Internet of Things: Application Areas and Research Results of the FIRST Project

Zoltán Gál, Béla Almási, Tamás Dabóczi, Rolland Vida, Stefan Oniga, Sándor Baran, István Farkas

***Abstract* - The FIRST/IoT project coordinated by the Faculty of Informatics, University of Debrecen, Hungary has important impact on the R&D work in this field. Six activity areas have been covered in the twenty-seven months long project. More than thirty researchers from half dozen Hungarian and other universities and research institutes have been involved in this activity. The results of this work are planned to be used for other international IoT projects in the following time period. Other institutes and individual researchers from abroad are invited to join to this open initiative and become partner. In the paper are presented the results and the most exciting aspects of the research activity.**

***Index Terms* - IoT, MPT, Sensor/Actuator, Big Data, Data Clusterization, Cyber-Physical Space, Bloom-filter, E-health, Ensemble Forecasting, Virtual Organization.**

1. Introduction

Several universities and academic research institutes in Hungary working together with over forty professors and researchers from the United Kingdom, Russia and Romania are involved in effective research activity in the topics of IoT. Faculty of Informatics of the University of Debrecen in Hungary has leader role in the IoT research based on consortium project financed by the EU structural fund and the government of Hungary.

The R&D activity includes six topics: i) Integration of the IoT into the IPv4/IPv6 systems (development and analysis of multipath protocol stack networks; evaluation of L1/L2 transmission mechanisms of the sensor networks; energy usage efficiency of WSNs; analysis of the random fields defined on space-time domain to model the transmission events of radio channels - kriging; cluster analysis of sensor variables; surprise event detection at CEP - Complex Event Processing and ESP - Event Stream Processing supported services; bilateral teleoperation over wireless networks). ii) Cyber physical systems (embedded digital systems and integration of the network technologies; analysis of the complex, real time, dynamic reconfigurable systems; network security and intrusion detection in sensor network critical infrastructures). iii) Self-optimizing and self-managing communication mechanisms of the IoT systems (context dependent addressing for IPv4/IPv6 and 6LoWPAN systems; context dependent clustering, routing and multicast on the IoT; opportunistic networking; context-aware communication for the IoT). iv) E-health powered by IoT (development of intelligent home and vital technologies; real time human activity monitoring; remote supervision; elder people activity recognition; life quality enhancing services; indoor localization techniques using wireless sensor network). v) Weather prediction network tool development and analysis (statistical calibration by BMA and EMOS methods of the temperature and wind velocity ensemble prognosis; analysis of the cosmic background relay with the spectrum of random fields defined on the sphere). vi) Development of testbeds and virtual service platforms (authentication method with two factors and increased security level). In the following chapters the subjects listed above are presented.

2. Integration of the IoT with the IPv4/IPv6 systems

In this topic two R&D fields were included. The importance of the multipath transmission (MPT) of the packet switched technology on network and transport layers was analysed. The effect of the MPT to the IPv4/IPv6 protocol stack was demonstrated by an own developed software library. The other group of tasks was oriented to the statistical analysis of the multicast traffic, to the cluster analysis of the data coming from network with high number of variables and to the frequency resource usage of a supercomputer system.

2.1 The MPT software library

The integration of the IoT with the IPv4/v6 systems opens questions on the efficient bandwidth usage of the available multiple interfaces (e.g. RJ-45, WiFi, 3G, Bluetooth) of the hosts (especially of mobile hosts) especially in the transition process from IPv4 to IPv6. The traditional IP communication infrastructure is restricted to a single IP address (and single interface) usage on the communication endpoints. The IP address is used not only to identify the interface of

[1] Manuscript received June 16, 2014, revised September 8, 2014.

Zoltán Gál, Béla Almási, Stefan Oniga and Sándor Baran are with the Faculty of Informatics, University of Debrecen, Hungary.

Tamás Dabóczi and Rolland Vida are with Inter-University Cooperative Research Centre, Hungary.

