QoS and Resilience in Self-Aware Networks

Erol Gelenbe

Imperial College London, United Kingdom

Abstract:
Self-awareness in a network means that all end-nodes of the network are measuring the state of the paths and links which are relevant to their needs and to their end users. It also means that all intermediate nodes also probe their own environment. End-nodes are also informed both about their end-users' QoS needs and reliability, and of their ongoing experience. This probing should be done at a rate that on the one hand offers an acceptably accurate and timely view of the network, but the overhead it causes should remain at a small fraction of the total processing and traffic conveying that the network undertakes for its users. We will explore approaches to self-awareness with a special focus on achieving demonstrably better resilience and QoS, including security and protection against attacks, and effective power management. Attention will be given both to the wired and to the wireless domain. Special emphasis will be placed on results and techniques based on experimentation.

Biography:
Erol Gelenbe PhD DSc FIEEE FACM FIET is a Member of the French National Academy of Engineering, of the Turkish Academy of Sciences and of Academia Europaea. He has graduated over 50 PhDs, holds the “Dennis Gabor Chair” and is Head of the Intelligent Systems and Networks Group in the Electrical and Electronic Engineering Department at Imperial College, where he conducts research on computer systems and networks. Author of over 140 journal papers, and several books published in English, French, Japanese and Korean, he has won numerous major international awards and honours for his work, including the ACM SIGMETRICS Life-Time Achievement Award, the Honoris Causa Doctorate from the universities of Liège in Belgium (2006), Bogaziçi in Istanbul (2004) and Rome II (1996), a prize from the French Academy of Sciences, and several decorations from the governments of Italy and France. His recent work includes path finding algorithms in noisy and uncertain conditions, the use of neural networks to control routing in computer networks, the analysis of decision making based on market based techniques, and modeling problems from the basic sciences including neural networks, gene regulatory networks, and models of chemical reactions. His research is currently funded by EPSRC with significant industry participation (BT, BAE Systems), and by the EU FP7 programme. Appointed to his first chair at the age of 27 at the University of Liège in Belgium, he served as a research director at INRIA (France), with successive professorial posts at the University of Paris, Duke University where he was Department Head, and the University of Central Florida where he held a distinguished chair and was Associate Dean of Engineering. He is the Editor in Chief of The Computer Journal, and editorial board member of the Proc .of the Royal Society A, Performance Evaluation, and Acta Informatica.

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Management and monitoring issues in transparent optical and converged optical wireless networks

Kyriakos Vlachos
University of Patras, Greece

Abstract:
In this presentation, some critical issues are discussed with respect the management and monitoring of futures networks. In particular, the case of transparent optical networks and the case of converged fixed wireless networks is presented. In the first case, the evolution of opaque optical network to transparent (all-optical networks) faces some critical constraints. The signal Quality of Transmission (QoT) degrades due to the physical layer impairments and thus introducing transparency on one hand leads to a dynamic, flexible optical layer with the possibility to add extra "intelligence", but however transparency reduces the ability of the digital electronic layer to interact with the optical layer. Thus, optical transparency has an impact on network design and management, since it is quite difficult to monitor and thus manage transparent all-optical paths. Further, performance monitoring is also a cumbersome task. Still there does not exist, an impairment monitoring system and only end-to-end Q-factor can be considered. Here we present, a cross-layer optimization (*impairment aware*) framework, which is a viable solution for routing, wavelength assignment, network protection and performance monitoring.
In the second case of converged optical wireless networks, issues with respect the promising WiMax-PON integration are presented. Due to the large geographical span of these networks, crossing many different domains, with different technologies, managing and performance monitoring is a difficult task. Here, we present a traffic monitoring scheme to pro-actively and dynamically re-allocate bandwidth especially for cases of major network failures. The scheme uses a traffic prediction scheme for estimating aggregated data for each period of time and identifies if errors are due to false predictions or due to traffic increases. In the latter case, it signals the OLT's bandwidth allocation module to greed increase and transfer capacity, where necessary, bypassing admission control.

Biography:
Kyriakos G. Vlachos received his Dipl.-Ing. degree in electrical and computer engineering from the National University of Athens (NTUA), Greece, in 1998 and his Ph.D. in electrical and computer engineering, also from NTUA, in 2001. In April 2001 he joined Bell Laboratories, Lucent Technologies, working on behalf of the Applied Photonics Group. Prof. Vlachos conducted research on high-speed optical networks and DWDM transmission techniques. During 2003, he joined the National Regulation Authority of Telecommunication and Postal Service of Greece (EETT), where he served as a scientific advisor for various techno-economic issues for the promotion of broadband technologies. Since 2003, he was also a member of Computer Engineering laboratory of Technical University of Delft and since 2005, a faculty member of Computer Engineering and Informatics Dept. of University of Patras, Greece. Prof. Vlachos has participated in various research projects funded by the European Commission (IST-STOLAS, IST-PRO3, ESPRIT-DOALL, ephoton/ONe+, IST-PHOSPHROUS, ICT-BONE and ICT-DICONET). Prof. Vlachos is a member of IEEE and the Technical Chamber of Greece. Prof. Vlachos is the (co) author of more than 90 journal and conference publications and holds five (5) patents.

