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# 분산 WSN하에서 적응적 재구성이 가능한 OS 모델링

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# Adaptive and Reconfigurable OS Modeling in Distributed WSNs

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Abstract

This paper describes the architecture and modeling of adaptive and reconfigurable OS in wireless distributed sensor networks. Before initial sensor nodes are deployed in a sensor field, minimum functions including basic OS and routing algorithms are required for these nodes to send request messages for dynamic reconfigurations and receive response messages from a task manager. When the downloading is finished, each sensor node can reconfigure the initial state and be ready to start its functions. By applying this reconfigurable modeling, sensor nodes can be easily deployed in the sensor field and dynamically programmed during a bootstrap process.

## 1. Introduction

Wireless sensor networks (WSNs) have attracted considerable research attention in the last few years. Typically, a WSN consists of a large number of nodes that sense the environment and collaboratively work to process and route the sensor data. A distributed sensor network is a self-organized system composed of a large number (hundreds or thousands) of low-cost sensor nodes. Self-organization means that the system can achieve the necessary organizational structures without requiring human intervention, i.e., the sensor network should be able to carry out functional operations through cooperation among individual nodes rather than requiring set up and operation by manual operators [1].

Usually, a large number of sensors should be networked in order to facilitate the transmission and dissemination of the measured/monitored parameters to some collector sites where the information is further processed for decision-making purposes. Ideally, it is desirable to be able to program the sensor network dynamically as a whole (as an aggregate) and not as a mere collection of individual nodes. To satisfy this idea, the ability to download executable messages into each node is feasible with minimum routing and downloading features. The primary objective of our work is to design, implement and verify a dynamic reconfigurable OS for the distributed wireless sensor networks.

The remaining sections are organized as follows. Section 2 introduces related work. In Section 3, we present the initial node status. The self-routing mechanism is described in Section 4. In Section 5, we present architecture and modeling of dynamic reconfiguration. Finally, in Section 6, we present our conclusions.

## 2. Related work

Deployment of a sensor network can be in random fashion (e.g., dropped from an airplane) or planted manually (e.g., fire alarm sensors in a facility). These networks promise a maintenance-free, fault-tolerant platform for gathering different kinds of data. The sensor nodes are usually scattered in a sensor field as shown in Figure 1.

Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink node and finally to the end users. Data are routed back to the end user by a multihop infrastructureless architecture through the sink node.

The sink node may communicate with the task manager node via Internet or Satellite [2].

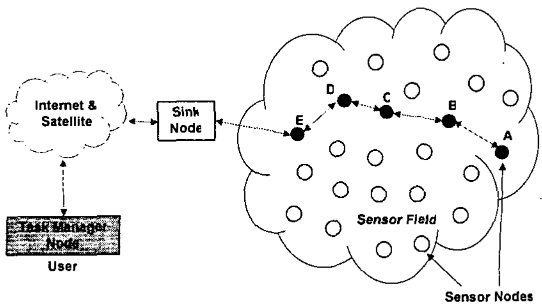


Figure 1. Sensor nodes scattered in a sensor field.

A WSN node integrates sensing, signal processing, data collection and storage, computation, and wireless communications along with an attached power supply on a single chip. Generally, each sensor node is made up of four basic components: a sensing unit, a processing unit, a communication unit and a power unit. The system architecture of a typical sensor node is shown in Figure 2 [3].

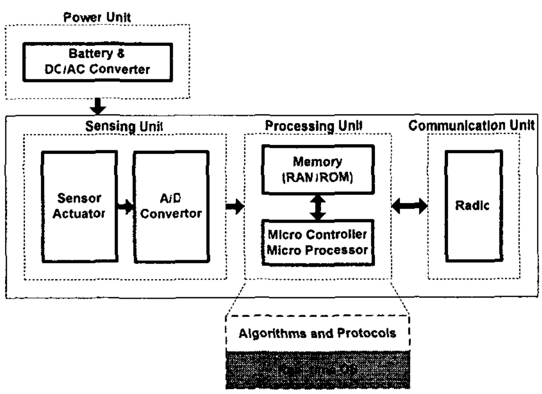


Figure 2. System architecture of a sensor node.

A real-time micro-operating system controls and operates the sensing, computing, and communication units through micro-device drivers and decides which parts to turn on and off. This OS can be adaptive and reconfigurable with basic routing algorithms and communication functions through wireless networks.

3. Initial sensor node architecture

Figure 4 shows an initial architecture of a wireless sensor node. Dashed boxes (Application, Actuating, and Sensing part) are able to be dynamically reconfigurable components through downloading during the bootstrap process. So these components may be replaced with new functions. The filled boxes, especially Communication component should have at least two functions: (1) basic OS and (2) self-organizing routing mechanism. While each node is successfully bootstrapped, the basic HAL (hardware abstraction layer), Communication, and Scheduler components are used and they communicate with the task manager to send and receive request and response messages through RF (Radio Frequency), respectively.