István Farkas is with National Information Infrastructure Development Institute, Hungary.

the node, but it is also used to identify the communication session (i.e. socket id). Distributing a communication session between different paths is an interesting question, and it is a focused research area today. Easy to see, that the usage of multiple interfaces and paths will increase the throughput of the communication (see e.g. [1]). If the communication session is terminated on a moving node (e.g. computer located on a moving car) the request of changing the IP address inside a communication session may appear. The traditional L3 roaming solution suffers from the efficiency problem of "triangular inequality". Opening the possibility of changing the IP address of the end node (with the assumption, that the communication session must continue the work), could open a quite new solution area for these situations: The moving computer could easily change its IP address without losing the communication session's state, and this solution could eliminate the triangular inequality problem.

At the Faculty of Informatics, University of Debrecen a software library was created (named as "MPT software library), which opens the possibility of using multiple interfaces (and multiple paths) inside a communication session between the endpoints. The individual paths can be turned off and on without losing the connection. The MPT introduces a new conceptual working mechanism, which differentiates the identification of the communication session (i.e. the socket id) and the identification of the physical interfaces. The solution is based on creating a logical (tunnel) interface on the endpoint. The logical interface is used to identify the node's communication sessions, and it is independent of the physical interfaces. The MPT software library maps the logical interface to multiple physical interfaces dynamically, so offering a L3 multipath working environment. Measurement results show, that the MPT library is able to aggregate the throughput of independent paths very efficiently (see [1], [2]). As the logical interface and the physical interfaces are handled independently, it is also possible to use different IP versions on the logical interface (i.e. by the communication software) and in the physical network environment (see [2]), so the MPT library also offers a seamless IP version changing solution. The detailed description on the MPT library can be found in [3].

2.2. Analysis of the IPv4/IPv6 data traffic and control signals transmitted through the sensor networks

The service effect of the new virtual interfaces based on the new IEEE 1905.1 technology was analysed in PAN/SOHO environment. The current smart devices (tablets, phones, etc.) have multiple physical interfaces with different communication technologies (i.e. Bluetooth, NFC, WiFi, USB) able to communicate concurrently. In the classical protocol stack architecture each interface should have own logical address to communicate simultaneously. A given logical address is mapped to the unique physical address of the interface and each logical address should be placed in separated logical network. Introducing a virtual interface function between the LLC and MAC sublayers, the smart device becomes a switch in the OSI layer L1.75 with only one logical address in the network layer. All the physical interfaces remain active with the own communication technology and participate in the merged group of layer L1.5 channels.

Nice results were obtained by the analysis of the congestion effect to the streaming transmission in low bandwidth, sensor based network environment. It was found that both, the channel load and the channel intensity need to be considered for proper evaluation of the congestion in homogeneous TCP or heterogeneous aggregated TCP/UDP multimedia traffic. The aggregated traffic of the congested streams has long range memory (LRD) characteristic [4].

The coexistence of different wireless transmission technologies (i.e. IEEE 802.11 and IEEE 802.15.4) on the same physical environment was studied in function of the frame size transmitted [5].

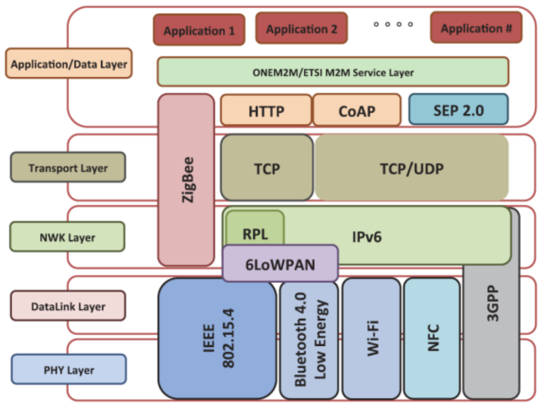

Fig. 1. Relation of the IoT technologies and the OSI model

The radio interference created in the 2.4 GHz radio channels produces three times higher error rate for the IEEE 802.15.4 channel as for the WiFi. Development of stochastic models for systems distributed in space and time and their application in the description of radio channel noise characteristics in WiFi system with high number of base stations serving as sensor nodes [6]. Based on this idea a new kriging method is proposed for continuous extrapolation of the signal field intensity in 4D physical coordinates (space-time domains) not sampled by the discrete sensor nodes [7].

Clustering method was developed and applied to extract information content from sensor network data sets and application of it to characterize the resource usage of a supercomputer system. The method based on artificial neural networks, cluster analysis and wavelets reduces by one order of magnitude the number of variables needed to be sampled to presage surprise events at the CEP (Complex Event Processing) and ESP (Event Stream Processing) supported services based on huge number of logical and physical sensor nodes [8].

