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# Advanced Adaptive Communication Protocol for Ubiquitous Sensor Networks

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***Abstract*:** There is growing expectation for a wireless sensor network as a means of realizing ubiquitous information environments. A wireless sensor network, which is a key network to facilitate ubiquitous information environments, has great potential as a means of realizing a wide range of applications, such as natural environment monitoring, environmental control in office buildings and factories, object tracking, and precision agriculture. Control mechanism for a wireless sensor network should adapt to the variety of types of communication (one-to-one, one-to-many, many-to-one, many-to-many), depending on application requirements and the context. This paper proposes a new adaptive communication protocol for the long-term operation of a wireless sensor network. We evaluate the proposed protocol using computer simulations and discuss its development potential. In the experiments performed, the performance of the proposed protocol is investigated in detail to verify its effectiveness.

***Keywords*: Wireless Sensor Networks, Ubiquitous Environments, Adaptive Communication Protocols.**

## I. INTRODUCTION

Various network services have been provided. They include inter-vehicle communication, which is a network service in intelligent transport systems, natural environmental monitoring, and emergent communication between mobile nodes in such the case of emergency as disaster. As a means of realizing the above network services, autonomous decentralized networks, such as a mobile ad-hoc network and a wireless sensor network, have been intensively studied with great interests. Especially, a wireless sensor network, which is a key network to facilitate ubiquitous information environments, has great potential as a means of realizing a wide range of applications, such as natural environmental monitoring, environmental control in office buildings and factories, object tracking, and precision agriculture [1]. In a general wireless sensor network, hundreds or thousands of micro sensor nodes, which are generally compact and inexpensive, are placed in a large scale observation area and sensing data of each node is gathered to a sink node by inter-node wireless multi-hop communication. Each sensor node consists of a sensing function to measure the status (temperature, humidity, motion, etc.) of an observation point or object, a limited function on information processing, and a simplified wireless communication function, and generally operates on a resource of a limited power-supply capacity such as a battery. Therefore, in the existing studies, the efficient and load-balancing data transmission scheme to sink nodes has been proposed.

This paper proposes a new adaptive communication protocol for the long-term operation of a wireless sensor network. We evaluate the proposed protocol using computer simulations and discuss its development potential. In the experiments performed, the performance of the proposed protocol is investigated in detail to verify its effectiveness. This paper is organized as follows. In Section II, the proposed protocol is outlined. In Section III, the experimental results are reported and the effectiveness of the proposed protocol is demonstrated by comparing the performance of it with those of the existing ones. Finally, the paper closes with conclusions and ideas for further study in Section IV.

## II. PROPOSED PROTOCOL OUTLINE

For facilitating ubiquitous information environments, control mechanism for a wireless sensor network should adapt to the variety of types of communication, i.e., one-to-one, one-to-many, many-to-one, and many-to-many, depending on application requirements and the context. Recently, many adaptive protocols for a large scale and dense wireless sensor network, which are "directed diffusion"[2,3] and "ant-based rendezvous communication protocol"[4] have been proposed. "directed diffusion", that a representative scheme for adaptive communication consists of the following protocols: Two-Phase Pull diffusion, One-Phase Pull diffusion, Push diffusion, where "Pull" adapts itself to the case that the number of source nodes is more than the number of sink nodes. "Push" adapts itself to the case that the number of sink nodes

