Editorial

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Biographical notes: Theodore Tsiligiridis is a Professor at the InfoLab, General Sciences Department, Agricultural University of Athens, Greece. He worked in various public and academic posts and he coordinated (or actively involved) many research and development projects. His research interests include traffic modelling and performance evaluation of broadband, high-speed networks and wireless multimedia communication. He also works in the area of ambient intelligence, ubiquitous computing – communication, intelligent user interfaces, location based services and GIS, middleware architectures, multi-agent and web-service technologies, particularly applied in environmental pervasive systems. He is a member of IEEE, ACM, Mathematical Society, the Statistical Institute and the OR Society.

Christos Douligeris is a Professor at the Department of Informatics, University of Piraeus, Greece. From 1989 to 1999, he was with the Department of Electrical and Computer Engineering at the University of Miami, where he reached the rank of Associate Professor. He has published extensively in the networking scientific literature and he has participated in many research and development projects. He is the co-editor of a book on network security published by IEEE Press/John Wiley. He is serving on the editorial board of several scientific journals and in the programme committees of several conferences.

1 Introduction

Nowadays, the emerging information and communication technologies offer new opportunities for improved monitoring and management of the environment. Collecting real-time data at appropriate temporal and spatial scales is critical to understand complex environmental processes. At the heart of environmental monitoring is the Environmental Sensor Network (ESN) which comprises an array of sensors that gather data autonomously and forward it automatically to a central server. What differentiates modern sensor networks from previous techniques is an emphasis on intelligence in the sensor packages as well as the speed, availability and robustness of the underlying data network. Modern sensor networks also typically publish the data on the server to the World Wide Web and allow real-time access to the data.

These networks require a unique combination of technological and environmental understanding, and have the potential of creating a revolution in environmental monitoring. Different types of data are collected by the sensor nodes. These include specific environmental parameters, as well as generic data, such as meteorological or dGPS (differential GPS). These data can be in different forms, digital and analogue, spatial and temporal, database or image, fixed or moving. At the server level the data can be visualised and analysed within a Geographic Information System (GIS), combined with a satellite image and/or map, and published via the web to give researchers seamless access to information.

ESNs have the capability of capturing local and broadly dispersed information simultaneously; they also have the capacity to respond to sudden changes in one location by triggering observations selectively across the network, while simultaneously updating the underlying complex system model and/or reconfiguring the network. Data gathered by ESNs pose unique challenges for environmental modelling, as a complex system is being observed by a dynamical network. These challenges lie in the fields of computer science (from self-organising networks to algorithm analysis), mathematics (from computational geometry to data fusion and robotics) and statistics (from sampling design to prediction and prediction uncertainty).

In many environments, data on basic environmental processes can be measured for the first time. Sensor nodes can store data, make decisions about what data to pass on, and even make decisions about when and what to sense. The network may be able to respond to data sent by the sensor nodes and to act as a warning system; e.g. if an oil spill happens or a weather forecast suggests a storm will occur, then the nodes can switch on or change their behaviour. The aim of future sensor networks would be the monitoring of the environment at all scales, with the data automatically forwarded to the internet where it would be integrated and analysed with different data sets within an intelligent infrastructure that has been made efficient and effective because of the miniaturisation of electronics and wireless technology.

The new data collection methods raise a number of research problems. One inevitable consequence of continuous data gathering from numerous sensor nodes is the generation of enormous amounts of data. This will need to be handled within a GIS which allows other systems to find out what types of data are available and how to get them automatically. This is where semantic web technologies will be indispensable, as common ontologies can evolve to help unify differently named data on the servers. In principle, these web services would allow, for example, a sensor network to fetch weather data from a completely different provider and allow researchers to have one view of data even though it may come from many different sources.

Sensor nodes need to be low cost (so that many can be deployed to sense the environment at a small scale), low power (otherwise they will not be able to run without constant battery maintenance), robust (due to the hostile nature of most environments) and non-polluting. Certain sensor nodes need to be specifically designed for the environment they are sensing. Other nodes need to be at the appropriate scale, record the necessary environmental parameters at a suitable time interval and, if possible, behave like a natural part of the environment.

2 Presentations

This special issue contains eight papers that were selected out of 17 papers submitted through a blind review process. It is obvious that these papers cannot cover all the areas in this very important and current research area. They provide though a good starting point for other researchers and practitioners to build upon and make further contributions. Below is the brief overview of the papers, which appear in this issue.

