Autonomous Measuring by Sensing Node in Telemetry System

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Abstract. *Self controlled sensor system to input signal condition, sampling and signal/data processing operates flexibly to change by measurement environment and measuring object. In telemetry system, distributed autonomous sensor system expands the geometrical measuring range from a point to a plane. Moreover in the local area network of sensor system by wireless communication, the autonomous sensor system enhances cooperation between systems and realizes data exchange and storage in common. This paper describes the hardware construction and operation modes of the autonomous sensor system(sensing node) in distributed telemetry system.*

Keywords: Telemetry System, Sensing Node, Autonomous Measuring

1. Introduction

Telemetry system is a convenient and effective measuring method for the measurement at a long distance place, at a large scale area, at a danger area physically and mentally and the measurement for a long time[1-5]. Most of the telemetry system transfers periodically the data acquired by sensing node at a measuring point to a host system. They are designed in consideration of a sufficient input condition to change by measuring environment and measuring objects. The sensing node operates as a passive device for signalization and data transmission merely. Such telemetry system is valid to a stationary measuring object. But it has various losses on energy, operation time and transmission rate to a non-stationary measuring object or distributed sensing node system. Distributed telemetry system realizes the measurement system considered geometrical characteristics by expanding a measuring range from a point to a plain. In addition to that, by a local area network of sensing nodes, the telemetry system realizes various kinds of triggering, a measurement dependent on other parameters and an estimation of input signal. In the telemetry system, the sensing nodes operate actively and flexibly on a signalization, a data processing and a data transmission. The autonomous sensing nodes decrease the dependence to a distant host system and enhance the effectiveness of measurement system totally.

2. Operating Mode of Sensing Node

The purposes to operate a sensing node autonomously in telemetry system are

1) to decrease communication cost,
2) to avoid the congestion with host system and other sensing nodes,
3) to hold a data in common with other sensing nodes,
4) to save power consumption of the sensing node,
5) to realize self control function as an unmanned system,
6) to follow dynamical changes of measuring object and measurement environment,
7) to store a measurement data temporally corresponding to communication troubles.

To satisfy these demands, the sensing node should be operated by different kinds of operation node (Regular mode, Irregular mode, Event driven mode and On demand mode). The Regular mode is the operation mode to input signals by a constant sampling rate. The data is transmitted to host computer regularly. The sampling rate is decided by the message sent from host computer. This mode promotes a passive operation by static parameters without effects by an external environment and condition. The Irregular mode is the operation mode to presume fluctuations of measuring data and to manage autonomously selections of input signal and a sampling time interval by using a stochastic process model (AR, MA, ARMA, …) or a static estimation model. These autonomous controls realize the effective measuring according to characteristics of input signal, the low power operation of sensing node and the decrease of communication cost without the loss of information in measuring data. The data is transmitted to host computer according to a variable sampling rate. This mode saves the resource of sensing node system by the local control for the measurement of a fluctuation of input signal. The Event driven mode is the operation mode to monitor input signals at a threshold level of

amplitude. At crossing over the level, the sensing node starts to measure the input signals. And at crossing down that level, the measurement is stopped. This mode saves the resource of sensing node system by the local control for measurement. The On demand mode is the operation mode to measure an input signal and to transmit the data by the command message from host system and other sensing nodes. This mode operates the sensing node passively as a slave of host system and other sensing nodes. Four kinds of mode transfer to each other by the command message from host computer. The Regular mode presents the isolated measuring environment by a static internal parameter. The On demand mode presents the isolated measuring environment by discontinuous external command messages. The Irregular mode and the Event driven mode are in a cooperation relation by the autonomous transition of sensing node. The Event driven mode also transfers to itself.

