Project Details

Issues and objective

The scientific objective of this proposal is to specify, develop and evaluate algorithms and mechanisms for providing the adaptive QoS that supports real-time applications in CPS. One of the technical objectives is integrating the proposed solutions in the existing sensor network chips based on the standards such as IEEE802.15.4 and Zigbee, ZigbeePRO, 6loWPAN. Another one is to achieve a concrete multi-robots WSAN application, demonstrating thus the full utility of our proposal.

The scientific advances will be clearly shown through the resolution of the five challenging problems for providing QoS in WSAN aforementioned in section 1, namely the lack of scalability, energy optimization and flexibility in TDMA-based schemes, and the lack of efficient QoS-aware routing with presence of mobile nodes, and the QoS guarantee evaluation method or framework.
This objective is clearly ambitious but we believe achievable based on the competences of the two implied laboratories, our long collaboration experience and most importantly our already obtained preliminary and promising results.

The fundamental point is the design of new on-line QoS mechanisms. For this purpose, we will adopt two complementary approaches. One is the design of dynamic on-demand TDMA scheme by jointly exploring dynamic time-slots and frequency channels allocation and this by considering duty cycles and different priorities. The resource reservation request can be made periodically by a central unit that in its turn proceeds the on-line scheduling for meeting the different QoS demands. Another completely opposite but complementary direction is to design distributed mechanisms above CSMA/CA for making it self-adaptive to the current network traffic load, providing thus a scalable solution with optimized QoS. The QoS mechanisms are mainly designed at MAC and routing levels with cross-layer optimization whenever possible. The difficulty for properly evaluate the QoS guarantee of a solution resides in the lack of a suitable formalism to describe the connectivity in a highly dynamic network such as the case of a WSAN we consider. In a parallel project at LORIA in collaboration with G. Stacey Staples of Southern Illinois Univ. Edwardsville (USA), we started to investigate the use the dynamic random graphs for mathematically characterize the probabilistic connectivity of a wireless networks and obtained some promising results [Schott10a], [Schott10b]. This analytic method

will be further developed within this project. Complementary approaches will also be developed, such as a software framework for the joint application-network simulation and an experimental platform composed of mobile robots, static sensors and a surveillance application with focus on multi-target tracking

Scenario

Let us consider an application scenario of future surveillance systems. It aims to monitor and secures a large critical zone for preventing intrusion. Static sensors with wireless transceiver (WSN) are deployed for ensuring the zone coverage for intrusion detection (target tracking). Those sensors are battery powered so the power consumption must be cared for maintaining the network lifetime. We assume that those sensors are also used for monitoring the environment for reporting critical and non-critical events/measures. In addition, mobile robots are used for capturing intruders. The event detection and its transmission to the central station and robots must be done with required reliability and real-time constraints to make possible the intruder tracking by both the supervision system and robots. Multi-robots coordination and cooperation are ensured by the WSAN with necessary QoS. Robots are also sensors at the same time and in this sense they can also be used as additional communication nodes for self-repairing network topology holes. Note that within the platform of this project, toy robots like Khepera III will be used instead of more performing ones since the objective of the platform is first of all demonstrative purposed and our experience on such kind of robots shows its suitability. Please also note that the main WSN we used should be compatible with IEEE802.15.4 for the sensor data and command transfer. Other type of traffic from wireless cameras like image and low quality video may be included (using i-mote2 cards for instance) but will also be conveyed using WIFI in case of insufficient data rate of WSN. The interconnection of the two kinds of networks will be ensured by developing appropriate gateway.
In such future systems, the communication will be performed through multi-hop mesh network. Such a network should be self-organised due to the great number of the nodes in general. Mobile nodes (i.e. robots) can also be used either to increase the sensing precision or to repair network topology holes.