ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow: Dr Djamel Djenouri
Visited Location : NTNU, Trondheim, Norway
Duration of Visit: 15/10/2008 to 14/10/2009

I - Scientific activity

Wireless sensor networks find many interesting applications ranging from environmental/traffic monitoring to health status monitoring. One of the main issues in these applications is to provide and maintain a set of quality of services. The research topic during this tenure was to investigate highly optimized routing protocols taking into consideration of some of the important parameters to provide robust and reliable services in a diverse traffic environment.

The main objective was the design and implementation of a localized multi-objective quality of service routing protocol for wireless sensor network, suitable for biomedical applications. This work was part of the MELODY project at NTNU, funded by research council of Norway. We considered the scenario of patient monitoring in a hospital, where medical sensors may be deployed in the patient's body (in-vivo) or outside it (ex-vivo) to make the appropriate measurements and interconnected through wireless links to provide the medical staff with the required information, and possibly to react automatically to some crucial events. Each patient's body includes several tiny biomedical sensors, which are connected (wirelessly or through cables) to a micro sensor. The micro sensor assumes to have larger and more power resources, and thus acts as a body cluster-head. This cluster-head can be a sensor mote such as the ones produced by Crossbow. In the patients' environment, around the hospital, sensor motes should be densely deployed such a way to ensure full coverage towards possible sinks. Mobile devices such as body-clusters and nurses' PDAs can occasionally be used. The proposed protocol serves to forward packet from body-area cluster-head sensors to remote sinks, while considering quality of service (QoS) requirement and energy constraints. Given the traffic diversity in medical applications, the protocol provides a traffic-based QoS differentiation, which represents the main contribution of the work. Localization information are used to avoid heavy procedures for route establishment.

The protocol was implemented within GloMoSim simulator and tested in a testbed of 15 TelosB sensor motes using Contiki operating system. The results show that the protocol operates correctly and outperforms comparable state-of-the-art protocols. It is also worth noting that the protocol is general and not confined to medical scenario; it can be applied in any application that has diverse data traffic with different QoS requirments.

In addition to this main project, a joint research work has been carried out with Dr Subramania, an ERCIM fellow at NTNU and his advisor Prof. Sindre. In that work we proposed a context-based solution for vehicular safety using wireless sensors networks. During this ERCIM post-doc tenure I have also served as program committee member for many conferences and reviewed several journal papers.

II- Publications during your fellowship

1. Djamel Djenouri, Ilangko Balasingham, "LOCALMOR: LOCALized Multi-Objective Routing for Wireless Sensor Networks". Proceedings of The 20th IEEE International Symposium On Personal, Indoor and Mobile Radio Communications (PIMRC), Tokyo, Japan, September 2009.

Abstract:
This paper proposes a multi-objective quality of service (QoS) routing protocol for general wireless sensor networks (WSN). The protocol takes into account the traffic diversity typical for many applications and provides a differentiation in routing using QoS metrics. It ensures several QoS metrics for different traffic categories, and attempts for each packet to fulfill the required metrics in a power-aware and localized way. It employs memory and computation efficient estimators in a distributed manner and uses a multi-sink single-path approach to increase reliability. The main contribution of this paper is data traffic based QoS with regard to all the considered QoS metrics. As far as we know, this protocol is the first that makes use of the diversity in the data traffic while considering latency,reliability, residual energy in the sensor nodes, and transmission power between nodes and casts QoS metrics as a multi-objective problem. Simulation results show the proposed protocol outperforms all compared state-of-the-art QoS and localized routing protocols.

2. Djamel Djenouri, Ilangko Balasingham, "Brief Announcement on MOGRIBA: Multi-Objective Geographical Routing for Biomedical Applications of Wireless Sensor Networks". Proceedings of the 5th International Workshop on Algorithmic Aspects of Wireless Sensor Networks (AlgoSensor'09), Rhodes, Greece July 2009. LNCS Vol 5804, Springer-Verlag GmbH, pp. 153–154.

Abstract:
A brief announcement of new routing protocol for wireless sensor networks is provided in this paper. The proposed protocol focuses on medical applications, by considering its traffic diversity and providing a differentiation routing using quality of service (QoS) metrics. The design is based on modular and scalable approach, where the protocol operates in a distributed, localized, computation and memory efficient way. The main contribution of this paper is data traffic based QoS with regard to all the considered QoS metrics, notably reliability, latency, and energy. To our best knowledge, this protocol is the first that makes use of the diversity in the data traffic while considering latency, reliability, residual energy in the sensor nodes, and transmission power between sensor nodes as QoS metrics of the multi-objective problem.

3 Djamel Djenouri, Ilangko Balasingham, "New QoS and Geographical Routing in Wireless Biomedical Sensor Networks". Proceedings of the Sixth International Conference on Broadband Communications, Networks, and Systems (Broadnets'09), Madrid, Spain, September 2009.