3. System Construction of Sensing Node

The basic construction of a sensing node in telemetry system becomes a sensor, a AD converter, a data converter, a communication unit and a power supply. To realized the autonomous operation, the sensing node needs to add some optional functions (an input signal selector, a sampling controller, data analyzer and so on). Fig.1 shows the system construction to manage four kinds of operation mode mentioned above. The Input Signal from Sensors go through the Input Selector and are transformed to digital signals at the Multi Channel AD Converter. Basically, these signals are transformed into a communication format and are transmitted to the Wireless Unit through the Communication Interface. Examples of Wireless Unit are PHS (Personal Handy Phone), wireless LAN (Local Area Network), Infrared transmitter and other kinds of radio transmitter. The Gate Controller switches the Input Signals individually according to an operation mode. The Input Monitor operates to monitor the amplitude level of input signal in the Event driven mode. When the signal crosses a threshold level of amplitude, the Input Monitor sends the command that the signal is valid or invalid to the Gate Control. The Sampling Controller is the function to manage a sampling rate in each operation mode. The Data Analyzer indicates a sampling rate by investigating the fluctuation of a series of data in the Irregular mode. And also, it controls to change into the Event driven mode. The Message Translator sets system parameters of the sensing node and changes the operation mode by the command message from host system and other sensing nodes. To operate the sensing node autonomously, an electrical power of system is supplied by a natural resource. Generally, the Power Control & Supply unit by solar energy is used. Fig.2 shows the exterior of sensing node (without the power supply) constructed actually. The Multi Channel AD converter has 16 channel input gates. The input signals are converted to digital signals by 12 bit resolution. The sampling rate is 6 to 100Ksamples/sec. But, by using external sampling control, the sampling time interval is able to extend to long time (ex. 1min., 10min., 30min., …). The sensing node is controlled by CPU (10MHz clock) compatible Z80. The CPU operates in cooperation with the Working Memory (SRAM 1MB) by the program stored in EEPROM (256KB). The sensing node communicates with host system and other sensing nodes through serial interface. The Wireless Unit in this sensing node is PHS.