- Michael Zink, Eric Lyons, David Westbrook, Jim Kurose and David Pepyne in their paper, entitled 'Closed-loop architecture for distributed collaborative adaptive sensing of the atmosphere: meteorological command and control', describe an end-to-end, distributed, collaborative and adaptive sensing of the atmosphere architecture. The system is user-driven and its performance is evaluated in an operational testbed with actual weather conditions. The results of this in-depth analysis show that the system is capable of real-time data processing and optimisation for the control of the radars, and sensing of the atmosphere is performed according to the end-users needs. A predicting component that tracks meteorological phenomena and predicts their future locations is also under development. New objects, corresponding to the predicted future locations of the phenomena, can then be added into the feature repository allowing these predicting modules to be easily integrated into the system.
- Hock Beng Lim, Mudasser Iqbal, Wenqiang Wang and Yuxia Yao present in their paper, entitled 'The National Weather Sensor Grid: a large-scale cyber-sensor infrastructure for environmental monitoring', the design of large-scale sensor infrastructure for environmental monitoring to support long-term weather monitoring. The authors pay special attention at the presentation of the necessary middleware components, the management of the platform and the performance indicators that such a system must be judged upon. The efficiency of the system is demonstrated through thorough numerical results.
- Susmit Bagchi, in the paper entitled 'A distributed algorithm for energy-aware clustering in WSN', proposes a distributed algorithm for cluster formation by the sensor nodes. The clustering of resource-constrained sensor nodes is an effective mechanism to enhance the operational lifetime of the nodes by reducing energy consumption, while performing intended operations. The design and analysis of the algorithm are presented and a comparative analysis of the algorithm to the other contemporary algorithms is illustrated.
- Shancang Li and Xinheng Wang in their paper, entitled 'Source nodes localisation algorithm for large scale wireless sensor networks using self-organising isometric mapping', focus on the necessary enhancements to the Self-Organising Isometric Mapping (SIEMAP), a distributed system that had been previously proposed for node localisation. The steps to create local maps are presented in detail as well as the techniques used to merge local maps. A detailed simulation environment is built in order to evaluate the efficiency of the method to solve large location estimation problems accurately and quickly.
- Andreas Terzis, Răzvan Musăloiu-E., Joshua Cogan, Katalin Szlavecz, Alexander Szalay, Jim Gray, Stuart Ozer, Chieh-Jan Mike Liang, Jayant Gupchup and Randal Burns in their paper, entitled 'Wireless sensor networks for soil science', provide their experience with the design and deployment of two experimental soil monitoring networks. The authors make a very concrete and detailed evaluation of the deployed system and present the technical difficulties encountered not only in the deployment phase but in the data collection and analysis phases as well. Thus, they provide guidelines that other scientists in the soil sensor area as well as in other sensor activities must take into account.

- Jianming Liu, Xiaohong Jiang, Susumu Horiguchi and Tony-Tong Lee in their paper, entitled 'Analysis of random sleep scheme for wireless sensor networks', develop an analytical framework to study the interaction between random sleep scheme and network performance. For a single sensor node, they derived its node throughput, mean packet number and analysed its responsive property, whereas, for the whole network, they derived the power consumption, the capacity and the mean packet delay. Finally, they explored the trade-off among the above-mentioned performance measures and validated their analytical results through extensive simulations.
- Mohamed Lehsaini, Hervé Guyennet and Mohammed Feham in their paper, entitled 'An efficient cluster-based self-organisation algorithm for wireless sensor networks', propose an efficient cluster-based self-organisation algorithm, which relies on weighting parameters k-density and residual energy for cluster head election. It creates balanced clusters with a number of nodes facilitating their management and whose cluster members are, at most, two hops from their respective cluster heads. Simulation results show that the algorithm provides better performance than LEACH and LEACH-C in terms of the number of clusters formed and packets received at the base station during network lifetime.
- Yongxuan Lai, Yilong Chen and Hong Chen in their paper, entitled 'Continuous monitoring of global events in sensor networks', present an energy-efficient scheme for continuous monitoring of global events in wireless sensor networks. Their approach divides global events into regional events so that a global event can be known from monitoring the regional events. The hierarchical division of the network and events makes it possible to safely suppress a large number of messages within the network. The scheme takes advantage of the temporal correlation of sensing data, and incorporates a weighted acknowledgement mechanism to resist the likely unreliability of the available communications. Experimental results show that their approach can reduce the transmissions of messages compared to other processing algorithms.

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