3. Cyber-Physical Systems

A Cyber-Physical System is a special case of the Internet of Things. It is characterised by a very intense interaction with the physical processes, and usually cooperating nodes solve a common task. Within the frame of this project we aimed at combining the advantageous behaviour of embedded- and IT systems. We are going to extend the possibilities of embedded systems through utilization of high performance IT solutions and through the possibility of strong cooperation of separate nodes by means of interconnections through the high speed internet. However, in our view, the interconnection of large set of embedded systems serve as general purpose cyber-physical resources, rather than resources for dedicated purposes.

We envision a farm of embedded systems, with a large set of sensors and actuators as a universal infrastructure for gathering information from the physical world, for interacting with it through actuators, and also as a universal computation resource [9]. A user utilising this infrastructure can develop a new application, based on the available new and historic sensor information and can influence the environment (in a controlled way).

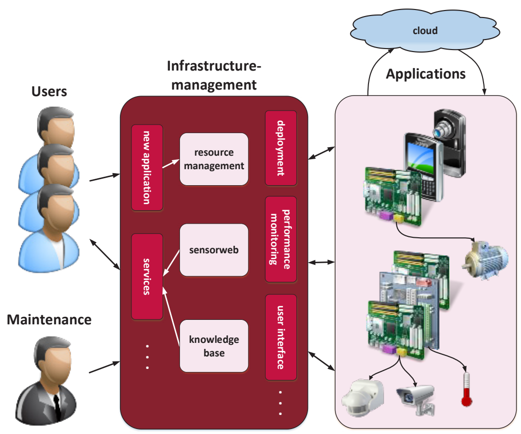

Fig. 2. Architecture of the Cyber-Physical infrastructure

New applications are automatically and dynamically allocated to embedded computing devices. Based on the measured resource utilization, the tasks are reallocated among devices in run-time by means of *Design-Space Exploration*. The above concept requires high level virtualization [10]. We use sensor virtualization (common interface, description structure and database) to access the information about physical processes from any embedded nodes. The possibility of reallocation of tasks also requires a certain level of virtualization, which might range from process *virtualization* to full platform virtualization. The computing nodes are strong enough to host virtual machines, guest operation systems and several applications at a time. However, if the application is very compute intensive, we can delegate certain parts of the calculations to the cloud (*cloud computing*) [11]. Sensor information collected by embedded nodes are accessible through an *ontology*, which allows the users to search for special types of sensors, or based on location, availability, accuracy etc.

4. Context-aware communication in the IoT

The 128-bit IPv6 addresses provide an unthinkably large address space, making it possible to assign trillions of addresses to each square centimetre on the surface of the Earth, so it is hard to envision any future scenario, including the "wildest" IoT-related predictions, whose needs would not be satisfied. However, in certain cases, size does not matter, or at least it is not the only thing that matters. The more relevant question is how can be those addresses used, how large will grow the routing tables, or how fast and how efficient can be the subsequent routing protocols and communication schemes. In the IoT we will probably very rarely use individual IPv6 addresses as is, we will not address a given sensor individually, but rather a group of smart "things" having in common some context-related characteristics. Therefore we propose to use a context-aware addressing and routing scheme, in which the network routes the queries to the proper place(s) based on a set of context parameters, but without knowing the IP addresses of the concerned objects.

We propose to encode context parameters in Bloom filters, which are considered a very resource-efficient and easy-to-process solution to handle set operations. IoT nodes will probably be grouped together in smaller areas behind several edge nodes connecting them to the traditional Internet architecture. The devices behind a specific edge will build and maintain a multi-hop tree over which context information in Bloom-filters can be easily exchanged and aggregated. When a context-based query is initiated, it will be rapidly routed to areas where IoT nodes exist, conforming to the requested context. The basic idea of this context-aware addressing solution was described in [12]. Currently we are working on implementing this approach in an IoT simulator and analysing its efficiency in different setups.

However, context-information can be very complex, involving several temporal and spatial correlations between the different context parameters. Capturing the evolution of most of these parameters is important, but usually only a very reduced set of these parameters affect effectively the behaviour of a given device, application or person. Another aspect of our research was therefore to provide a solution for filtering out these parameters based on the Hierarchical Temporal Memory approach (HTM), as described in [13].