COST is supported by the EU RTD Framework Programme

One network, two networks, three networks….multilayer networking

Xavi Masip-Bruin
Technical University of Catalonia, Spain

Abstract:
Monitoring, control and security are all key words in telecommunications networks. However, their links with the network are quite different. Broadly speaking, the first, monitoring is not directly concerned by network performance; instead, the second, control is highly worried not only on how network behaves but also on who is in; and the later, security deals with the fears users have when forwarding information throughout the network. But, these short descriptions acquire a specific rationale when applied to Critical Infrastructure Systems (CIS) since all three words are tightly related in this scenario. Nevertheless, despite the undoubtedly need of endowing the network with advanced and augmented monitoring, control and security functionalities, there is a common denominator referred to as quality. In fact, the quality metric is obtained by means of monitoring and measurement functions, managed by control functions and everything carried out on a secure scenario.
The network quality has been analyzed for the last 25 years in terms of the Quality of Service (QoS), and unfortunately the outcome is quite pessimistic. QoS is yet today a hot topic in networking research. Several causes motivate this two can be mainly blamed though. On the one hand, the network is continuously evolving not only in terms of clients' requirements (new applications, services and traffic requiring network functionalities otherwise unthinkable) but also in technology (growth of optical networking, wireless, etc). On the other hand the network is a distributed and hierarchical structure building different domains, each governed by a set of independent policies and business relationships. In this new network scenario where the research community is not talking about QoS but Quality of Experience (QoE), manufacturers are not only worried about traffic but also about energy consumption (green networking) and devices memory, and operators are not only concerned by providing connectivity but also on how multi-homing can be managed best, almost everything is still an open issue. At this stage, there is a trend in networking pushing for creating two (or more) different network infrastructures providing users with different levels of quality and allowing them to decide (pay) the traffic pattern delivery guarantees they expect from the network. Another option in networking design relies on the new capabilities different network layers are gaining over the time. Specifically, layer 1 with the advent of optical networking and layer 2 with the impressive benefits Ethernet can provide. This means that unlike traditional networks where all network decisions were taken at packet level (layer 3), new solutions for critical network issues such as protection and recovery, control and routing, security and even addressing, coming from lower levels can be envisioned. These new network capabilities require a strong interaction between levels, generally referred to as multi-layer or cross-layer. The big challenge nowadays is how multi-layer can provide a solution for the above mentioned causes sticking network quality deployment.

COST is supported by the EU RTD Framework Programme

Biography:

Xavi Masip got a MSc and Ph.D. degrees in telecommunications engineering both from the Technical University of Catalonia. He is currently an associate professor in the computer science department at the Technical University of Catalonia. He is leading the recently created Advanced Network Architectures Lab (CRAAX) at the UPC where he is actively working in the areas of broadband communications, QoS management and provision, traffic engineering and multilayer networks, focusing on both packet and optical networks and lastly in the e-health area. His publications include around 80 papers in national and international
refereed journals and conferences. He has also been member of the organizing team of many national and international conferences and also participated and participates in several national and international research projects funded by public institutions and industries.

State Machine Methods for Detection of Attacks in Cyber-Power Systems

Pavel Gladyshev
University College Dublin, Ireland

Abstract:
State machine methods provided a convenient mathematical framework for describing invetigative reasoning in cybercrime investigations. By constructing and relying on a rigorous model of the system under investigation, these methods can be used to prove or disprove hypotheses about the incident, to reconstruct events that must have definitely happened during the incident, and to detect abnormal system behaviour. This talk will present the concepts of state machine approach to investigation of digital systems and will discuss its potential for detecting and investigating cyber attacks in the context of hybrid cyber-power systems.

Biography:
Dr. Pavel Gladyshev is the Programme Director of the MSc programme in Forensic Computing and Cybercrime Investigation offered by the University College Dublin's Center for Cybercrime Investigation (Dublin, Ireland). Dr. Gladyshev has conducted and published fundamental research on the theory of event reconstruction in cybercrime investigations. He is a member of editorial boards of several journals including the International Journal of Digital Evidence and the International Journal of Digital Crime and Forensics. He is also serving as an invited expert to the INTREPOL working party on IT Crime - Europe. Dr. Gladyshev holds PhD and MSc degrees in Computer Science and a primary degree in Computer Engineering.

