Artif Life Robotics (2008) 13:264–270
DOI 10.1007/s10015-008-0570-0

ORIGINAL ARTICLE

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Broiler-house environment monitoring system using sensor network and mail delivery system

Received and accepted: July 16, 2008

Abstract In this paper, we propose the system that combines the sensor network with the mail delivery system to construct the system that observes an environmental change of the broiler-house. As a result of hearing of the producer, the environment system needs to able to be observed some broiler-houses, to inspect the summary data from the cellular phone, and to transmit the warning mail in a rapid temperature change. A basic part of the system is a sensor network by the sensor module that we developed. Only the sensor modules are put in the each broiler-house, and the network by wireless LAN communication is constructed, because the system needs to watch of two or more broiler-houses, and it is difficult to setup a large-scale system at the broiler-house. The always-connected high-speed Internet is preferable to accumulate, to process data, and to offer it to the user in a comprehensible form. But, it is difficult to build always-connected high-speed Internet at the chicken farm which is used by experiment. The server is set up in the remote place, and we propose the system that delivers data from the chicken farm with mail. The verification of the effectiveness of the proposed system and the problem are examined by actually setting up the system that proposes it in the broiler-house, and operating it.

Key words Sensor network · Mail system · Broiler-house environment monitoring system

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This work was presented in part at the 13th International Symposium on Artificial Life and Robotics, Oita, Japan, January 31–February 2, 2008

1 Introduction

Recently, we can obtain various data easily by a high performance of computer and the Internet. Data mining that extracted significant knowledge from a large amount of data become popular. The technique for applying data mining to text information such as Web page is developed recently though the data stored in databases was targeted in normal data mining. In the Internet, various time series data can be obtained. For instance, the image data of the weather satellite and the data of various sensors can be obtained. The feature of these data is continuous data in the time series. The techniques which applied data mining from databases are used for time series data, but some techniques were improved for time series data.

The digital measurements of the temperature and humidity, etc. become possible, and connecting the system that acquired the measured data on the network becomes possible. However, there are many measurement systems which are rich systems that are used sensors on PC or which are cheap microcomputer systems that need to construct a special network for the sensor network. We propose the sensor network system using the microcomputer board that can connect to the Internet. This proposed system can acquire information from the sensor of the microcomputer group arranged on the network, and can view collected information on Web browser.

In KES2006,[1] it was shown to be able to construct easily the microcomputer's sensor network which was combined microcomputer modules (Micro Cube) and the database server and the Web application server. The system that measured the room temperature in school campus was constructed, it has run for about two years, and the effectiveness is verified.

The research of ecopic[2,3] is similar to this research. The ecopic research has aimed the construction of ecopic of the

Table 1. Lineup of the CPU and extension boards of micro cube

Board Name	Features
H8/3048BV	CPU board for battery operation
H8/3069	Same for general purpose (see Fig. 2)
H8s/2638	Same for Controller Area Network (CAN)
LAN	Extension board for Ethernet Connection (see Fig. 3)
CF	Same for Compact Flash slot
IDE	Same for storage devices
ADIO	Same for analog/digital IO
COM4	Same for 4-port serial interface
RF	Same for wireless communication
PCMCIA	Same for PCMCIA slot

weather observing system that can make it easily by user. Our proposed system has aim of improving the extendibility by using Micro Cube that is generality module.

There are a lot of researches about MOTE which is the wireless sensor network plathome, and middleware that treats the sensor network as a database is researched.[4-6] The query processing system called TinyDB[7] that runs on TinyOS[8] which is compact OS for the wireless sensor equipment (MOTE) were proposed. A lot of sensor nodes are needed to construct the system that covers the entire university by the wireless sensor network. When the system that covers the campus is constructed, constructing it with small number of sensor nodes in using the wired network at the school becomes possible in the proposed system.

