S3 – SITUATION SPECIFIC SURVEILLANCE

K. Bilstrup[1], A. Böhm[1], M. Ericson[3], M. Gustavsson[2], H. Hoang[1], M. Jonsson[1], C. Kaestner[6], K. Kunert[1], T. Larsson[1], K. Lidström[1], E. Pignaton[1], H. Riomar[2], J. Sedelius Hörberg[3], M. Taveniku[5], E. Uhlemann[1], and P-A. Wiberg[4]

1. Centre for Research on Embedded Systems, Halmstad University; 2. Ericsson AB; 3. Emwitech AB; 4. Free2move AB; 5. XCube Communications inc; 6. InnovationTeam AB

The S3 project (Situation Specific Surveillance) is a platform for research in the areas of wireless sensor networks, ad hoc networks and wireless digital communication. The S3 project poses challenging questions on several different aspects and topics such as: energy efficiency, dependability, self-configuration, and scalability in wireless networks. These topics need to be addressed both in individual protocol layers as well as in a cross-layer design involving several levels. The project is therefore divided into three concurrent tracks: the link, network and application perspectives.

1. Background and Motivation

The S3 project (Situation Specific Surveillance) is a platform for research in the areas of wireless sensor networks, *ad hoc* networks and wireless digital communication.

The purpose of the S3 project is to investigate the potential of using wireless sensor networks for surveillance purposes. An application scenario in a real-world setting is used as a starting point for research on topics related to *ad hoc* wireless sensor networks. Key issues are energy-efficiency, mobility, self-configurability, dependability, scalability, and real-time support.

2. Problem

The S3 project poses challenging questions and reveals interesting problems on several levels and is therefore divided into three concurrent tracks.

At the link level the dynamic network conditions together with the power constraints impose strict requirements on forming reliable connections requiring a minimal amount of energy in terms of transmitted energy, transmission and receiving times, as well as low complexity decoding. Specific sub-goals are:

- Provide reliable and energy efficient communications on the wireless links in the sensor network by efficiently coding the information.
- Enable scalability and manage hot spots in the link layer by efficient coding and cooperation.

At the network level, we are faced with similar requirements on the end-to-end connections. Specific sub-goals are:

- Take a joint approach to connection setup methods, medium access control and routing in *ad hoc* networks to combine energy efficient communication with quick response times.
- Develop methods to ensure both timely and reliable end-to-end delivery of messages.

Application level design must be able to handle data aggregation, control and cooperation in a distributed system in secure and scalable ways. Specific sub-goals are:

- Design system and software architecture including principles for sensor data collection, aggregation or replication, distributed control and redundancy enabling graceful/safe function degradation.
- Define and evaluate principles and solutions for autonomous, sensing mission driven, system and software configuration and network setup.
- Design methods for component based software in distributed sensor network applications and solutions for cooperation and system coordination in distributed system with low duty ratio.

3. Application scenarios

There are many applications for wireless sensor network based surveillance systems ranging from locating mobile systems and tracking moving objects to monitoring of static objects and object relations. For the S3 project, a medium size harbor (Figure 1) was chosen as a suitable testing area since it offers a variety of applications for surveillance systems.

Figure 1. Aerial photo of harbor area with permission from Lantmäteriverket.

Containers with valuable goods need around-the-clock monitoring. Using a network of cooperating sensors enables immediate reporting if goods are moved out of a certain area or if the seal of a container is broken. A static network of sensor nodes can be used to monitor certain local spots of interest in the harbor area.

By deploying a net of sensors in larger parts of the harbor, intruders can be recognized and their movement over the property can be traced. Harbor workers and ship crews can be authorized to move freely in restricted parts of the area and are thereby not recognized as intruders.

For normal monitoring, only a few sensor nodes need to be active, while an alert causes additional sensors in the concerned area to wake up and take part in the data collection and processing required for tracking and evaluating the event.

4. Results

On the application level we have studied application scenarios, sensor types and composed measurement configurations involving multiple sensors. Techniques to find and allocate sufficiently good, although not always optimal, sensors to use and techniques for how to setup and configure measurement and surveillance missions have also been studied and compared.

We have made state-of-the-art surveys and protocol comparisons, with a focus on both energy-efficiency and real-time support. Both MAC protocols and routing protocols have been compared. Furthermore, we have made initial investigations of how to support real-time communication when using IEEE 802.15.4 for wireless sensor networks. Wireless industrial networks have many similarities with wireless sensor networks when used for surveillance. Short packets of control data should be transmitted reliably and time is often of essence either for the control process itself or for enabling short wakeup cycles to preserve energy. The state of the art in wireless technologies for industrial networks has been surveyed.

Regarding the support of timely and reliable end-to-end delivery of messages, we have developed a suitable framework which includes both a retransmission scheme and the analysis methods necessary to calculate real-time performance guarantees. We are now working on improvements to better tackle the high bit error rates often present in wireless sensor networks.

Relaying and packet combining is a way to increase reliability while at the same time preserving energy by reducing the number of retransmissions. Initial results of a simple and practically implementable protocol in which relaying and packet combining work together to improve the probability that packets are delivered within a prescribed deadline over fading channels show that these techniques can be successfully applied on top of commercially available transceivers

A simple demonstrator system for monitoring a group of children has been implemented using the Mica2 motes from Crossbow with TinyOS and TinyDB. Each node in the network used the received signal strength indicator (RSSI) to approximate the distance to its neighbors and a central analyzes the measurements and warns the teachers if a child is wandering off. Initial results indicate the RSSI is too imprecise for this type of distance measurements due to the fading properties of the radio environment.

PARTNERS AND STATUS

Industrial Partners: Ericsson AB, Emwitech AB, Free2move AB, XCube Communications inc, and InnovationTeam AB.

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