Distributed Gateway System based on Agent Middleware in Wireless Sensor Networks

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Abstract. This research challenges models of distributed gateway system based on agents in wireless sensor networks(WSNs). Sensor network is made up huge sensors or actuators and it occurs plenty of data traffics and data lack. To solve this problem is required the coordinators consist of gateway included sink node, other communication module, middleware platform for data acquisition, analysis, and presentation. In this paper we seek to challenge the agent based middleware system for huge sensor network and heterogeneous sensor networks. For solving the problem we suggest the Distributed Gateway System(DGS), Agents based Sensor Middleware (ASM). The DGS can manage the over thousands sensor nodes, coordinates it and transmits to the web-service interfaces efficiently. The ASM is core engine included in the DGS and is operated by itself.

Keywords: Wireless Sensor Network(WSNs), Sensor Gateway, Agent based Systems.

1 Introduction

Wireless sensor networks(WSNs) is a persistent computing system composed of a large number of sensor nodes that are densely deployed to measure a specific physical environment. Sensor nodes communicate with one another over wireless low-bandwidth links and have limited processing capacity. The sensor nodes are randomly installed in the monitoring area and constitute a network through the self-organization method [1]. Each of these nodes has the capability of collecting data and of routing data back to the base stations, and the base stations sends the information to the center through the Internet[2]. Overall data in these platforms is occurred large data traffic lack, so the coordinator is required. Most of the WSNs based information system has the middleware for sensor data processing. However, the standard platforms and applicable to huge and distributed sensor nodes does not exist.

In the current study, we suggest the distributed gateway system supporting the data communication and processing of large number of sensor nodes and the middleware platform based on the sensor agents.

2 Distributed Gateway System

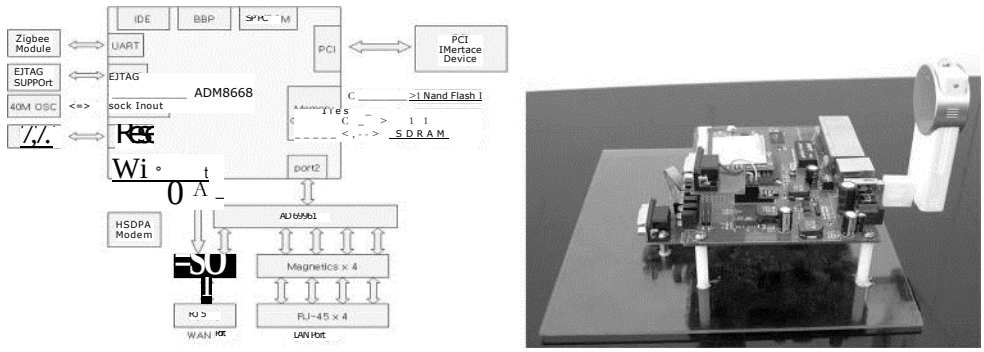

Fig. 1. Distributed Gateway System (DGS)

The Distributed Gateway System (DGS) is to acquire the data via the each sensor node. DGS is running as a server for data acquisition from sensor nodes and transmits the sensor data via the wireless network (IEEE802.11) or 3G networks. The DGS creates the sensor data packet using a combination of the sensor node ID and each sensor node's data.

The operating method of the DGS is the management of sensor networks via Zigbee, the control of sensor nodes and the transmission to the monitoring server by a data handling mechanism. After the OS is booted, the DGS performs the initialization step and changes the background process. The DGS includes one sink node for controlling the sensor nodes in the sub-sensor field. When the main module of the gateway is the first running step, the DGS transmits the initial command to the sink node. All sensor nodes set up network initialization through defining their own routing path and determining the parent node. After all of the initialization process is over, the DGS changes the state of data ready. After the DGS is performs the initialization step, the DGS performs the TCP/IP connection to the monitoring system server. The main module waits for next command, and the monitoring system server has a connection to the DGS. If the DGS operates the message acquisition command to the sensor nodes in its own sensor field, then the sensor nodes start the one cycle data from the last transmission to the brink data. The stop message is transmitted by the monitoring server; after the sensor nodes and the DGS have changed the idle states and are waiting for other control messages. The Zigbee module transmits the TOS message format which has the message frame unit via UART. A structure of a frame message byte starts and ends at Ox7e and Ox7e and is divided into Ox7d5d, Ox7d5d by a framing process. First, the TOS Message acquires the packet for which constructed message framing is dissolved and calculates the packet CRC by memory copy process from an internal field. The packet message creates the acquired sensor

data through the classification ID and the sensor type in the sensor node by reference to the SensorMsg area in the internal data field of the TOS message. The created packet includes the sensor data, the creation time, and the synchronization information and is stored in the transmission buffer of DGS. Second, the main process of the DGS is to run as a two sub thread. One thread is in charge of wireless communications via Zigbee and the other thread takes charge of the TCP/IP connection, reporting the ID of the DGS and the transmission of the sensor data by the transmission buffer if the transmission data exists. The proposed model of the DGS in this paper is a base station function of WSN construction. Because the DGS has 'BASE STATION ADDRESS(0)' as its local address and `TOS_UART_ADDR(0x007e)', the routed data is able to transmit the DGS via UART.