In this paper, we propose the system that combines the sensor network with the mail delivery system to construct the system that observes an environmental change of the broiler-house. As a result of hearing of the producer, the environment system needs to able to be observed some broiler-houses, to inspect the summary data from the cellular phone, and to transmit the warning mail in a rapid temperature change. The verification of the effectiveness of the proposed system and the problem are examined by actually setting up the system that proposes it in the broiler-house, and operating it.

Chapter 2 describes the sensor module using Micro Cube. Chapter 3 describes the composition of the sensor network as server-client system. We describe the installation of Micro Cube, the server and the client and the technique of collecting and viewing data. Chapter 4 describes the proposed sensor system with Micro Cube and mail delivery system. In chapter 5, we describe construction of our proposed system, and discuss about the problem when constructing sensor network. Section 6 describes conclusion and enhancing in a future.

2 Sensor module

In this section, we describe proposed sensor module.

2.1 Outline of micro cube

The Micro Cube is a board computer and is composed of several stackable boards.[9,10] Figure 1 is a photo showing one

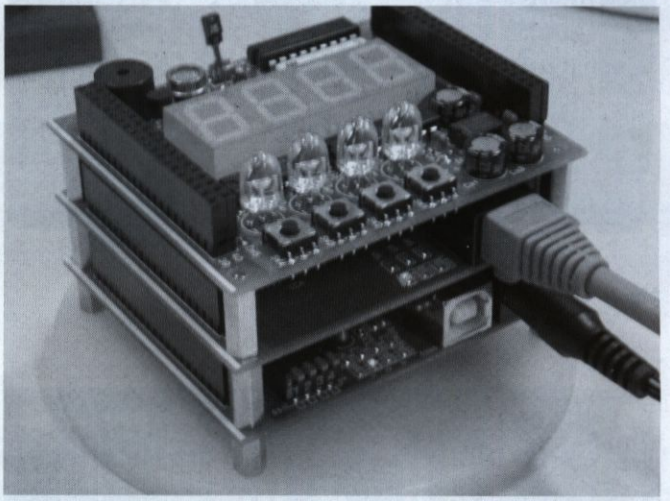

Fig. 1. Photo of a stacked micro cube

of the combinations of stacked Micro Cube. The specifications of the CPU and extension boards are summarized in Table 1. It has a CPU board with a RENESAS H8 CPU and a TCP/IP Protocol stack. Stackable boards can vary as follows: Ethernet LAN board, compact flash board, PCMCIA board, serial board (RS232C and RS422) and so on. (some boards shown in Figs. 2,3). Since the different combinations of stackable boards make a seamless connection with the sensors, users can structure an ad hoc sensor network very easily. To get sensor information through the Internet, HTTP is also employed so that user can get data via a standard Web browser.

2.2 Instrumentation of the present system

The Micro Cube used in the system to get the information of room condition is composed of the H8/3069 CPU board, LAN board, and special sensor board. The special sensor board is utilized the board used of the programming practice class in Future University-Hakodate. (The sensor board is shown in Fig. 1) Future University-Hakodate has the programming practice class with the microcomputer and assembler language as "Media Architecture Practice II". The special board for Micro Cube was designed for its practice class. The push switch, the thermally sensitive resistor (temperature sensor), and CdS sensor (optical sensor)