Abtract:
A new quality of service (QoS) routing protocol for biomedical wireless sensor networks is proposed in this paper. The protocol design relies on traffic diversityof biomedical applications and ensures a differentiation routing using QoS metrics. It is based on modular and scalable approach, where the protocol operates in a distributed, localized, computation and memory efficient way. The data traffic is classified into several categories according to the required QoS metrics ,where different routing metrics and techniques are accordingly suggested for

each category. The protocol attempts for each packet to fullfil the required QoS metrics in a power-aware way, by locally selecting the best candidate. It employs memory and computation efficient estimators, and uses a multi-sink single-path approach to increase reliability. The main contribution of this paper is data traffic based QoS with regard to all the considered QoS metrics. To our best knowledge, this protocol is the ¯rst that makes use of the diversity in the data traffic while considering latency, reliability, residual energy in the sensor nodes, and transmission power between sensor nodes as QoS metrics of the multi-objective problem. The proposed algorithm can operate with any MAC protocol, provided that it employs an ACK mechanism. Performance evaluation through a simulation study, comparing the new protocol with state-of-the QoS and localized protocols, show that it outperforms all the compared protocols.

4. Subramanian, Sattanathan, Djenouri, Djamel, Sindre, Guttorm, and Balasingham, Ilangko, "CoP4V : Context-Based Protocol for Vehicle's Safety in Highways Using Wireless Sensor Networks", Proceedings of the Sixth IEEE Information Technology New Generations (ITNG'09), pp 613-618, Las Vegas, USA, April 2009.

Abstract:

Safety is evergreen vital criteria for road traffic. We propose an infrastructureless solution based on contexts to increase safety of vehicle. Contexts characterize and track the moving environment of a vehicle. Here, environment means the vehicle's own status like geographical position, break-control's functional status, driver's status etc., and the status of neighboring vehicles. Contexts make use of wireless sensors for getting the environmental data. Sensors feed their data continuously to contexts. Contexts keep them as system understandable information. The status of a vehicle is continuously broadcasted to other vehicles.

Safety-decisions are derived based on contexts that are available in a vehicle. We have also provided an algorithm for our context-based solution. Finally, safety calculations are given for overtaking decisions through some linear equations.

5. Manuscript in preparation

Djamel Djenouri, Ilangko Balasingham "Traffic-Differentiation-Based Modular QoS Localized Routing for Wireless Sensor Networks", In preparation for Journal submission.

Abtract

A new localized quality of service (QoS) routing protocol for wireless sensor networks (WSN) is proposed in this paper. The proposed protocol targets WSN's applications having different types of data traffic. It is based on differentiating QoS requirements according to the data type, which enables to provide several and customized QoS metrics for each traffic category. With each packet, it attempts to fulfill the required data-related QoS metric(s) while considering power-efficiency. It is modular, and uses geographical information to eliminate the need of propagating routing information. For link quality estimation, the protocol employs distributed, memory and computation efficient mechanisms. It uses a multi-sink single-path approach to increase reliability. To our knowledge, this protocol is the first that makes use of the diversity in data traffic while considering latency, reliability, residual energy in sensor nodes, and transmission power between nodes to cast QoS metrics as a multi-objective problem. The proposed algorithm can operate with any MAC protocol, provided that it employs an ACK mechanism. An extensive simulation study with 900 nodes scenarios shows the proposed protocol outperforms all compared state-of-the-art QoS and localized routing protocols. Moreover, the protocol was implemented on sensor motes and tested in a sensor network testbed.

III -Attended Seminars, Workshops, and Conferences

- The 20th IEEE International Symposium On Personal, Indoor and Mobile Radio Communications (PIMRC), Tokyo, Japan, September 13-17, 2009. *For presenting accepted paper.*
- The 5th International Workshop on Algorithmic Aspects of Wireless Sensor Networks (AlgoSensor'09), Rhodes, Greece July 10-11 2009. *For presenting accepted paper.*
- Workshop on Wireless Communication, Oslo, May 2009. *For invited talk.*
- Melody Project kick-off Meeting, Oslo, February 2009. *For invited talk.*

IV – Research Exchange Programme

1- University Polytechnic of Catalonia (UPC Barcelona), member of SpaRCIM, from May 08 to May 15, 2009: This research visit gave an opportunity to become acquainted with different research projects at the Department of Telematic Engineering and to investigate possible future collaborations. Particularly, I attended a demo about LIASON project. This demo was on an implementation of a positioning system with IEEE802.11 through open source Linux WLAN network adapter driver modification. The demo also included a presentation of a simulator for positioning. During this visit I gave a lecture to postgraduate students about wireless sensor networks and localized routing. I had also several meetings and discussions with Prof. Francisco Barcelo, Prof. Jose Maria Barcelona, Prof Monica Aguilar Igartua, Mrs Enrica Zola, Mr Marc Ciurana, Mr Israel Martin, Dr Carmen Domingo Aladren, and Prof David Remondo Buenod

2- Swedish Institute of Computer Science (SICS), from June 09 to June 15, 2009: I visited the Computer Systems Lab, which developed the Contiki operating system. The visit was very helpful to get a better understanding of this operating system, which we used for the implemention of the proposed protocol in the sensor motes. The visit also gave me an opportunity to have meetings and discussions with researchers having a good experience in Contiki, notabely Dr Thiemo Voight, Mr Joakim Eriksson, Mr Niclas Finne, and Mr Fredrik Österlind. I was also invited to give a talk about our research project and the obtained results, which followed by interesting discussions and debates.