5. E-health powered by IoT

In the present world, millions of people die every year due to lack of information about their health. Increased costs in the healthcare system could be reduced, if it would give more attention to disease prevention through regular assessment of health status and their treatment in the early stages. Our research is oriented to develop technologies for independent daily life assistance of elderly persons or others with disabilities and to improve the quality of human life using Internet of things (IoT) techniques.

Our scope is to bring together latest achievements in the domains of IoT and of assistive technologies in order to develop a complex assistive system with adaptive capability. Learning behaviour that allows living for as long as possible in familiar environment is also in focus of our research work. We use IoT technologies to monitor in real time the state of a patient or to get sensitive data in order to subsequently analyse and to enhance the medical diagnosis.

We have developed an assistive assembly consisting of a smart and assistive environment. This equipment allows also indoor localization based on wireless sensor network and Wi-Fi infrastructure [14]. It was developed a human activity and health monitoring system [15], an assistive and telepresence robot, together with the related components and cloud services. For activity and health pattern recognition we developed a hardware module for vital parameters monitoring (temperature, heart rate, acceleration). The acquired data is used to train neural network that allows recognition of activity or health status of the patient and trigger alert signal in case of unusual state detection. We implemented and tested a recognition system for arm posture, body postures and simple activities like standing, sitting, walking, running, etc., see Fig. 3. These states and movement forms were correlated with the data acquired from a heart rate sensor. The recognition rate of the body postures was over 99 % on the data sets used for training.

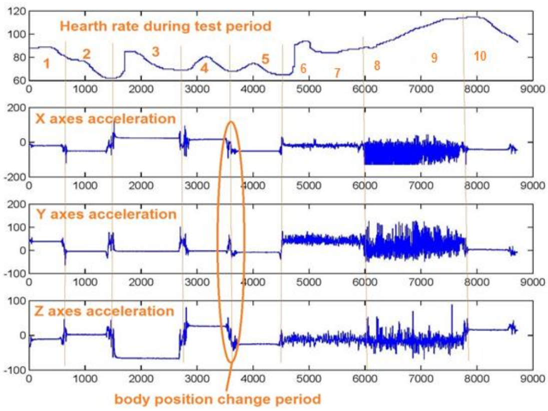

Fig. 3. Data acquired for 10 activities to be recognized.

On Fig. 4 can be seen that by setting the right threshold (red line) for the standard deviation, the static – dynamic postures discrimination can be easily differentiated. For recognizing the walking and running activities, we have extracted further relevant features from raw data set. The FFT transform was used to determine the stepping rate of a person as the most dominating frequency in the acceleration signal's spectrum.

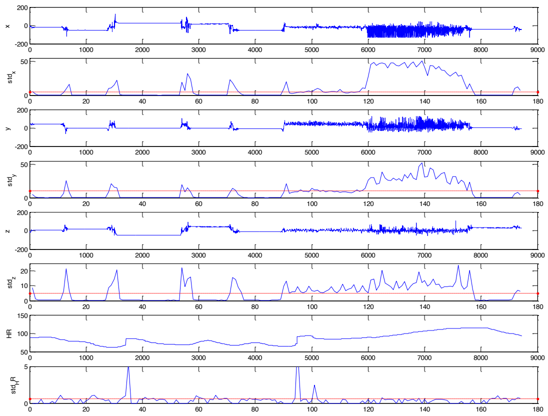

Fig. 4. Differentiating dynamic activity from static.

It was developed an own simulator application based on Qt application framework for feed forward neural networks [16]. Based on neural networks simulated in Matlab environment FPGA circuit was developed.

In our future development this monitoring module will be extended by new sensors (ECG, EMG, breath, etc.) and rules for sensor data fusion and fuzzy logic will be applied to enhance the body activity recognition. Further research based on different types of ANN is needed to simulate other activity/health status recognition. The best performing ANN type will be used to implement new recognition module based on FPGAs.