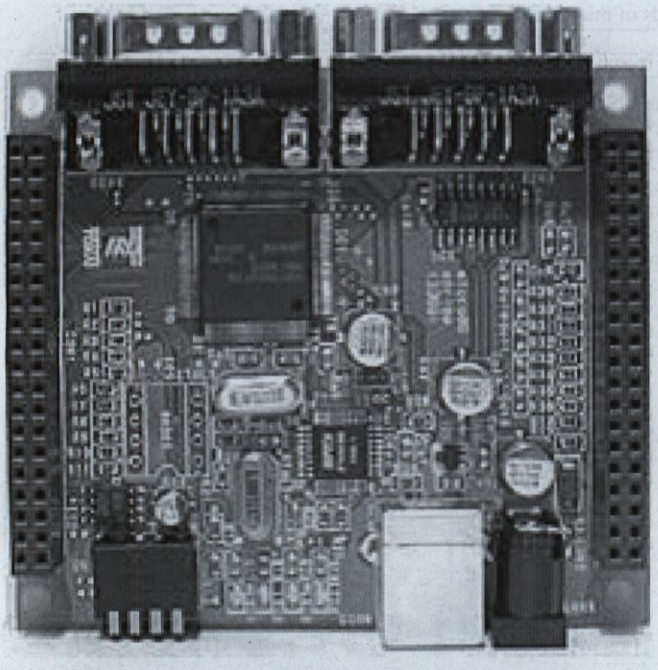

Fig. 2. CPU board

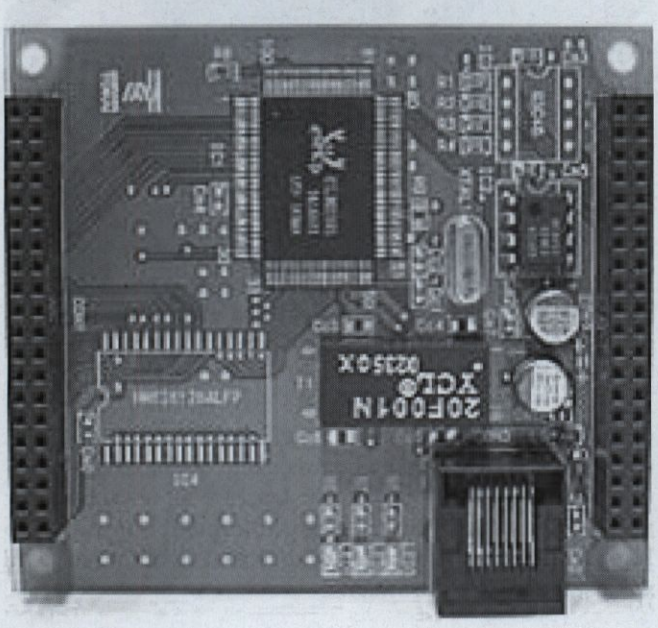

Fig. 3. LAN board

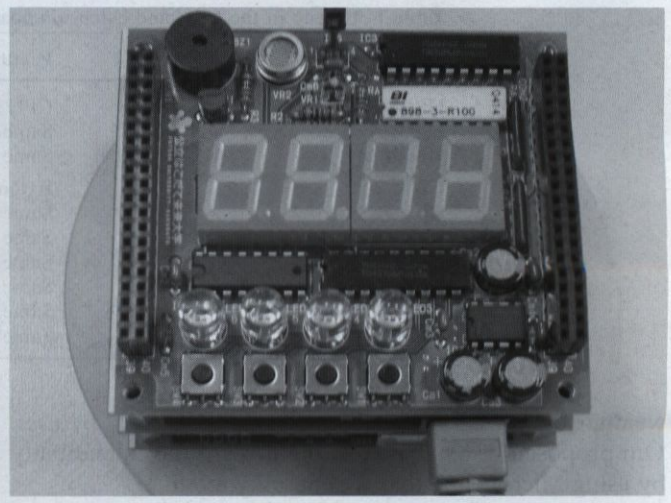

Fig. 4. Sensor board

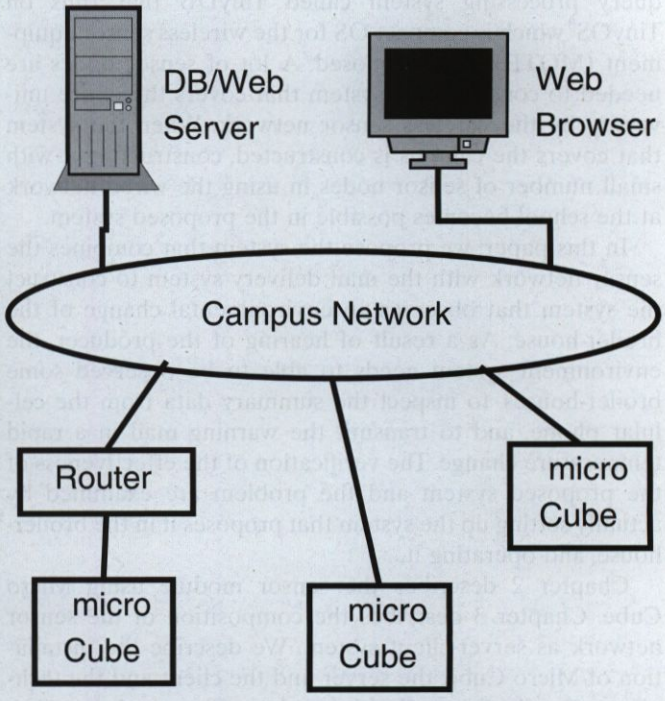

Fig. 5. Network configuration

were attached on this board as an input. Moreover, four digits seven-segments LED and four two-color LED were attached as an output. Because an accurate temperature measurement using the thermally sensitive resistor is difficult, a digital sensor is added in this board for our experiment. Humidity can be also measured in this digital sensor. Only the temperature data is acquired this experiment though some sensors are attached on the board. The exchange and the addition of the sensor can be easily done by exchanging the sensor boards (Fig. 4).

To confirm the measurement data easily, the measured data was displayed in seven-segments LED. Moreover, data can be got by HTTP though the network. When only one sensor module runs, the user can display a present temperature when the user accesses it using Web browser.

3 Network configuration with Micro Cube

The sensor network that measured the room temperature in school campus was constructed by using the microcomputer that explained in Chapter 2. Figure 5 shows the composition of the constructed sensor network system. This

Table 2. Software used in the web database server

System	Software
OS	Red Hat Linux release 9
HTTP	Apache 2.0.40
Database	PostgreSQL 7.3.2
Software codes	Tomcat 5.0.28 and Perl 5.8.0

network configuration is used for personal buoy system for fishery.[11–13]

The used software is shown below (see Table 2). The data store part is implemented by Perl, and the data display part is implemented by JSP.