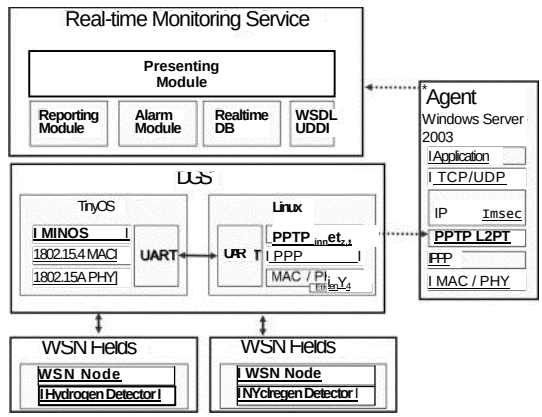

Fig. 2. Distributed Gateway Systems

3 Agents based Sensor Middleware

In this paper, we suggest the Agents based Sensor Middleware (ASM). The sensor agent is defined for a protocol to interconnect between sensor gateways and information systems. We define the sensor agent as the set of API protocols. There are agents in the middleware processing mechanisms of interfaces for data request and transmission and protocol for data communication between distributed sensor gateways. The middleware protocol for sensor data management is defined with respect to its physical and logical protocol. Sensor agents perform as delivery media for the monitoring service. Fig 3(a) shows the architecture of ASM.

TCP/IP network modules support the standard TCP/IP protocol and provide the protocol set between the DGS and the agents. The VPN(Virtual Private Network) supports network security and protection from external attacks, such as network hacking and node faking by concealed hiding networks. The agent in a TCP/IP-based network configuration uses the socket directly or web-service based on the TCP/IP socket. Thus, the agent system is located in the middle of the business processing logic and the network configuration and is constructed with a simple and fast network configuration. Web Service Provider is that the agent middleware performs the

conversion of the signal between the legacy type of network and the web service. Especially, the agent converts the entire signal to web-service modules to become control messages by legacy networks. The agent provides a web-service interface for all control messages of the DGS through this mechanism. Web service consumer is that the agent middleware transmits the sensor information from the DGS data through the web-service provided with the monitoring system. The agents create the web service consumer module to connect with the web-service and to use the data. When data is transmitted using the web-service, the legacy data type has to convert the web service form; in the other direction, the web service data has to convert the data type to the legacy signal.

The proposed model of the web service model is based on the XML form and the agent includes the transform module for converting between the XML and the legacy signals. The agent has the module for storing the data from the DGS and the sensor and performs the management of reporting from connections with the DGS and the sensors. Sensor value storage modules have the role of memory buffer and storage interface for web service data and legacy information. The DGS and sensors transmit the large quantity of data in real-time. The agent is accumulating the DGS and the sensor data and manufactures the web data for the evaluation and quality of service. For supporting the QoS, the agent supports the monitor for the network status and load balancing. If the sensor network node or the DGS is damaged, the agent creates an emergency signal and sends the alarm signal. Agents always monitors the network signals and request control messages. Agents request control messages by reporting the status, if the peak level is detected. An agent transmits the control message for the management of sensors with connections to the DGS. Agent UI provides the interactions of the users. Agents are located on the upper DGS in the real-time monitoring structure and convert from signals between Legacy signals from sensor nodes or the DGS and web-service XML forms by the interactions of twelve sub-modules. Agents have the role of network management for supporting the quality of service and for light network traffic. Fig. 3(b) presents the function flow diagram.