COST is supported by the EU RTD Framework Programme

Wide area monitoring in power systems: Data aggregation and measurement uncertainty issues

Mihaela Albu
University Politehnica Bucharest, Romania

Abstract:
In the attempt of performing a reliable management and control of the electric power systems, voltage measurement is one of the most important sources of information. The large deployment of various measurement chains with digital output is offering high versatility at the cost of resulting in significantly large volume of data. Therefore new algorithms and techniques, including aggregation, are necessary. In addition, various sources of uncertainties – including those related to signal modelling, measurement and control system – have to be considered when designing the methodologies for intelligent management and control. The presentation will be dedicated to a short introduction to measurement uncertainties and their estimation according to the *Guide to the Expression of Uncertainty in Measurement – ISO-GUM*, followed by a summary of the measurement requirements for estimating power quality parameters as in the IEC **61000-4-30** together with some implications of data aggregation in case of voltage monitoring.

Biography:
Mihaela Albu graduated 1987 the Power Engineering Department of the “Politehnica” University of Bucharest (U.P.B.). In 1998 she obtained the PhD from the same university with a thesis on "Electromagnetic Transients on HV Aerial Lines with Application to Digital Distance Protection Design". Since 1990 she is with the Department of Electrical Engineering of U.P.B., teaching electrical measurement, signal processing, power quality and nonlinear phenomena in distribution networks and instrumentation for power systems. She is IEEE senior member and member of the AdCom of the IEEE Instrumentation and Measurement Society (2009-2012). She is conducting research on smart grids topics, including DC networks. In 2010 she will be on leave at Arizona State University as a Senior Fulbrighter, in the group of Prof. G.T. Heydt, where she had awarded a previous Fulbright Fellowship in 2002.

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the EU RTD Framework Programme

The FP7 Viking Project

Pontus Johnson
Royal Institute of Technology, Sweden

Abstract:
Society is increasingly dependent on the proper functioning of the electric power system, which in turn supports most other critical infrastructures: water and sewage systems; telecommunications, internet and computing services; air traffic, railroads and other transportation. Many of these other infrastructures are able to operate without power for shorter periods of time, but larger power outages may be difficult and time consuming to restore. Such outages might thus lead to situations of fully non-functioning societies with devastating economical and humanitarian consequences. For this reason, the FP7 Viking Project has decided to concentrate its research to the systems for transmission and distribution of electric power. We anticipate that most of the results will be applicable to the protection of other critical infrastructures.
The operation and management of the electric power system depend on computerized industrial control systems. Keeping these systems secure and resilient to external attacks as well as to internal operational errors is thus vital for uninterrupted service. However, this is challenging since the control systems are extremely complex. Yet, the systems are operating under stringent requirements on availability and performance: If control and supervision are not done in real-time, the power network may come to a collapse.
The objective of the project is to develop, test and evaluate methodologies for the analysis, design and operation of resilient and secure industrial control systems for critical infrastructures. Methodologies will be developed with a particular focus on increased robustness of the control system. As mentioned, the focus is on power transmission and distribution networks. The project combines a holistic management perspective—in order to counteract sub-optimization in the design—with in-depth analysis and development of security solutions adapted to the specific requirements of networked control systems.

Biography:
Pontus Johnson is Professor at the Royal Institute of Technology in Stockholm, Sweden. He is the principal investigator of the FP7 Viking project. He also leads the research on Enterprise Architecture at the Department of Industrial Information and Control Systems. Active within this group are fifteen researchers and PhD students focusing particularly on the analysis of architectural models of information systems and their context. Pontus is the secretary of the IFIP Working Group 5.8 on Enterprise Interoperability, organizer, program committee member, associate editor and reviewer of several conferences, workshops, and international journals. He supervises a number of PhD students. He is also the coauthor of a book with the title Enterprise Architecture: Models and Analyses for Information Systems Decision Making, available in many book stores. Pontus received his MSc from the Lund Institute of Technology in 1997 and his PhD and Docent title from the Royal Institute of Technology in 2002 and 2007. He was appointed professor in 2009.