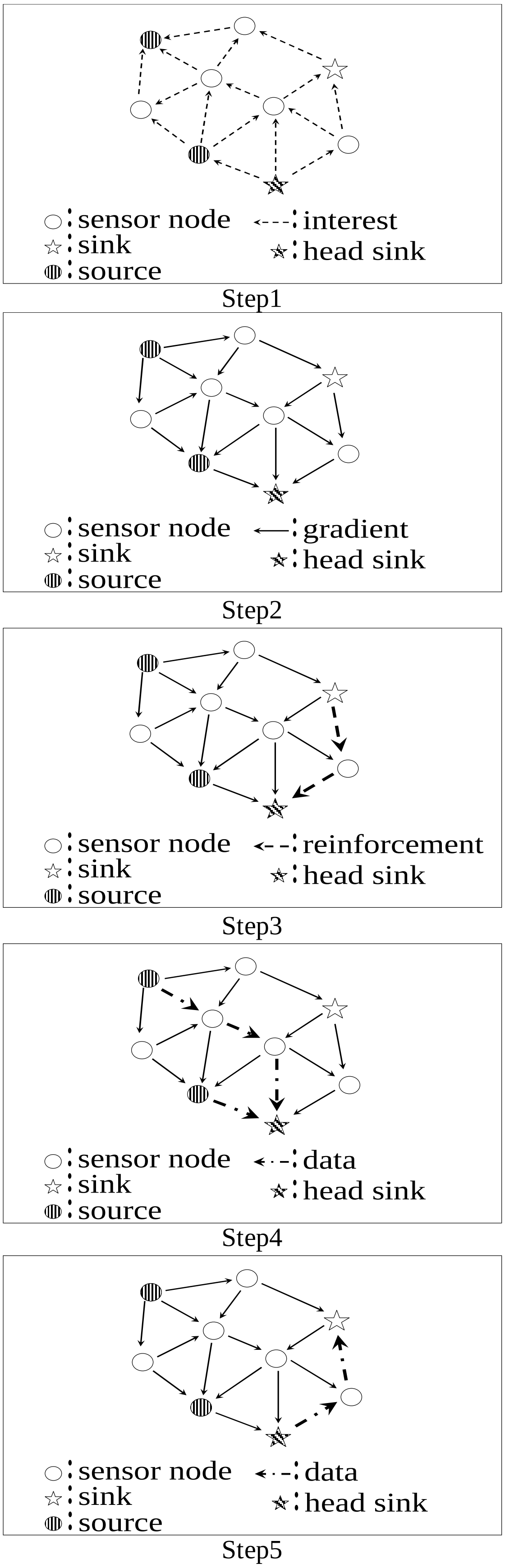


Fig.1. From sink node

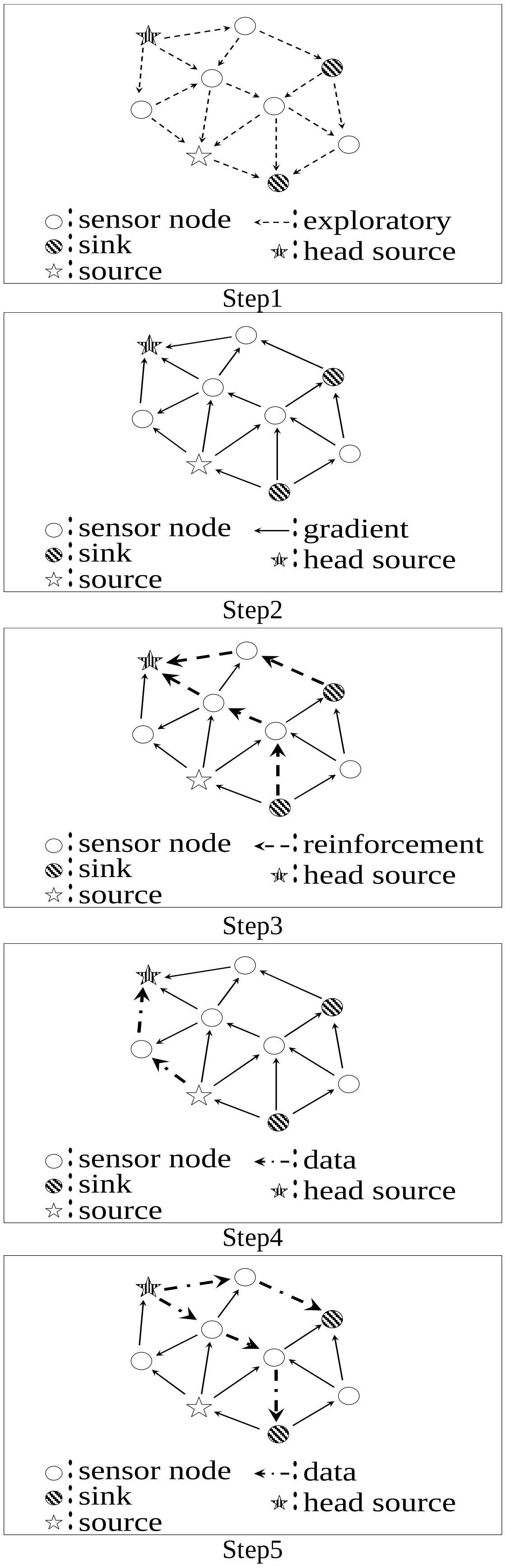


Fig.2. From source node

is more than the number of source nodes. However, the existing adaptive communication protocols cause flooding storm problems. The proposed protocol improves flooding storm problems. In Fig.1 and Fig.2, the example on the proposed protocol is shown.

## IV. SIMULATION EXPERIMENT

Through simulation experiments, the performance of the proposed protocol is investigated in detail to verify its effectiveness. A wireless sensor network consisting of many sensor nodes placed in a wide range is assumed. The conditions of simulation, which were used in the experiments performed, are shown in Table1. In the simulation area, sensor nodes are randomly placed. In Fig.3, the network configuration is illustrated.