The following steps shows the steps of the collection of data and the display stored data.

3.1 Data storage

(a) The Perl script accesses to URL of Micro Cube.
(b) Micro Cube returns the measurement result by HTML format.
(c) HTML is parsed, and necessary data is preserved in the database.

3.2 Data browse

(a) URL of the server is opened from a Web browser.
(b) JSP accesses the database.
(c) Necessary data is acquired from the database.
(d) The result is processed to the graph and displayed it on a browser.

The Micro Cube arranged in school is connected with campus network (LAN). The data of each sensor module is acquired with the server set up on the campus network at regular intervals, and stores in the database. In shool experiment, data is acquired from the sensor module every ten minutes. The acquired data is processed with the Web application server set up on the same server, and can be displayed from Web browser of PC on the campus network.

At first, Micro Cube connected to campus network by arranging it in the router because the router had not been exceeded in LAN of the micro cube. Afterwards, connecting Micro Cube to the campus network even if we modified the program, and the router is not set up became possible so that the router was exceeded.

4 Broiler-house environment monitoring system using sensor network and mail delivery system

We apply the know-how of proposed system construction to operate of the system in a field environment. In this paper, we discuss an environmental monitoring system of the broiler-house. It is necessary to observe the temperature change in the broiler-house for a baby bird which is weak in the change of environment, and the sensor network is needed in the chicken farm.