COST is supported by
the EU RTD Framework Programme

Toward Resilient, Self-healing and Smart Interdependent Infrastructures

Massoud Amin
University of Minnesota, USA

Abstract:
How to manage or control a heterogeneous, widely dispersed, yet globally interconnected system is a serious technological problem in any case. It is even more complex and difficult to control it for optimal efficiency and maximum benefit to the ultimate consumers while still allowing all its business components to compete fairly and freely.
From a broader view, global trends toward interconnectedness, privatization, deregulation, economic development, accessibility of information, and the continued technical trend of rapidly advancing information and telecommunication technologies all suggest that the complexity, interactivity, and interdependence of infrastructure networks will continue to grow.
Virtually every crucial economic and social function depends on the secure, reliable operation of energy, telecommunications, transportation, financial, and other infrastructures. From a strategic R&D viewpoint, the agility and robustness/survivability of large-scale dynamic networks that face new and unanticipated operating conditions is being addressed. A major challenge is posed by the lack of a unified mathematical framework with robust tools for modeling, simulation, control and optimization of time-critical operations in complex multicomponent and multiscaled networks.
Mathematical models of such complex systems are typically vague (or may not even exist); moreover, existing and classical methods of solution are either not available, or are not sufficiently powerful. Any complex dynamic infrastructure network typically has many layers, decision-making units and is vulnerable to various types of disturbances.
Management of disturbances in all such networks, and prevention of undesirable cascading effects throughout and between networks, requires a basic understanding of the true system dynamics, rather than mere sequences of steady-state operations. In addition, in many complex networks, the human participants themselves are both the most susceptible to failure and the most adaptable in the management of recovery.
In any situation subject to rapid changes, completely centralized control requires multiple, high-data-rate, two-way, communication links, a powerful central computing facility, and an elaborate operations control center. But all of these are liable to disruption at the very time when they are most needed, i.e., when the system is stressed by natural disasters, purposeful attack, or unusually high demands. Effective, intelligent, distributed control is required that would enable parts of the networks to remain operational and even automatically re-configure in the event of local failures or even threats of failure.
This presentation briefly describes holistic risk-managed dynamical systems approaches to analysis of the interdependent national infrastructure that build on advances in the mathematics of complexity, methods of probabilistic risk assessment, and techniques for fast computation and interactive simulation with the goal of increased agility and resilience for large-scale systems.

COST is supported by
the EU RTD Framework Programme

Biography:

Dr. Massoud Amin, Professor of Electrical and Computer Engineering, holds the Honeywell/H.W. Sweatt Chair in Technological Leadership, and is the Director of the Technological Leadership Institute at the University of Minnesota in Twin Cities. In addition to his administrative and research responsibilities, he serves as the director of graduate studies for the security technologies program and teaches several courses.

His research focuses on two areas: 1) Global transition dynamics to enhance resilience, agility, security and efficiency of complex dynamic systems. These systems include national critical infrastructures for interdependent energy, computer networks, communications, transportation and economic systems; and 2) Strategic scanning, mapping, assessment and valuation to identify new science and technology-based opportunities that meet the needs and aspirations of consumers, organizations, and the broader society.

Prior to joining the University of Minnesota in March 2003, Dr. Amin held positions of increased responsibility including head of Mathematics and Information Sciences and Area Manager of Infrastructure Security, Grid Operations/Planning, Energy Markets, Risk and Policy Assessment at the Electric Power Research Institute (EPRI) in Palo Alto, California.

In the aftermath of the tragic events of 9/11, he directed all security-related research and development at EPRI, including the Infrastructure Security Initiative (ISI) and the Enterprise Information Security (EIS). Prior to October 2001, he served as manager of mathematics and information science at EPRI, where he led strategic research in modeling, simulation, optimization, and adaptive control of national infrastructures for energy, telecommunication, transportation, and finance.

At EPRI, Dr. Amin pioneered R&D into smart grid, coined the term 'self-healing grid' and led the development of more than 24 advanced technologies transferred to the industry.

Dr. Amin serves on several boards including the Board on Infrastructure and the Constructed Environment (BICE) at the U.S. National Academy of Engineering (2001-2007), and is a member of the Board on Mathematical Sciences and Applications (BMSA) at the National Academy of Sciences. Dr. Amin is the author or co-author of more than 170 research papers and the editor of seven collections of manuscripts, serves on the editorial boards of six academic journals. Please see http://umn.edu/~amin for selected presentations and publications.

Distributed Monitoring of Large-Scale Critical Infrastructure Systems

Marios Polycarpou
University of Cyprus, Cyprus

Abstract:
The intelligent management, monitoring and security of critical infrastructure systems is becoming increasingly more challenging as their size, complexity and interactions are steadily growing. Moreover, these critical infrastructures are susceptible to natural disasters, frequent failures, as well as malicious attacks. Therefore, there is an urgent need to develop a common system-theoretic framework for modeling the behavior of various critical infrastructure systems and for designing algorithms for intelligent monitoring, control and security of such systems. The goal of this presentation is to motivate the need for a new system-theoretic framework suitable for critical infrastructures and to describe a distributed monitoring approach based on networked intelligent agent systems. We will present a distributed fault diagnosis and accommodation framework and provide a methodology for detecting, isolating and accommodating both abrupt and incipient faults in a class of complex nonlinear dynamic systems.