6. Weather prediction systems and analysis

The main area of our research is statistical post-processing of ensemble forecasts which is a pioneering work in this direction in Hungary. A forecast ensemble is obtained from several runs of a numerical weather prediction model with different initial conditions and makes possible the estimation of the probability distribution of future weather variables. This allows probabilistic weather forecasting, where not only the future atmospheric states are predicted, but also the related uncertainty information [20]. Recently several meteorological services provide ensemble forecasts, the leading organization is the ECMWF, while the Hungarian Meteorological Service (HMS) operates the ALADIN-HUNEPS ensemble prediction system. However, the spread of these forecast ensembles is often too small, they are uncalibrated and statistical methods are needed to account for this deficiency. The most popular tools of post-processing are the Bayesian Model Averaging (BMA) [22] and the Ensemble

Model Output Statistics (EMOS) [21]. Both approaches provide estimates of the densities of the predictable weather quantities and once a predictive density is given, a point forecast can be easily determined (e.g., mean or median value). As a first step we tested the existing BMA models implemented in the R package ensembleBMA on ALADIN-HUNEPS ensemble forecasts of wind speed [18] and temperature [19]. We found that statistical post-processing significantly improves the calibration of probabilistic and accuracy of point forecasts. We also developed a new univariate BMA model for wind speed prediction [17] and a bivariate BMA model for joint calibration of ensemble forecasts of wind speed and temperature. Both methods were successfully tested on ALADIN-HUNEPS ensemble forecasts and on forecasts of the University of Washington Mesoscale Ensemble and the results were compared to the predictive performances of the existing methods. We also performed a detailed comparison of BMA and EMOS calibration of ALADIN-HUNEPS temperature and wind speed forecasts and recently we are working on a new EMOS model for wind speed prediction. The predictive performance of this new model has already been tested on forecasts of wind speed of the UWME and of the ECMWF and ALADIN-HUNEPS ensemble prediction systems.

All new models are implemented in R and compatible with the existing ensembleBMA and ensembleMOS packages. The final goal of our research is the operation application of some statistical post-processing methods at the HMS.

7. Virtual service platforms and testbeds

More than 25 years of continuous development in the research networking area and later in the areas of those higher level e-Infrastructure services as grids, clouds, HPC, storage, collaboration and data infrastructures, have resulted in a leading edge e-Infrastructure system in Hungary that offers the provision of national and international services for the entire Hungarian research and education as well as public collection communities. The service portfolio includes, among others, communication, information access, and collaboration tools and platforms (e.g. remote co-operation and virtual community environments). The country-wide Hungarian e-Infrastructure is connected into the European and global e-Infrastructures via GÉANT, the European backbone of the research and education community. The services, having been developed and being operated by the NIIF Institute, are available also for the Future Internet research communities, and are extended to novel opportunities such as providing Virtual Research Environment (VRE) platforms and supporting Virtual Research Organisations (VRO) by making applications VO ready. An important special example of the major activities related to the e-Infrastructure is the development of a Shibboleth 2.x IdP X.509/LDAP authentication module. The basic motivation is to provide the opportunity of using hardware tokens as authentication source. SPs can decide if they want to force the X.509 authentication, or intend to simply keep a password based solution. Besides Shibboleth X.509 authentication (with or without PKI), also X.509 + LDAP certificate authentication and combining X.509 with username/password authentication are also possible options.

Based on GÉANT, also a specific, reconfigurable testbed operating in a federated virtual networking environment is provided by NIIFI, and its European partners, to the R&D community. The Hungarian segment of the testbed infrastructure is built on the high speed network of NIIFI and, together with its international connections, it is also available for supporting Future Internet research activities. Application of a two-factor authentication module for simpleSAMLphp in the federated virtual networking environment and in the testbed system has been developed, in order to achieve increased security by pairing a time-based token with other credentials, such as a username and a password. SimpleSAMLphp is used as a SAML2 Single-Sign-on solution based on php. Google Authenticator implements time-based one-time password (TOTP) security tokens from RFC6238 in mobile apps made by Google. The Authenticator provides a six digit one-time password users must provide in addition to their username and password to log into Google services. The Authenticator can also generate codes for third party applications, such as password managers or file hosting services.

8. Summary

The FIRST/IoT R&D project executed with the collaboration of several universities and institutes from Hungary, United Kingdom, Romania, Ukraine and Serbia has considerable effect on the Internet of Things topic. More than thirty journal and conference proceeding papers were published based on the theoretical and practical research work during the last two years. The results obtained in this way are considered promising basics for the continuation of the IoT field by next international joint projects.