Table1. Conditions of simulation

| | |
|---|---|
| Simulation times | *1,000s* |
| Simulation size | *2,400m ×2,400m* |
| The number of sensor nodes | *1,000* |
| Range of radio wave | *150m* |
| Data transmission interval | *10s* |
| Model change interval | *250s* |

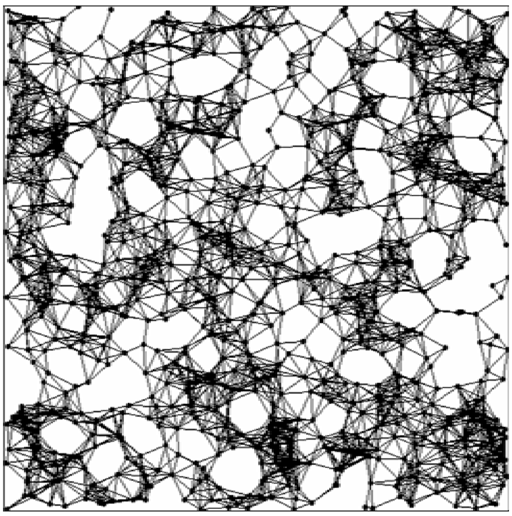

Fig.3. Network configuration

In the experiments performed, the proposed protocol is evaluated through the comparison with "Pull" or "Push" of "directed diffusion". Figs.4 and 5 show total energy consumption of a network. Figs.6 and 7 show the transition of delivery ratio, where the battery capacity of each sensor node has been set to 0.5J. Experimental results verify that the proposed protocol is substantially advantageous for the long-term operation of a large scale and dense wireless sensor network.

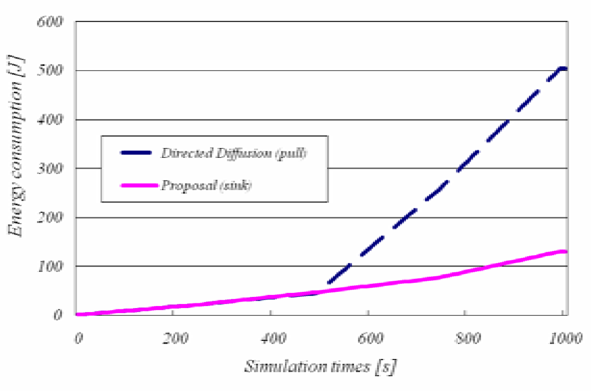


Fig.4. Total energy consumption (from sink node)

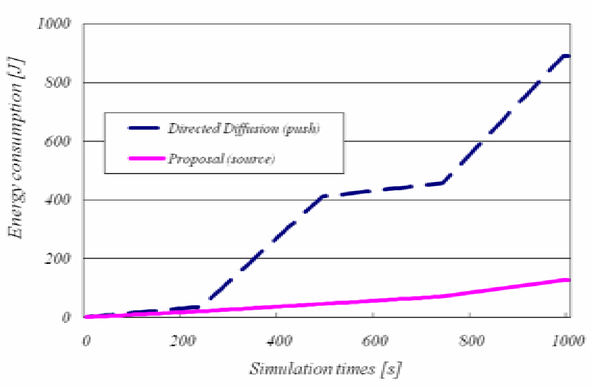


Fig.5. Total energy consumption (from source node)

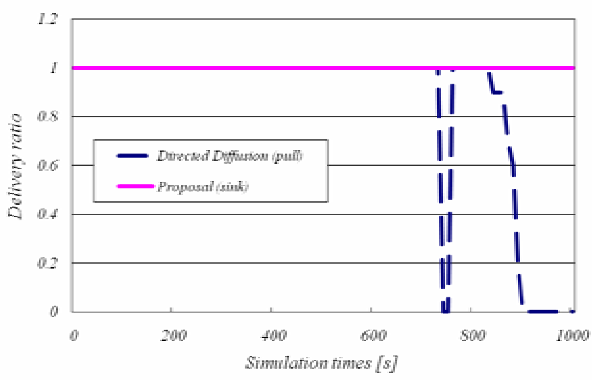


Fig.6. Transition of delivery ratio (from sink node)

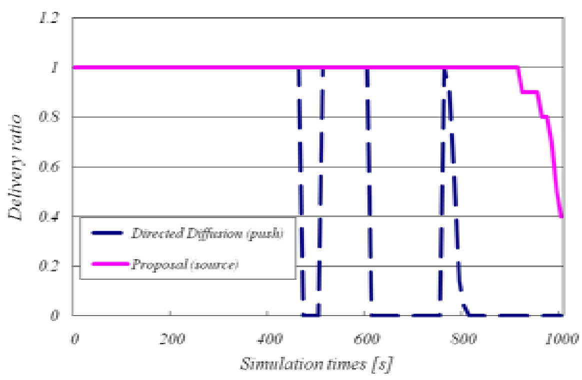


Fig.7. Transition of delivery ratio (from source node)

## IV. CONCLUSIONS

In this paper, a new adaptive communication protocol, which adapts itself to the variety of types of communication, has been proposed. This protocol can improve flooding storm problems. In the experiments performed, the performance of the proposed protocol was compared with those of the existing ones. Experimental results indicate that the proposed protocol is superior to the existing ones and has the development potential as a promising one from the viewpoint of the long-term operation of a wireless sensor network. In future studies, we evaluate the performance of the proposed protocol in detail.

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