Biography:
Marios M. Polycarpou is a Professor of Electrical and Computer Engineering and Director of the KIOS Research Center for Intelligent Systems and Networks at the University of Cyprus. He received the B.A. degree in Computer Science and the B.Sc. degree in Electrical Engineering both from Rice University, Houston, TX, USA in 1987, and the M.S. and Ph.D. degrees in Electrical Engineering from the University of Southern California, Los Angeles, CA, in 1989 and 1992 respectively. In 1992, he joined the University of Cincinnati, Ohio, USA, where he reached the rank of Professor of Electrical and Computer Engineering and Computer Science. In 2001, he was the first faculty and the founding department Chair of the newly established Electrical and Computer Engineering Department at the University of Cyprus. His teaching and research interests are in intelligent systems and control, adaptive and cooperative control systems, computational intelligence, fault diagnosis and distributed agents. Dr. Polycarpou has published more than 195 articles in refereed journals, edited books and refereed conference proceedings, and co-authored the book *Adaptive Approximation Based Control*, published by Wiley in 2006. He is also the holder of 3 patents.

Prof. Polycarpou is currently the Editor-in-Chief of the *IEEE Transactions on Neural Networks*. He serves as an Associate Editor of two international journals and past Associate Editor of the *IEEE Transactions on Neural Networks* (1998-2003) and of the *IEEE Transactions on Automatic Control* (1999-2002). He served as the Chair of the Technical Committee on Intelligent Control, IEEE Control Systems Society (2003-05) and as Vice President, Conferences, of the IEEE Computational Intelligence Society (2002-03). He is currently an elected member of the Board of Governors of the IEEE Control Systems Society and an elected AdCom member of the IEEE Computational Intelligence Society. Dr. Polycarpou was the recipient of the William H. Middendorf Research Excellence Award at the University of Cincinnati (1997) and was nominated by students for the Professor of the Year award (1996). His research has been funded by several agencies in the United States, the European Commission and the Research Promotion Foundation of Cyprus. Dr. Polycarpou is a Fellow of the IEEE.

COST is supported by the EU RTD Framework Programme

The Structured Intelligence Approach for Modelling and Simulation of Intelligent Behaviour

Essam Badreddin
University of Heidelberg, Germany

Abstract:
A generic structure for the modelling and simulation of intelligent behaviour is proposed.
The main building blocks are Innovation, Memory, Learning and Fusion. Innovation, in contrast to creativity, is an interesting component that has not been adequately covered in the intelligence research. This structure offers a formal framework for studies and investigations of human and machine intelligence that avoids linguistic definitions.
In particular, it allows for comparative simulations and implementations of intelligent behaviours.
It is shown how it can be employed for the intelligent agent and its environment (intelligence-in-the-loop). Prototypical implementations of the different blocks are proposed and latest experimental results of the path-planning problem for an autonomous mobile robot are discussed.

Biography:
Prof. Dr.sc.techn. Essam Badreddin is currently the head of the Automation laboratory at the University of Heidelberg, Germany.
He earned his Swiss Diploma (Dipl.Ing. ETH) in Electrical Engineering, the Doctor of technical sciences (Dr.sc.techn.) in Control Theory and Habilitation (Habil.) in Mechanical Engineering from the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland.
He then served in the industry at Contraves-Zurich as an R&D System Engineer in the air-defence sector, where he also holds several international patents (Silver Dollar awarded).
He returned to the ETH-Zurich to found and lead the first robotics research group and build, one of if not, the first autonomous mobile robot of an industrial scale in Europe and introduce one of the first courses on the design of autonomous mobile robots worldwide. As Deputy Chair for Risk&Safety Technology, he lead the research group for risk and safety modeling & assessment at the ETH-Zurich.
In Japan, he served as a Monbushu associate Prof. at Toyohashi University of Technology before he moved to Germany to establish and lead the Automation Laboratory at the Institute of Computer Engineering at the University of Mannheim; currently at the University of Heidelberg.
Prof. Badreddin's research interests span process control, robotics, cognitive engineering and dependable hybrid systems.
Among other national and international boards, he is the coordinator of the European project OpenGain and the State project ECOMODIS, a member of the management committee and financial raporteur of the European project IntelliCIS, peer-reviewer for the United Nation and reviewer of the German Research Foundation (DFG).

COST is supported by the EU RTD Framework Programme

Wireless, Wired and Hybrid monitoring systems

Cesare Alippi

Politecnico di Milano, Italy

Abstract:
Recent advances in embedded systems have provided a large number of monitoring applications of Wireless Sensor Networks and environmental-based monitoring system. Unfortunately, only few of them are credible, here to be intended as effective, able to survive in harsh environments for long time, autonomous also declined in the energy harvesting ability. It appears that most authors focus on the wireless aspect which is an interesting issue addressing communication. What it is generally forgotten is that the wireless component is a degree of freedom but not a trendy compulsory gadget. As a matter of fact, many and many applications should be solved with a "less wired" philosophy instead of a "fully wireless" one due to sensors bandwidth, application constraints and energy availability.

In this direction, hybrid solutions can be considered with the wireless unit managing a wired sub-network with sensorial units connected through a fieldbus. Starting from wired solutions the presentation will address some aspects related to the design of wireless and hybrid wireless sensor networks with attention devoted to energy harvesting and management aspects at the unit and network levels.

