

Chapter 4

Location-Based Performance Tuning in Mobile Sensor Networks

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ABSTRACT

The author of this chapter considers the location-based approach for performance tuning that significantly facilitates the challenge of utilizing Mobile Sensor Networks. The authors introduce mobile nodes that can be deployed in conjunction with stationary sensor nodes to perform mission critical surveillance and monitoring tasks. It details the past advances in this field and discusses other approaches to this challenge.

MOBILE SENSOR NETWORKS

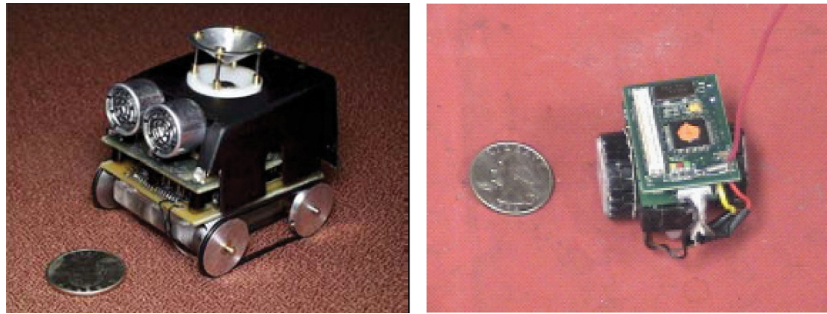
Recent advances in wireless communications and microelectronics have enabled wide deployment of smart sensor networks. Such networks naturally apply to a broad range of applications that involve system monitoring and information tracking (e.g., airport security infrastructure, monitoring of children in metropolitan areas, product transition in warehouse networks, fine-grained weather/environmental measurements, etc.). Wireless sensors are small resource-constrained devices with wireless communication capability, processing power, and environment sensing equipment.

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Sensor nodes can be attached to mobile devices such as mobile robots forming a *Mobile Sensor Network (MSN)*.

There has been considerable research on designing mobile platforms to transport wireless sensors. The Millibot project at Carnegie Mellon University (Bererton et al., 2000) focused on constructing heterogeneous distributed robots that combine mobile platforms with different sensor devices such as cameras, temperature sensors, movement sensors, and so forth. Robomote (Sibley et al., 2002), designed in the Robotic Embedded Systems Laboratory at the University of Southern California is a robot platform that functions as a single mobile node in a mobile sensor network. Figure 1 shows actual pictures of the millibot and

Figure 1. Millibot (left) and robomote (right)



robomote platforms. Another example includes efforts on using commercial-off-the-shelf components to build inexpensive and modular robots (Bergbreiter and Pister, 2003).

Mobile Sensor Network consists of mobile platform (e.g., mobile robots) carrying wireless sensor devices that can be deployed in conjunction with stationary sensor nodes to acquire and process data for surveillance and tracking, environmental monitoring for highly sensitive areas, or execute search and rescue operations. Resource constraints of MSNs make it difficult to utilize them for advanced environmental monitoring that requires data intensive collaboration between the robots (e.g., exchange of multimedia data streams) (Scerri et al., 2003; Scerri, Xu et al., 2004). To meet the application requirements, the data exchange must be performed over a wireless link. Meanwhile, even high rate wireless networks (e.g., 802.11 networks) use a best-effort service that has limitations of data intensive multimedia applications since it can lead to packet loss, delay and jitter (Kurose and Ross, 2005). The problem aggravates in low rate wireless sensor networks, (e.g., 802.15.4 networks) (Zheng and Lee, 2004).

In this chapter, we consider location-based approach for performance tuning in MSNs. This approach assumes that each node in MSN is aware of its geographic location. Note, that using Global Positioning System (GPS) is not always possible in such systems because of severe energy and location precision constraints. Commonly MSNs

utilize ad-hoc localization methods based on nodes calculating their coordinates using special beacon nodes whose positions are known. Further consideration of this subject is beyond the scope of this chapter.

PERFORMANCE TUNING IN MOBILE SENSOR NETWORKS

Applications using MSNs have stringent requirements for efficient mechanisms of querying sensor data and delivering the query result. Minimizing sensor query response time becomes crucial in mobile sensor networks. At the same time, minimizing energy consumption per query is equally crucial for these battery-powered devices. In general, the time/energy trade-offs involve energy and time gain/loss associated with specific layouts of the nodes. Proper positioning (relocation) of mobile sensors combined with changing the transmission ranges of sensors have a considerable impact on the time/energy trade-off. Specifically, both factors impact the following characteristics of a Mobile Sensor Network:

- **Collision-free concurrency:** Packet collisions is one of the major sources of energy and time waste in MSN. Once any two or more nodes in the same *Collision Domain (CD)* transmit packets at the same time, a collision occurs, and packets are

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