текстовой информации (задача классификации) с помощью модификации вероятностной нейронной сети Д.Шпехта. Поскольку при обработке текстов классы достаточно часто пересекаются, введенная модификация реализует процедуру нечеткого вывода, для чего в сеть дополнительно введены два слоя. Результатом на выходах сети есть уровни принадлежности каждого текстового документа к каждому из возможных классов.

Prepare your paper according to the following requirements:

Unconditional requirement - paper should not be published earlier.

(i) Suggested composition (frame) of paper:
- Issue formulation stressing its urgent solving; evaluation of recent publications in the explored issue
- short formulation of paper's purpose
- description of proposed method (algorithm)
- implementation and testing (verification)
- conclusion.

(ii) Use A4 (210 x 297 mm) paper. Size of paper has to be extended up to 6-8 pages.
(iii) Please use main text two column formatting;
(iv) A paper must have an abstract and some keywords;
(v) Place a full list of references at the end of the paper. Please place the references according to their order of appearance in the text.
(vi) An affiliation of each author is wanted.
(vii) The text should be single-spaced. Use Times New Roman (11 points, regular) typeface throughout the paper.
(viii) Equations should be placed in separate lines and numbered. The numbers should be within brackets and right aligned.
(ix) The figures and tables must be numbered, have a self-contained caption. Figure captions should be below the figures; table captions should be above the tables. Also, avoid placing figures and tables before their first mention in the text.
(x) As soon as you have the complete materials, the final versions should come electronically in MS Word'97 of MS Word 2000 format to the address computing@computingonline.net.
(xi) A hardcopy of your article is needed to be sent by regular mail for our publishing house.
(xii) Please send short CVs (up to 20 lines) and photos of every author.
(xiii) There is no other formatting required. The publishing department makes all rest formatting according to the publisher's rules.

Journal Topics:
- Algorithms and Data Structure
- Bio-Informatics
- Cluster and Parallel Computing, Software Tools and Environments
- Computational Intelligence
- Computer Modeling and Simulation
- Cyber and Homeland Security
- Data Communications and Networking
- Data Mining, Knowledge Bases and Ontology
- Digital Signal Processing
- Distributed Systems and Remote Control
- Education in Computing
- Embedded Systems
- High Performance Computing and GRIDS
- Image Processing and Pattern Recognition
- Intelligent Robotics Systems
- Internet of Things
- Standardization of Computer Systems
- Wireless Systems

Основні вимоги до подання і оформлення публікацій наукового журналу "Комп'ютинг":

Безумовною вимогою є те, щоб стаття не була опублікована раніше!

(i) Наукові статті повинні мати такі необхідні елементи:
- постановка проблеми у загальному вигляді та її зв'язок із важливими науковими чи практичними завданнями;
- аналіз останніх досліджень і публікацій, в яких започатковано розв'язання даної проблеми і на які спирається автор, виділення невирішених раніше частин загальної проблеми, котрим присвячується означена стаття;
- формулювання цілей статті (постановка завдання);
- виклад основного матеріалу дослідження з повним обґрунтуванням отриманих наукових результатів;
- висновки з даного дослідження і перспективи подальших розвідок у даному напрямку.

(ii) Використовуйте A4 (210 x 297 mm) формат сторінки. Загальний розмір статті має містити 6-8 сторінок.

(iii) Використовуйте двоколонкове форматування основного тексту;

(iv) Стаття повинна обов'язково містити основний текст українською мовою, анотацію (написану на Англійській і Українській мовах) і список ключових слів;

(v) В кінці статті розмістіть список літератури. Розміщуйте список літератури в порядку її цитування.

(vi) Необхідною є інформація про наукові звання, титули та посади авторів.

(vii) Текст повинен бути набраним одинарним інтервалом із використанням шрифту Times New Roman (11 points, regular).

(viii) Формули повинні відділятись від основного тексту пустими стрічками а також пронумеровані у круглих дужках та відцентровані по правому краю.

(ix) Таблиці і рисунки повинні бути пронумерованими. Заголовки рисунків розміщують під рисунком по центру. Заголовки таблиць розміщують по центру зверху таблиці.

(x) Завершені версії статей повинні бути надісланими в електронному MS Word'97 або MS Word 2000 форматі за адресою computing@computingonline.net.

(xi) Просимо надсилати поштою роздруковані копії статей.