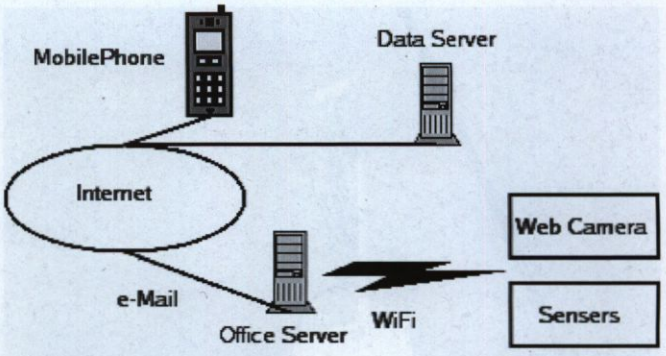

Fig. 6. Network configuration with a mail delivery system

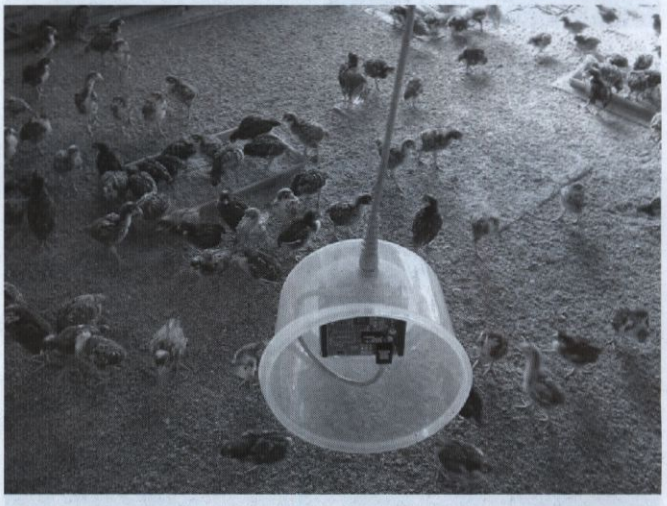

Fig. 7. Setup sensor module

In this paper, we propose the system that combines the sensor network with a mail delivery system to construct the system that observes an environmental change of the broiler-house. As a result of hearing of the producer, the environment system needs to able to be observed some broiler-houses, to inspect the summary data from the cellular phone, and to transmit the warning mail in a rapid temperature change. Figure 6 shows the composition of the constructed sensor network system with a mail delivery system.

A basic part of the system is a sensor network by the sensor module that we developed. Only the sensor modules are put in the each broiler-house, and the network by wireless LAN communication is constructed, because the system needs to watch of two or more broiler-houses, and it is difficult to setup a large-scale system at the broiler-house. Figure 7 shows the sensor module which is put in a plastic case for dust-proof and the drip-proof. The server is put on the office. It was understood that the transmission power was insufficient in usual wireless LAN equipment because the office and the broiler-house had the distance (over 80m), then we used the equipment of wireless LAN of