Acknowledgement

The publication/poster was supported by the TÁMOP-4.2.2.C-11/1/KONV-2012-0001 project. The project has been supported by the European Union, co-financed by the European Social Fund. Tamás Dabóczi also acknowledges the support of ARTEMIS JU and the Hungarian Ministry of National Development (NFM) in frame of the R5-COP (Reconfigurable ROS-based Resilient Reasoning Robotic Cooperating Systems) project.

References

[1] Almási, B., Szilágyi, Sz., "Throughput Performance Analysis of the Multipath Communication Library MPT", Proceedings of the 36th International Conference on Telecommunications and Signal Processing (TSP 2013, ISBN:978-1-4799-0403-7), pp. 86-90, Rome, Italy, 2013

[2] Lencse, G., Kovács, Á., "Testing the Channel Aggregation Capability of the MPT Multipath Communication Library", Proceedings of International Conference on Internet Technologies and Applications 2014 (ICITA 2014) (part of World Symposium on Computer Networks and Information Security 2014, WSCNIS 2014), Hammamet, Tunisia, Accepted to appear, 2014.

[3] Almási, B., "MPT Userguide", availale at http://irh.inf.unideb.hu/user/almasi/mpt

[4] T. Balla, Z. Gal, A. Sz. Karsai, "Resource allocation for real time application in low bandwidth network environment", Advances on Wireless Sensor Networks (AWSN 2013) Conference Proceedings, Debrecen, Hungary (ISBN: 978-963-318-356-4), pp 21-25, 2013.

[5] T. Balla, Z. Gal: "Overview of the Internet of Things Short Range Communication Technologies", Proceedings of the 9th International Conference on Applied Informatics (ICAI 2014), Eger, Hungary, January 29- February 1, 2014 (to appear)

[6] Z. Gal, T. Balla, A. Sz. Karsai, "On the WiFi interference analysis based on sensor network measurements", IEEE 11th International Symposium on Intelligent Systems and Informatics (SISY 2013) Conference Proceedings, September 26-28, 2013, Subotica, Serbia (ISBN: 978-1-4799-0303-0), pp 215-220, 2013.

[7] T. Subba Rao, Gy. Terdik: "A space-time covariance function for spatio-temporal random processes and spatio-temporal prediction (kriging)", arXiv:1311.1981 [math.ST], 2013.

[8] Z. Gal, Tibor Tajti, "Complex Event Processing in Supercomputer Environment: Sensor and Neural Network Based Analysis", Proceedings of IEEE 4th International Conference on Cognitive Infocommunications (CogInfoCom 2013), Budapest, Hungary (ISBN: 978-1-4799-1544-6), December 2-5, pp. 735-740, 2013.

[9] Dabóczi, T., Pataricza, A., Strausz, Gy., and Varró, D., "Next Generation Embedded Systems," Advances on Wireless Sensor Networks (AWSN 2013) Conference Proceedings, Debrecen, Hungary (ISBN: 978-963-318-356-4), pp. 47-52.

[10] Kovácsházy, T., Wacha, G., Dabóczi, T., Erdős, Cs., and Szarvas, A., "System Architecture for Internet of Things with the Extensive Use of Embedded Virtualization,", *4th IEEE International Conference on Cognitive Infocommunications - CogInfoCom 2013*. Budapest, Hungary (ISBN: 978-1-4799-1-1543-9), Dec. 2-6, 2013. IEEE Press, pp. 549-554.

[11] Kocsis, I., Toth, Á., Szatmari, Z., Daboczi, T., Pataricza, A., and Guta, G., "Towards Cyber-Physical System Technologies over Apache VCL," *2nd International IBM Cloud Academy Conference ICA CON 2014*, May 8-9, 2014, Atlanta, Georgia USA. pp 1-10.

[12] A. Kalmar, R. Vida, M. Maliosz. Context-aware Addressing for Internet of Things based on Bloom Filters, in proc. of IEEE CogInfoCom 2013, Budapest, Hungary, December 2013.

[13] A. Kalmár, R. Vida, „Towards Context-Aware Mobile Services Through the use of Hierarchical Temporal Memory", in Proceedings of SoftCom 2013 – 21st International Conference on Software, Telecommunications and Computer Networks, technically co-sponsored by IEEE Communications Society, Split-Primosten, Croatia, September 2013.