Two applications, i.e., marine environment and rockfall monitoring will be the experimental leitmotiv of the presentation.

Biography:
Cesare Alippi received the Dr.Ing. degree in electronic engineering (summa cum laude) in 1990 and the Ph.D. degree in computer engineering in 1995, both from Politecnico di Milano, Milan, Italy. He has completed research work in computer sciences at the University College, London, U.K., and the Massachusetts Institute of Technology, Cambridge, MA. Since 2002, he is a Full Professor in Information Processing Systems at Politecnico di Milano.

Alippi is a Fellow of the IEEE, Associate Editor of the *IEEE-Transactions on Instrumentation and Measurements*, Associate Editor of the *IEEE-Transactions on Neural Networks*, Chair of the *IEEE Neural Networks technical Committee of the IEEE Computational Intelligence Society*, Co-Chair of the *Technical Committee TC-22 Intelligent Measurement Systems of the IEEE Instrumentation and Measurement Society*.

In 2004 he received the IEEE Instrumentation and Measurement Society Young Engineer Award. Current research activity addresses Adaptive Algorithms in non-stationary environments, and Active and Passive Intelligent Wireless Sensor Networks. Research is also carried out on the industrial front with several well known companies. Alippi holds 5 patents and has published more than 150 papers in international journals and conference proceedings.

Home Page: http://home.dei.polimi.it/alippi/

COST is supported by the EU RTD Framework Programme

Technologies and Infrastructures for Information and Knowledge Processing in Intelligent Monitoring Systems

Vincenzo Piuri
Università degli Studi di Milano, Italy

Abstract:
Modular information and knowledge processing infrastructures are increasingly needed to create intelligent monitoring systems for modern applications. These complex systems should be able to easily incorporating hardware and software components dedicated to specific aspects of the monitoring process (e.g., sensing, data acquisition, signal and image processing, data storing and transmission, networking, hierarchical control, data analysis, data fusion, data mining, knowledge discovery, resilience, maintenance). Very critical aspects of modular infrastructures are the global system structure, data analysis and networking, in a strongly interdisciplinary scenario.
To address the needs for modularity, interoperability, integration, and scalability multi-agent architectures have been proved effective. The hardware support for this structure is a distributed information processing architecture, possibly encompassing robots for active mobile search of data in the environment, sensor networks and wireless sensors networks for data collection from the field, and satellites for remote sensing. The multi-agent software architecture allows for easily modeling the complex activities to be carried out in this scenario by logically partitioning the operations among cooperating entities, each focusing on specific subtasks. Modularity is ensured by the overall framework in which specialized agents can be connected to deal with specific activities. Partitioning and information hiding allow also for structuring the operations so that management responsibility is distributed in the infrastructure. Modularity allows for introducing a hierarchical management model to coordinate the systems activities and the cooperation among agents, possibly by introducing a holonic perspective. Cooperation and modularity allow also for ensuring resilience of the overall system when sufficient redundancy has been taken into account in the design phase.
To extract information in particular from sensor data and, then, to create new knowledge from the collected information about the environment, suited techniques for data analysis, data fusion and knowledge extraction and discovery should be adopted. The modular architecture of the monitoring system allows for integrating these technologies for multi-sensor data fusion, feature extraction, data mining and knowledge extraction, typically based on computational intelligence methods.
When monitoring systems are connected to a network to easy the data access or when the system structure itself includes networking to interconnect various information processing units, security of the interconnection network and the databases as well as privacy of data become of paramount importance, especially for mission-critical applications. In these cases it is important both to prevent intrusion of unauthorized persons in the system infrastructure and access to data, and to ensure not to disclose critical information which may be related to sensible information or operations.

Biography:
Vincenzo Piuri obtained the Ph.D. in Computer Engineering in 1989, at Politecnico di Milano, Italy. Since October 2000 he is Full Professor in Computer Engineering at the Università degli Studi di Milano, Italy. His research interests include signal/image processing for industrial and environmental applications, theory and industrial applications of neural networks, and intelligent measurement systems. Original results have been published in more than 250 papers in book chapters, international journals, and proceedings of international conferences. He is IEEE Fellow and ACM Distinguished Scientist. He was President of the IEEE Computational Intelligence Society and Associate Editor of the IEEE Transactions on Instrumentation and Measurement and the IEEE Transactions on Neural Networks; he is Vice President for Publications of the IEEE Systems Council.