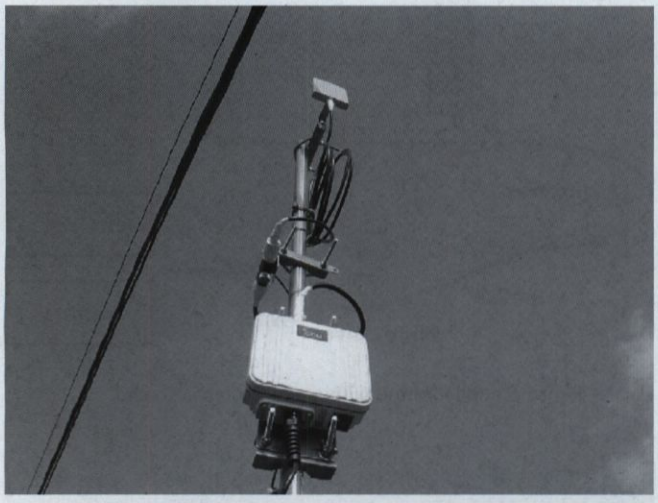

Fig. 8. Setup wireless LAN

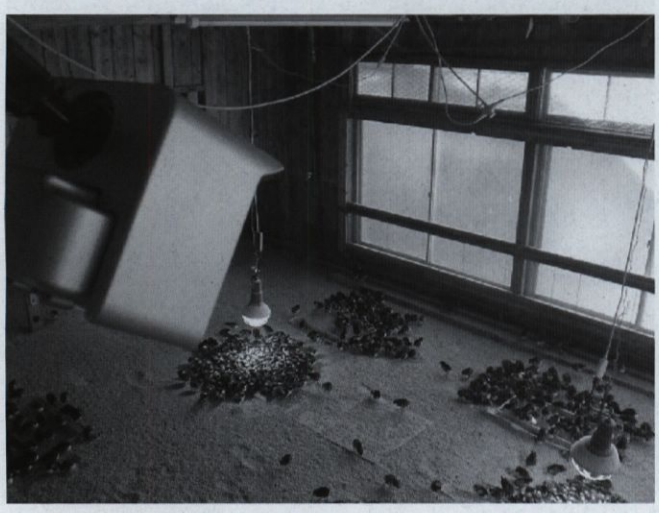

Fig. 9. Setup web-camera

Fig. 8. Wireless LAN equipment was able to be used to set up the Web camera, and people in the office can confirm baby birds of the broiler-house. The Web camera was set up as shown in Fig. 9.

The always-connected high-speed Internet is preferable to accumulate, to process data, and to offer it to the user in a comprehensible form. But, it is difficult to build always-connected high-speed Internet at the chicken farm which is used by experiment. The server is set up in the remote place, and we propose the system that delivers data from the chicken farm with mail. The sensor data is accumulated in the server set up in the office every 10 minutes, and transmitted to the server for the total with mail every hour. In this experiment, the server connected to the Internet with the dial up access every time. Using dial up access and note PC as office server, it is able to be constructed that the system is able to transmit mail when a power failure for a short time is happened.

The accumulation of data, making the output for the celluar phone, and making the warning mail are done with

Fig. 10. Screenshot of list view

the server for the total put on the remote place. The accumulation data can be referred to by putting the server on the remote place regardless of the communication environment of the office. Because the server was put on the remote place, it is possible that warning to a rapid temperature change slows. In this experiment, we considered about producer's communication fee and the easiness of the server installation.

5 Experimental results

The verification of the effectiveness of the proposed system and the problem are examined by actually setting up the system that proposes it in the broiler-house, and operating it.

In the experiment, we construct the broiler-house environment monitoring system which contains the sensor modules arranged in the broiler-houses, sensor network to bring together sensor information in the chicken farm and to transmit it to the server by mail, and the server to inspect from the cellular phone and to transmit the warning mail about a rapid temperature change.

The system that explained in Chapter 4 was actually constructed. The system is constructed in November, 2007, and it is running now.

Some data display examples are shown as follows. (See Figs. 10–11) The displayed volume of information was decreased for the output for the celluar phone and it devised it as seen easily. The output of list view and graph view are mutually switched. The electric wave situation of the celluar phone was bad, then it was not possible to communicate by the celluar phone of a part of career in the office.

Figure 12 shows one example of temperature output. It was able to be confirmed that the change in a rapid room temperature for a short time had occurred from Fig. 12 with considerable frequency. Because it is difficult in a present network environment to warn of the temperature change in a short time, it has been understood to have to increase network connections to correspond to a rapid temperature change in a short time.

Because data began to collect, temperature data is scheduled to be analyzed in the future.

6 Conclusion

In this paper, we propose the system that combines the sensor network with the mail delivery system to construct the system that observes an environmental change of the broiler-house. As a result of hearing of the producer, the environment system needs to able to be observed some broiler-houses, to inspect the summary data from the cellular phone, and to transmit the warning mail in a rapid temperature change. A basic part of the system is a sensor network by the sensor module that we developed. Only the sensor modules are put in the each broiler-house, and the network by wireless LAN communication is constructed, because the system needs to watch of two or more broiler-houses, and it is difficult to setup a large-scale system at the broiler-house. The always-connected high-speed Internet is preferable to accumulate, to process data, and to offer it to the user in a comprehensible form. But, it is difficult to build always-connected high-speed Internet at the chicken farm which is used by experiment. The server is set up in the remote place, and we propose the system that delivers data from the chicken farm with mail.