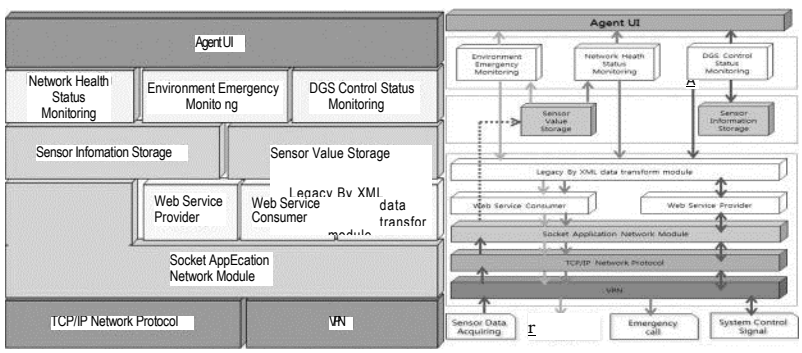

Fig. 3. Architecture of AMS (a)Block Diagram, (b) Function Flow

The module for agent construction consists of sensor data acquisition, sensor data reporting, delivery of system emergency signals and system control signals. First, sensor data acquisition stores the sensor data received from the DGS in the Sensor Value Storage. In this step, sensor data analysis and processing is not processed because the sensor data transmission transferred the large numbers of data at high speeds to network load balancing (reasons include the loss of sensor data value and

the overload of agents). Second, sensor reporting starts when the Sensor Value Storage module stores the sensor data from below the DGS. The sensor reporting process performs the analysis of sensor values and evaluates the reliability and converts the legacy data to XML forms using the web service. The data converted to XML is delivered to the service via web service. Third, a system emergency is created from the legacy signal of sensors through the analysis of the DGS. When the emergency signal from the legacy signal of a TOS message is created, an agent converts it to XML data and sends the web-service modules. Last, the control message for the monitoring system has two parts to its signal. One part is the delivery signal from the monitoring system that converts the legacy signal to web service; the other part is a self-created control message. The monitoring service receives the sensor data from various DGSs. A DGS is trying to connect the monitoring server by initially running, in this step, the authorization process for running by their own ID. In this step, the monitoring server creates the TCP/IP socket and is ready to receive the sensor information. Between the DGS and the monitoring server is the construction of a general server/client architecture based on the TCP/IP. The final sensor data from the DGS is presented as Fig. 4(a) and includes the Gateway ID, the original source ID of the sensor nodes, and the payload, which sensor values. The Monitoring server can receive the real-time sensor value from the gateway and the control signal for starting, ending, setting up the period. The received data from the sensor gateway can be stored in the database server and can be presented as real-time data by the graphic user interface. The agent structure that is in our proposed model runs the monitoring agent by XML script, supporting the connection with the monitoring system and the DGS. The monitoring agent provides the list of gateways that connect with the monitoring server, the installation information, and the current status of running. The monitoring agent can create dynamic XML scripts by searching the database and transmitting them to clients. The structure of the monitoring agent includes the explanation of sensor data, location information for the DGS installation, the total running time, and the list of connections. All clients can perform real-time monitoring shown as Fig. 4(b) by referring to this information and receiving the sensor node data by selecting their own DGS.

```
<?xml mersion="1.0" encoding="euc-kr"?>
<OGSList count="1">
   <HS id="1013" location="3092" uptime="2007-10-21 21:40:03" state="idle">
      <SensorModule id="10130001" type="A" sensorCount="4">
         <sensor type="Temperature" number="1" min="0" mam="100"        C" />
         <sensor typeehumiditm" number="2" min4"0" max4"100" uniter />
         <sensor type="TSR" number="3" min="0" max="1000" uniteLux" I>
         <sensor type="PAR" number="4" min="0" max="4000" unit="Lum" I>
      </SensorModule>
      <SensorModule W4'10130002' type="8" sensorCount4"2">
         <sensor typeeCO" number="1" min="0" max="1000· uniteppm" I>
      <sensor typeeCO2" number4"2" min4"0" max4"1500" uniteppm" />
      </SensorModule>
   </00S>
</Mist>
```

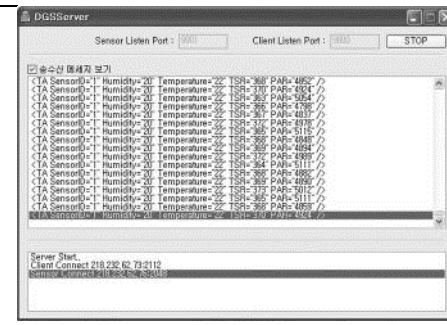

Fig. 4. (a) XML scripting , (b) DGS Monitoring

4 Conclusion

The use of amounts of sensors networked to central systems bring a lot of complexity to the system, making data traffic lack and require the coordinators from sensor nodes to central data systems. Sensor middleware systems can solve this problem located on between sensor fields and user experience area. In order to construct the efficient sensor networks systems we suggested the DGS based on agent as role of sensor gateways and middleware. DGS operates as the network coordinator implemented the hardware platforms based on various types of agents. This platform can apply the huge sensor networks such as from power plants, factory to national disaster management.

Acknowledgement

This work was supported by the Korea Research Council of Fundamental Science and Technology (KRCF) through National Agenda Project.

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