COST is supported by the EU RTD Framework Programme

Risk-based Methodology for Monitoring and Operational Management of Water Distribution Systems

Dragan Savic
University of Exeter, United Kingdom

Abstract:
Data collection and communications systems, which are being installed by the water industry to provide up-to-date information on the state of their water networks, are mostly used to monitor the system and raise alarms and less for extracting useful knowledge for more efficient operation, reduced energy consumption and reduced costs. This talk will present an application of a risk-based methodology to health monitoring and operational management of a water distribution system under failure conditions. Information gathered from the field, including near real-time pressure and flow data and customer contacts, is combined in order to identify the most likely locations of failures. Furthermore, the impact of potential failures is evaluated using a set of proposed operational impact factors based on the outputs from a pressure-driven hydraulic model coupled with a GIS and a discolouration model. The methodology enables system operators to investigate failures based not only on the information about the likelihood of occurrence, but as also based on the impact the failures might cause. The risk-based decision making is illustrated on a case study in the UK and set into a broader context of a decision support system helping operators to prioritize actions when abnormal situations arise. One of the main benefits of the methodology presented here is that it enables operators to become more effective and efficient in handling these situations.

Biography:
Dragan Savic is Professor of Hydroinformatics at the University of Exeter, UK, where he has been since 1994. He is also Director of the Centre for Water Systems (www.ex.ac.uk/cws) and Head of Informatics Research Institute.
His research and teaching interests are in urban water systems and hydroinformatics, focusing on decision support methodologies for water and wastewater asset management. He has co-authored four books, four edited volumes and published over 100 research and professional papers in refereed journals. He is currently serving as the Editor-in-Chief for the Journal of Hydroinformatics.
Professor Savic has lectured extensively abroad and has given research presentations at many national and international conferences and institutions on all continents. He is currently a Visiting Professor at the Universities of Bari (Italy) and Belgrade (Serbia), UNESCO-IHE (Delft, The Netherlands) and Harbin Institute of Technology (Harbin, China).

COST is supported by the EU RTD Framework Programme

Intelligent Control and Security of Critical Infrastructure Systems: methodology, structures, algorithms and applications to drinking water distribution systems and integrated wastewater treatment systems – control systems engineering approach

Mietek Brdys
Gdansk University of Technology, Poland

Abstract:
The CIS are spatially distributed and of a network structure. The dynamics is nonlinear, uncertain and with several time scales. There is variety of different objectives to be reliably met under a wide range of operational conditions. The operational conditions are influenced by the disturbance inputs, operating ranges of the CIS, faults in the sensors and actuators and abnormalities occurring in functioning of the physical processes.
The lecture will discuss the intelligent multiagent structures for controlling such systems and performing the security functions by employing the control systems engineering approach. Each agent is an intelligent unit of high autonomy to perform the control and security functions over an allocated region of the CIS. Its mechanisms are structured in a form of a multilayer hierarchy. The regional agents are then integrated into the multiagent structure capable of handling an overall CIS. Several structures will be considered starting from the completely decentralised ones with passive information system regarding interactions between the local regions and ending up with the hierarchical architectures with the coordinating units, which are equipped with the instruments to coordinated activities of the agents across their functional layers. The required ability of the control system to meet the control objectives under a wide range of operating conditions will be achieved by supervised reconfiguration of the agents. Recently proposed robustly feasible model predictive control technology (one/multiple criterion) with soft switching mechanisms between different control strategies will be the control technology very suitable for soft and safe agent reconfiguration. Fault tolerant mechanisms will be employed to accommodate faults that will not require changes of the control strategies.
The generic ideas and solutions will be illustrated by applications to two CIS's: drinking water distribution systems and integrated wastewater treatment systems.

Biography:
Mietek A. Brdys received the M.Sc. degree in Electronic Engineering and the Ph.D. and the D.Sc. degrees in Control Systems from the Institute of Automatic Control at the Warsaw University of Technology in 1970, 1974 and 1980, respectively. From 1974 to 1983, he held the posts of Assistant Professor and Associate Professor at the Warsaw University of Technology. In 1992 he became Full Professor of Control Systems in Poland. Between 1978 and 1995, he held various visiting faculty positions at the University of Minnesota, City University, De Montfort University and University Polytechnic of Catalunya. Since January 1989, he has held the post of Senior Lecturer in the School of Electronic, Electrical and Computer Engineering at University of Birmingham where he is Head of Decision Support and Control. Since February 2001 he has held the post of Full Professor of Control Systems in the Department of Automatic Control at Gdansk University of Technology. In 2008 he founded at Gdansk University of Technology the Department of Control Systems Engineering and became its head. He has served as Consultant for Honeywell Systems and Research Centre in

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Minneapolis, GEC Marconi and Water Authorities in UK, France, Spain, Germany and Poland. His research is supported by the UK and Polish Research Councils, and industry and European Commission. He is author and co-author of about 220 refereed papers and six books. His current research includes hierarchical multilayer and spatially distributed structures and algorithms for intelligent decision support and control of complex uncertain systems, robust monitoring, diagnosis and fault tolerant control, softly switched robustly feasible model predictive control, supervisory control, hybrid dynamics. The applications include: monitoring, control and security of integrated quality and quantity in drinking water networks under a wide range of operational states; hierarchical multilayer control of integrated wastewater systems under full range of weather scenarios, optimizing control of technological processes, autonomous intelligent vehicles and defence systems. He is a Chartered Engineer, a Member of the IEE, a Senior Member of IEEE, a Fellow of IMA and a Chair of IFAC Technical Committee on Large Scale Complex Systems. He was IPC Chair of the 11th IFAC Symposium on Large Scale Complex Systems, Gdansk, July 23-25, 2007.