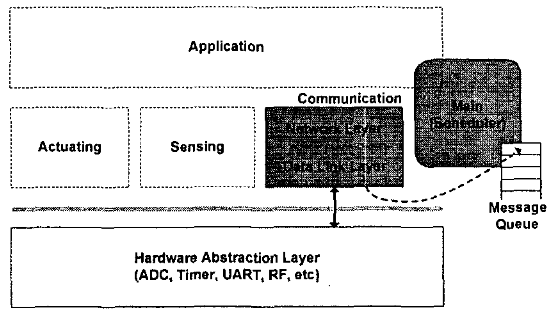


Figure 4.Initial architecture of a sensor node.

The Communication component is composed of two layers: a network layer and a data link layer.

(1) The network layer has two primary functions: routing and addressing. In sensor networks, energy aware, simple, adaptable, and stable characteristics are required.

(2) The primary functions of the data link layer are to provide access control, ID assignment, neighbor list management, and power control. The link layer also keeps a list of its neighbors and metrics, such as the neighbor' s position and the energy needed to reach it.

4. Self-routing mechanism

To communicate between sensor networks in a distributed network and a task manager, self-routing must be established during the bootstrap. In general, routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and adaptive-based routing. As there will ordinarily be little opportunity for repairing the network beyond the initial deployment of new nodes, the routing protocol is designed to extend the useful life of the network for as long as possible.

Among these several routing protocols, one must be applied to each initial sensor nodes before being deployed, because this routing protocol is used to communicate between sensor nodes and the task manager to deliver each message.

Figure 3 shows an example of the working of Directed Diffusion (sending interests, building gradients, and data dissemination) [4]. This protocol is a well-known data dissemination mechanism for sensor networks, whose main aspects include data-centric routing, in-network aggregation and attribute-based data naming.

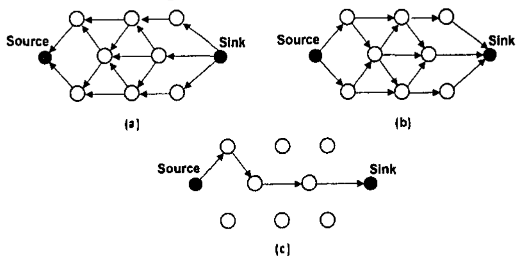


Figure 3. Example of directed diffusion: (a) propagate interest, (b) set up gradient and (c) send data.

Comparisons and revisions of several dissemination protocols including Directed Diffusion are shown in [5]. Energy-efficiency-accuracy tradeoff s should be considered to choose the best-fit routing protocol for each sensor field.

## 5. Adaptive and reconfigurable modeling

The ability for each node and the network as a whole to self-organize will be essential to the success of the sensor network. Because of the nonmobile nature of the sensor nodes, as well as the limited energy resources of sensor nodes, there is a distinct bootup phase. There are two ways to reconfigure the initial sensor nodes; (1) Node initiated reconfiguration and (2) network initiated one. Both types need to notify and propagate the initial node status to the task manager to start adaptive reconfiguration. The idea of bootstrap process for this modeling is a little similar in self-organizing to the BOOTP [6].

Figure 5 shows the process of reconfigured architecture of a sensor node with the task manager node. After the successful reconfiguration of Application, Actuating, and Sensing components, the Scheduler is fully-functioned and sensor nodes can start their functions.

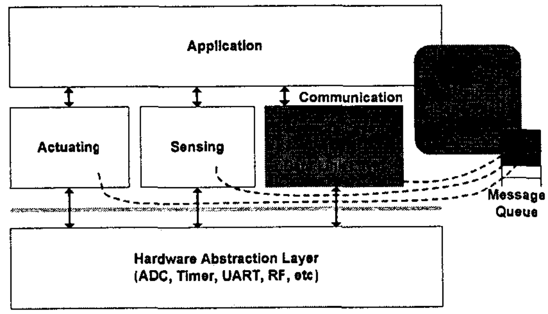


Figure 5. Reconfigured architecture of a sensor node.

## 6. Conclusion

The adaptive and reconfigurable OS is useful for sensor nodes to be deployed in the distributed sensor networks easily and to be dynamically programmed according to the property of each node. Sensor nodes have only basic reconfigurable functions to communicate with the task manager and neighbor nodes, so lighten the load on each initial node by the programming and installation.

The efficiency of this organizational process can be a little dependent on the particular deployment of the sensor network and the degree and accuracy of information that is preprogrammed into each node including the basic routing protocol. So more organized startup process is required to set up the nodes at slightly different times, one by one.

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