(xii) В кінці кожної статті потрібно подати її назву, резюме (абстракт) і ключові слова англійською мовою.

(xiii) Просимо надсилати нам короткі біографічні дані (до 20 рядків) і скановані фотографії кожного із авторів.

(xiv) Видавництво здійснює остаточне форматування тексту згідно із вимогами друку.

(xv) У закордонних читачів можуть виникнути проблеми при ознайомленні з працями на російській та українській мовах. В зв'язку з цим редакційна колегія просить авторів додатково прислати розширений реферат (резюме), щоб б містило дві сторінки тексту англійською мовою, і супроводжувалось заголовком, прізвищами та адресами авторів. Авторам рекомендується використовувати у рисунках статті позначення переважно англійською мовою, або давати переклад у дужках. Тоді у розширеному резюме можна буде посилатися на рисунки у основному тексті.

Тематика журналу:

- Алгоритми та структури даних
- Біо-інформатика
- Кластерні та паралельні обчислення, програмні засоби та середовище
- Обчислювальний інтелект
- Комп'ютерне та імітаційне моделювання
- Кібернетична безпека та захист від тероризму
- Обмін даними та організація мереж
- Видобування даних, бази знань та онтології
- Цифрова обробка сигналів
- Розподілені системи та дистанційне управління
- Освіта в комп'ютингу
- Вбудовувані системи
- Високопродуктивні обчислення та ГРІД
- Обробка зображень та розпізнавання шаблонів
- Інтелектуальні робототехнічні системи
- Інтернет речей
- Стандартизація комп'ютерних систем
- Безпровідні системи

Основные требования к подаче и оформлению публикаций научного журнала “Компьютинг”:

Безусловное требование – чтобы статья не была опубликована ранее!

(i) Научные статьи должны иметь такие необходимые элементы:
- постановка проблемы в общем виде и ее связь с важными научными или практическими задачами;
- анализ последних исследований и публикаций, в которых начаты решения данной проблемы и на которые опирается автор, выделение нерешенных прежде частей общей проблемы, которым посвящается обозначенная статья;
- формулирование целей статьи (постановка задача);
- изложение основного материала исследования с полным обоснованием полученных научных результатов;
- выводы из данного исследования и перспективы дальнейших изысканий в данном направлении.

(ii) Используйте А4 (210 x 297 mm) формат страницы. Общий размер статьи 6-8 страниц.

(iii) Используйте двухколоночное форматирование основного текста;

(iv) Статья должна обязательно содержать основной текст на Русском языке, аннотацию (написанную на Английском и Русском языках) и список ключевых слов;

(v) В конце статьи разместите список литературы. Размещайте список литературы в порядке ее цитирования.

(vi) Необходима информация о научных званиях, титулах и должностях авторов.

(vii) Текст должен быть набранным одинарным интервалом с использованием шрифта Times New Roman (11 points, regular).

(viii) Формулы должны отделяться от основного текста пустыми строками, а также пронумерованные в круглых скобках и отцентрованные по правому краю.

(ix) Таблицы и рисунки должны быть пронумерованными. Заголовки рисунков размещают под рисунком по центру. Заголовки таблиц размещают по центру сверху таблицы.

(x) Завершенные версии статей должны быть присланы в электронном MS Word'97 или MS Word 2000 формате по адресу computing@computingonline.net.

(xi) Просим присылать распечатанные копии статей по почте.

(xii) В конце каждой статьи необходимо предоставить ее название, резюме (абстракт) и ключевые слова на английском языке.

(xiii) Просим присылать нам короткие биографические данные (до 20 строчек) и сканированные фотографии каждого из авторов.

(xiv) Издательство осуществляет окончательное форматирование текста в соответствии с требованиями печати.

(xv) У зарубежных читателей могут возникнуть проблемы при ознакомлении с трудами на русском и украинском языках. В связи с этим редакционная коллегия просит авторов дополнительно прислать расширенный реферат (резюме), который содержал бы две страницы текста на английском языке, и сопровождался заголовком, фамилиями и адресами авторов. Авторам рекомендуется использовать в рисунках статьи обозначения преимущественно на английском языке, или давать перевод в скобках. Тогда в расширенном резюме можно будет посылаться на рисунки в основном тексте.