Multi-objective optimization of urban water networks: two problems

Dimitri P. Solomatine
UNESCO – IHE Institute for Water Education, The Netherlands

Abstract:
There are several areas in urban water management where multi-objective optimization is of help. We present two problems here.
First, the problem of operational responses for contaminant flushing in water distribution networks is considered. Contamination emergency in water distribution systems is a complex situation where optimal operation becomes important for public health. Under emergency corrective operational actions for flushing the pollutant out of the network are needed, which have to be fast and accurate. Under such a stressful situation, trial-and-error simulation experiments with the hydrodynamic and water quality models cannot be applied since significant number of model evaluations may be required to identify the optimal solution. A methodology for finding optimal set of operational changes in a supply network for flushing a contaminant with minimal impact on the population has been developed. The situation is posed as an optimization problem, which is solved by using single- and multi-objective evolutionary optimization approaches, in combination with the EPANET solver engine. The methodology is tested on a simple, imaginary network configuration, as well as on a real case study. The results prove the usefulness of the approach for advising the operators and decision makers.
The second problem relates to urban flooding which has become a very important and growing issue around the world. In order to maintain an acceptable performance of urban drainage systems (UDS), early rehabilitation plans must be developed and implemented. The allocation of funds to support rehabilitation works must be optimized. This is a complex task linked to the rehabilitation process, technical, environmental and social interests, which are typically conflicting. In this respect, multi-objective optimization using hydrodynamic urban drainage models appear to be promising and more reliable than the traditional engineering approaches and it was used in this paper for the evaluation of urban drainage rehabilitation scenarios. A realistic rehabilitation problem has been posed and solved. The approach undertaken has proved to be efficient and effective and can provide valuable information for decision makers.

Biography:
Dimitri Solomatine started his professional career in 1979 at the Institute for Systems Studies (Russian Academy of Sciences). In 1990 he joined IHE Delft in The Netherlands (currently UNESCO-IHE Institute for Water Education) where currently he is the Professor in Hydroinformatics and Head of Core. His research interests include various aspects of hydroinformatics including data-driven modelling of water-related processes, Internet-based computing, systems analysis, optimization. He was and is an active participant of various research projects, including those funded by EU. He (co) authored 150+ publications and co-edited several special journal issues. One of the latest works to that could be mentioned is the edited volume (together with Linda See and Bob Abrahart) “Practical Hydroinformatics” (Springer, 2008).

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Early warning monitoring design and forensic investigation in drinking water systems

Marco Propato
Cemagref, Bordeaux, France

Abstract:
Technological developments, increased security concerns and regulatory requirements call for new, sensitive sensor devices to continuously monitor water quantity and quality in drinking water distribution systems. Consequently, there is a growing need to develop appropriate methods to acquire, process and interpret large amounts of data in real time to assist the decision making process for optimal system management. I will present recent methodologies to design early warning systems to prompt the appropriate response to eliminate or mitigate consumer exposure should a contamination event occur in. In general, design requirements are multiple: it should provide maximum public health protection, cover all possible threats, should be affordable and be able to identify the contamination source. A procedure that uses probability theory is proposed to assist the forensic investigation following contaminant detection to identify the probable source locations. Finally, I will discuss challenges and opportunities of continuous monitoring of quality and hydraulics to better manage drinking water systems operation.

Biography:
Dr. Propato has a bachelor's degree in Physics from the University of Florence, Italy, and received his PhD in Environmental Science and Engineering from the University of Cincinnati, USA in 2003. Since then, he has returned to Europe and joined, as a recipient of a European Marie Curie Reintegration Research Grant, the networks, water treatment and water quality research unit of Cemagref in Bordeaux, France. His research interests are in environmental systems analysis, design of drinking water distribution systems operation, asset management, and water quality monitoring and maintenance. He is currently involved in the collaborative research project SECUREAU on security and decontamination of drinking water distribution systems following a deliberate contamination supported by the European Commission under the Seventh Framework Programme. He collaborates with Brazilian colleagues to develop mathematical approaches and implement technologies for the simulation, design, control, and operation of water systems. In addition, he serves as a reviewer of several environmental engineering journals and as an independent expert to assist the European Commission in the monitoring of funded research projects.

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