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Because data began to collect, temperature data is scheduled to be analyzed in the future. In the analysis of data, it is thought that it is possible to refer to a technique of the multiagent base[14,15] and an analytical technique of the analysis of the fixed point observation data.[16]

Whether the operation of a long term can be endured will be examined in the future. Moreover, the temperature change warning system that decreases network connection as much as possible is scheduled to be developed.

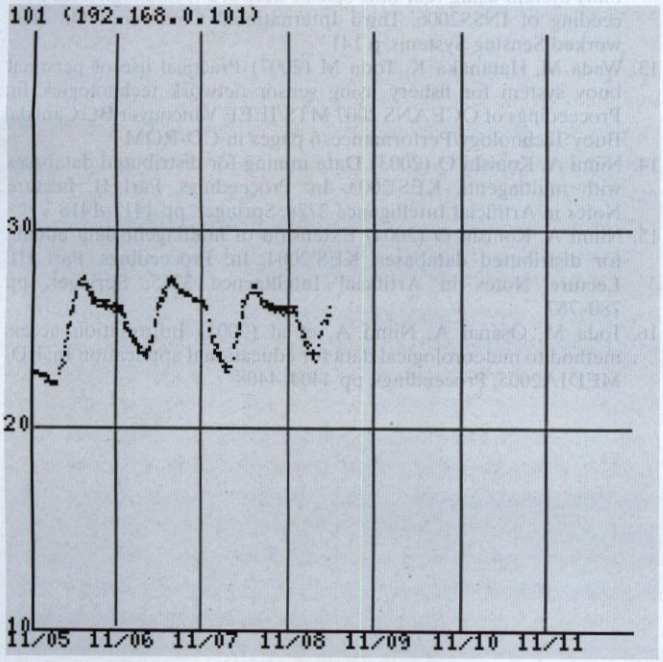
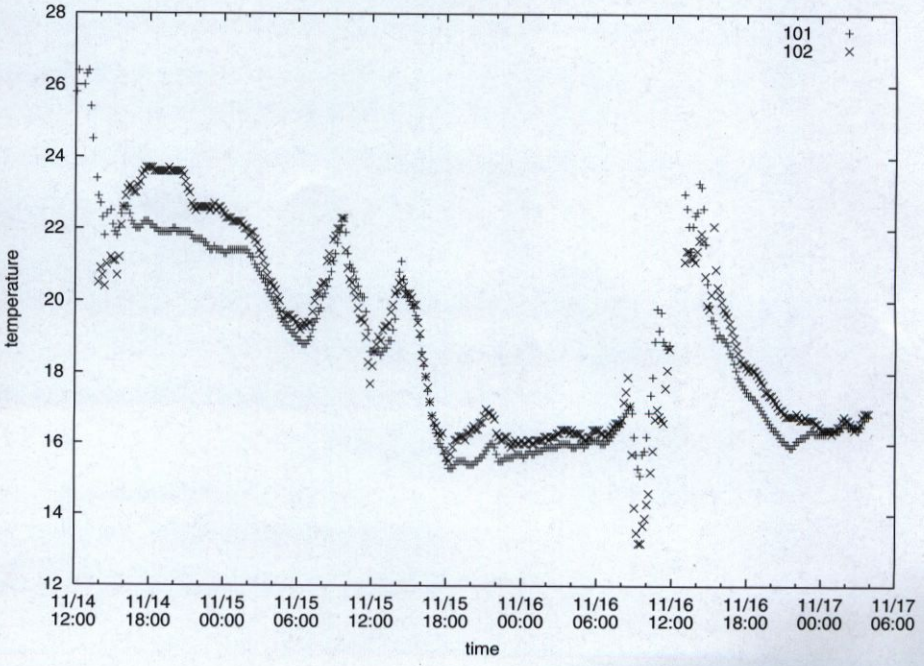


Fig. 11. Screenshot of graph view

Fig. 12. Output temperature



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