[14] A. Buchman, C. Lung, "On the relationship between received signal strength and received signal strength index of IEEE 802.11 compatible radio transceivers", Carpathian Journal of Electronic and Computer Engineering, Volume 6, no. 2, 2013, pp 15-20.

[15] S. Oniga, J. Sütő, "Human activity recognition using neural networks", IEEE 15th International Carpathian Control Conference - ICCC 2014, Velke Karlovice, l, Czech Republic, 28-30 May 2014, pp 403-406.

[16] J. Sütő, S. Oniga, "A new C++ implemented feed forward artificial neural network simulator", Carpathian Journal of Electronic and Computer Engineering, Volume 6, Number 2, 2013, pp 3-6.

[17] Baran, S., "Probabilistic wind speed forecasting using Bayesian model averaging with truncated normal components," Computational Statistics and Data Analysis, vol. 75, pp. 227-238, 2014.

[18] Baran, S., Horányi, A., and Nemoda, D., "Statistical post-processing of probabilistic wind speed forecasting in Hungary," Meteorologische Zeitschrift, vol. 22, pp. 273-282, 2013.

[19] Baran, S., Horányi, A., and Nemoda D., "Probabilistic temperature forecasting with statistical calibration in Hungary," Meteorology and Atmospheric Physics, vol. 124, pp. 129-142, 2014.

[20] Gneiting, T. and Raftery, A. E., "Weather forecasting with ensemble methods", Science, vol. 310, pp. 248-249, 2005.

[21] Gneiting, T., Raftery, A. E., Westveld, A. H., and Goldman, T., "Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation", Monthly Weather Review, vol. 133, pp. 1098-1118, 2005.

[22] Raftery, A. E., Gneiting,T., Balabdaoui, F., and Polakowski, M., "Using Bayesian model averaging to calibrate forecast ensembles," Monthly Weather Review, vol. 133, pp. 1155-1174, 2005.

Zoltán Gál (ZG'66) received MSc degree in electrical engineering and informatics from Politehnica University of Timisoara in 1990 and PhD degree in informatics from the University of Debrecen (UD) in 2010, respectively. Since 1991 he is lecturer at the Informatics Institute of Lajos Kossuth University of Debrecen and Department of Informatics of the UD. In 1999 he joined Cisco Network Academy Program where he is CCNA and CCNP registered instructor. He was chief information officer (CIO) of the UD and of the Center of Arts Humanities and Sciences of the UD for 2001-2006 and 2007-2013, respectively. He was presidency member of Hungarnet Association for ten years starting in 2005. As CIO he managed several infrastructure development projects at national and international levels including LAN, MAN, WAN and supercomputer installations. His research interest includes computer and network architectures, high speed and multimedia networks. He is member of IEEE Communications Society since 1997 and he is currently head of the Internet of Things subproject of the Hungarian national project named Future Internet Research Services and Technologies (FIRST). Dr. Gál is author of 50 papers and 75 conference publications and he wrote two books in computer architectures and cloud computing, respectively.

Béla Almási is an associate professor at the Department of Informatics Systems and Networks at the Faculty of Informatics, University of Debrecen, Hungary. He received his Ph.D. in 1998. at the University of Debrecen, Hungary and Habilitation from University of Debrecen in 2006. His primary research interests are network systems, multipath communication and performance analysis of queueing systems and their application.

Tamás Dabóczi received the M.Sc. and Ph.D. degrees in electrical engineering from Budapest University of Technology, Budapest, Hungary, in 1990 and 1994, respectively. In 1990 he joined the same university. He spent several months at the Swiss Federal Institute of Technology (ETH), Zürich, Switzerland as academic guest in 1992; at the Technical University of Karlsruhe, Germany as visiting researcher in 1994. In 1995 he was invited to National Institute of Standards and Technology, NIST, USA, Gaithersburg, MD as guest researcher, where he developed and implemented inverse filtering algorithm for calibration of ultra-high-speed digital sampling oscilloscopes. Currently he is an associate professor and deputy head of Department of Measurement and Information Systems, Budapest University of Technology and Economics, Budapest, Hungary. His research area includes embedded systems, cyber-physical systems, digital signal processing, especially inverse filtering. He is senior member of IEEE.