Тематика журнала:

- Алгоритмы и структуры данных
- Био-информатика
- Кластерные и параллельные вычисления, программные средства и среды
- Вычислительный интеллект
- Компьютерное и имитационное моделирование
- Кибернетическая безопасность и защита от терроризма
- Обмен данными и организация сетей
- Добыча данных, базы знаний и онтологии
- Цифровая обработка сигналов
- Распределенные системы и дистанционное управление
- Образование в компьютинге
- Встраиваемые системы
- Высокопроизводительные вычисления и ГРИД
- Обработка изображений и распознавание шаблонов
- Интеллектуальные робототехнические системы
- Интернет вещей
- Стандартизация компьютерных систем
- Беспроводные системы

CALL FOR PAPERS

IDAACS'2013

The 7th IEEE International Conference on
Intelligent Data Acquisition and Advanced Computing Systems:
Technology and Applications

September 11-14, 2013
BERLIN, GERMANY

Organized by
Research Institute of Intelligent Computer Systems,
Ternopil National Economic University and V.M. Glushkov Institute of Cybernetics, National Academy of Sciences of Ukraine
in cooperation with
University of Applied Sciences,
Hochschule für Technik und Wirtschaft (HTW)
Berlin, Germany
www.idaacs.net

Conference Co-Chairmen
Anatoly Sachenko, Ukraine
Jürgen Sieck, Germany
International Programme Committee Co-Chairmen
Vladimir Haasz, Czech Republic
Kurosh Madani, France
IDAACS International Advisory Board
Dominique Dallet, France
Richard Duro, Spain
Domenico Grimaldi, Italy
Vladimir Haasz, Czech Republic
Robert Hiromoto, USA
Theodore Laopoulos, Greece
George Markowsky, USA, Chair
Vladimir Oleshchuk, Norway
Fernando Lopez Pena, Spain
Peter Reusch, Germany
Anatoly Sachenko, Ukraine
Wieslaw Winiecki, Poland

Important Dates
Abstract submission: 1 March 2013
Notification of Acceptance: 15 April 2013
Camera ready paper: 1 June 2013
Early registration: 15 April – 30 June 2013

CORRESPONDENCE

The correspondence should be directed to IDAACS Organizing Committee:

IDAACS Organizing Committee
Research Institute of Intelligent Computer Systems
Ternopil National Economic University
3 Peremoga Square
Ternopil 46020 Ukraine
Phone: +380352-475050 ext.: 12234
Fax: +380352-475053 (24 hours)
E-mail: orgcom@idaacs.net

Topics

The conference scope includes, but it's not limited to:

1. Special Stream in Wireless Systems
2. Special Stream in Project Management
3. Special Stream in Cyber Security
4. Special Stream in High Performance Computing
5. Special Stream in eLearning Management
6. Special Stream in Advanced Information Technologies in Ecology
7. Advanced Instrumentation and Data Acquisition Systems
8. Intelligent Distributed Systems and Remote Control
9. Virtual Instrumentation Systems
10. Cluster and Parallel Computing, Software Tools and Environments
11. Embedded Systems
12. Artificial Intelligence and Neural Networks for Advanced Data Acquisition and Computing Systems
13. Advanced Mathematical Methods for Data Acquisition and High Performance Computing
14. Pattern Recognition and Digital Image and Signal Processing
15. Data Analysis and Modeling
16. Intelligent Information Systems, Data Mining and Ontology
17. Robotics and Autonomous Systems
18. Information Computing Systems for Education and Commercial Applications
19. Bio-Informatics
20. Safety, Security and Reliability of Software
21. Intelligent Testing and Diagnostics of Computing Systems
22. Internet of Things
23. Special Stream in Intelligent Robotics and Components

It's our pleasure to invite the interested scientists to organize own Streams.

Підписано до друку 25. 12. 2012 р.
Формат 60х84 $^{1}/_{8}$. Гарнітура Times.
Папір офсетний. Друк на дублікаторі.
Умов. друк. арк. 10,1. Облік.-вид. арк. 18,2.
Зам. № М004-12П. Наклад 300 прим.

Свідоцтво про внесення суб'єкта видавничої справи
до Державного реєстру видавців ДК № 3467 від 23.04.2009 р.

Віддруковано у Видавничо-поліграфічному центрі «Економічна думка ТНЕУ»
46004 м. Тернопіль, вул. Львівська, 11
тел. (0352) 47-58-72
E-mail: edition@tneu.edu.ua