Rolland Vida, born in August 1974, obtained his BSc and MSc degrees in Computer Science, as valedictorian, from the Babes-Bolyai University Cluj-Napoca, Romania, in 1996 and 1997 respectively. He then pursued his PhD studies in Computer Networking at Universite Pierre et Marie Curie Paris VI, France, and obtained his PhD degree in 2002. In 2003 he joined Budapest University of Technology and Economics, Department of Telecommunications and Media Informatics, where he is currently an associate professor. Between 2007 and 2010 he was a Bolyai Janos Postdoctoral Research Fellow of the Hungarian Academy of Sciences. His research interests are mostly related to wireless sensor networks, internet of things, vehicular networking, peer-to-peer communications and multicast technologies. He is member of IEEE, and is involved in the organization of many international conferences, either as a member of the TPC or the Organizing Committee. He is currently the Operations Manager of the GLOBECOM/ICC Management & Strategy Committee of the IEEE Communications Society. Dr. Vida was involved in several national and international research projects, participating in numerous FP5, FP6 or FP7 consortia. He has published more than 65 research papers, which generated more than 600 independent citations.

Stefan (István) ONIGA was born in Baia Mare, Romania, on Apr. 20, 1960. He received his M.Sc. and Ph.D. degrees from PUT ("Politehnica" University of Timisoara) in 1985 and 2005, respectively. Since 1992 he has been working at Faculty of Engineering, North University of Baia Mare (now North University Center of Baia Mare, Technical University of Cluj-Napoca), where he holds a position of associate professor in Digital Design, Microcontrollers and Embedded Systems. Between 2008 and 2010 was director of Electronic and Computer Engineering Department. Since 2010 he is associate professor at Faculty of Informatics, University of Debrecen where he teaches Digital Design with Programmable Logic, Digital Technologies, and Reconfigurable Embedded Systems. He is the author and co-author of more than 80 journal and conference papers, 20 research projects and 6 books and books chapters. His major areas of interest are embedded systems design and applications, implementation of artificial neural networks in field-programmable gate arrays, digital neural network based smart devices, e-Health systems and ambient assisted living and assistive robots. Dr. Oniga is chief editor of the peer reviewed journal Carpathian Journal of Electronics and Computer Engineering. He is a member of IEEE, Industrial electronics society since 2006.

Sándor Baran (SB'73) graduated as a mathematician in 1995 and as a teacher of mathematics and English-Hungarian technical translator of mathematics in 1996 at the Kossuth Lajos University in Debrecen. He received PhD degree in Mathematics and Computer Science at the University of Debrecen (UD) in 2001 and in 2006 he defended his habilitation thesis at the same institution. From 1999 instructor, from 2001 assistant professor and from 2006 associate professor at the Department of Applied Mathematics and Probability Theory of the Faculty of Informatics of the UD. Between March and September 2013 he worked as a visiting professor at the University of Heidelberg. For his research work in statistics and probability theory he was twice awarded by the Bolyai János Mathematical Society, between 2001 and 2004 he was a grant holder of the Bolyai Grant of the Hungarian Academy of Sciences (HAS) and in 2012 he was awarded by the Gyires Béla Price of the HAS. From 2012 he is a member of the Regional Committee of the Bernoulli Society. Sándor Baran's research topics are measurement error regression models, parameter estimation of random fields, autoregressive and other time-series models, spatial autoregression, stochastic optimization (simulated annealing), probabilistic weather forecasting, applied statistics (biological, geological and medical applications). He has published 33 papers is refereed journals, 6 papers in conference proceedings, co-author of a university lecture notes and has given 40 talks and 2 poster presentations on international conferences.

István Farkas (1976–) is a network systems engineer at the National Information Infrastructure Development Institute (NIIFI) since 2006. He is head of the Network Operation Department at this institute. Prior to this he was research fellow at the Hungarian Academy of Sciences Institute for Computer Science and Control (MTA SZTAKI). He worked together with the NIIFI team since 1999, where his main activities included operation and maintenance of the Hungarian research network (HBONE) connection to the European TEN-34/TEN-155 network. He was technical representative of the Hungarian research backbone network (HBONE) in the European research network project, GÉANT/GÉANT2 since 2000 and 2004, respectively. He is member of the HBONE project leaders since 2004.