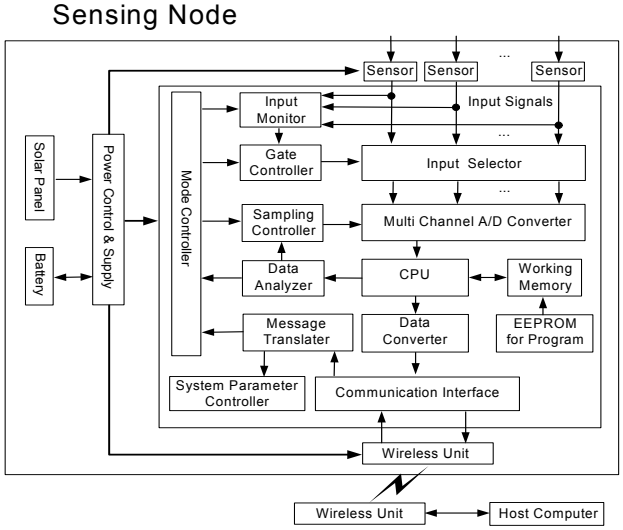

Fig.1. System Construction of Sensing Node

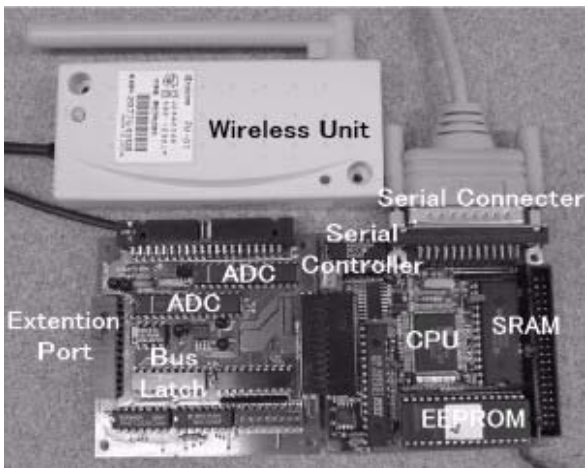

Fig.2. Exterior of Sensing Node

4. Sampling Control in Irregular Mode

Irregular mode controls a sampling time interval according to a fluctuation of input signal. At that time, it is necessary for a sensing node not to loss characteristics(information) of the input signal. To investigate that a sampling control is valid in the Irregular mode, a room temperature is measured in the Regular and Irregular mode by using the sensing node shown in Fig.2. A capacity of the room is $40m^2*3m$(height). At the beginning of measurement, the room was air-conditioned, but it was switched of halfway. As the measurement was continued night to early morning of next day, the room temperature was not affected by sun shine. Fig.3 shows an outline of the measurement. Two kinds of sensing node measured an output of temperature sensor module. The Sensing Node_A operated in the Regular mode. The sampling time interval was 30sec.. The Sensing Node_B operated in the Irregular mode. The sampling time interval was 30sec. at the beginning of operation. After that, the interval was changed autonomously by the sensing node. The interval was selected from 1/6, 1/2, 1, 10 and 30min.. These sensing nodes transmitted the measuring data to two different host computers through independent communication routes each other. In addition to that, the Sensing Node_B transmitted the sampling time interval. After the measurement, by the comparison of the data stored in the computers, it has been investigated that the measuring data in the Irregular mode is valid. Fig.4 shows the measurement results. Two records of the room temperature in Regular mode and Irregular mode have been almost same. The room temperature in Period_I changes regularly between 26 and 29C each 16min.. The sampling time interval in the Irregular mode is constantly. In Period_II switched off the air conditioner, the room temperature falls down gradually. The sampling time interval becomes long step by step. Fig.5 shows a series of the rate divided differences between two data into the data in Regular mode. The rates have been between 0.5 and 1.0%, and the average is 0.74%. Bias of the rate in Period_I is around 0.7%, and that in Period_II is around 0.85%. Coefficient of the correlation is 0.999 totally. Number of measuring data in Regular mode is 682 and that in Irregular mode is 327. The efficiency of measurement becomes about 2 times. It has been confirmed that the data in Irregular mode is valid enough. Fig.6 shows the change of room temperature and sampling time interval for 16 hours in Irregular mode. The sampling time interval becomes short in Period_I and Period_III acc ording to a fluctuation of air conditioned room temperature. In Period_II, the interval becomes long step by step according to a slow downward tendency of the room temperature. And at the end of Period_II, the interval becomes short quickly according to a sudden upward tendency of the room temperature. It has been confirmed that the sensing node corresponds to the fluctuation of room temperature sensitively.

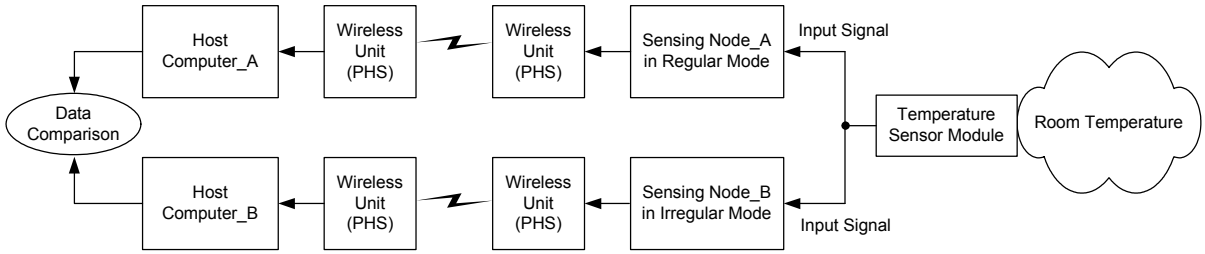

Fig.3. Measurement of Room Temperature by Regular and Irregular Mode

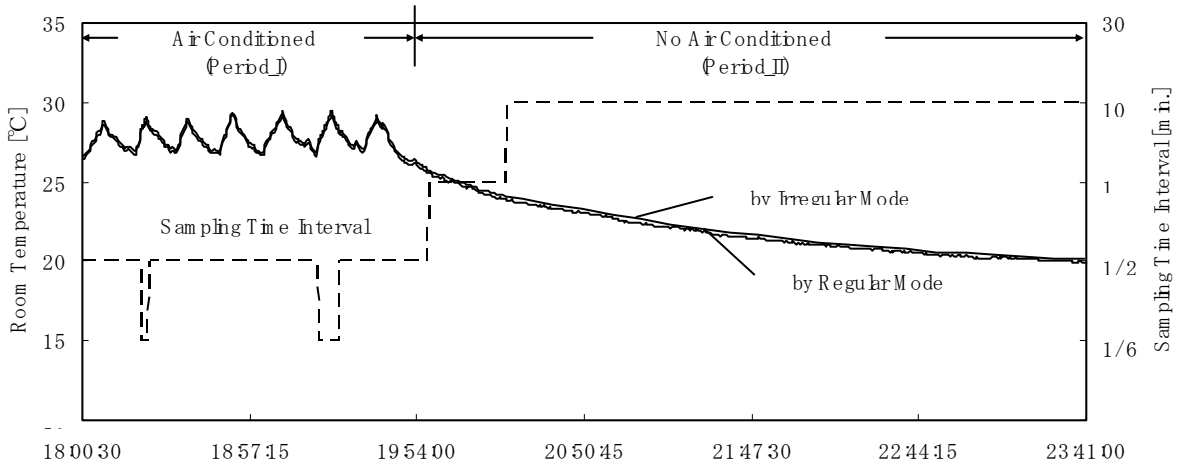

Fig.4. Measurement Results of Room Temperature and Sampling Time Interval

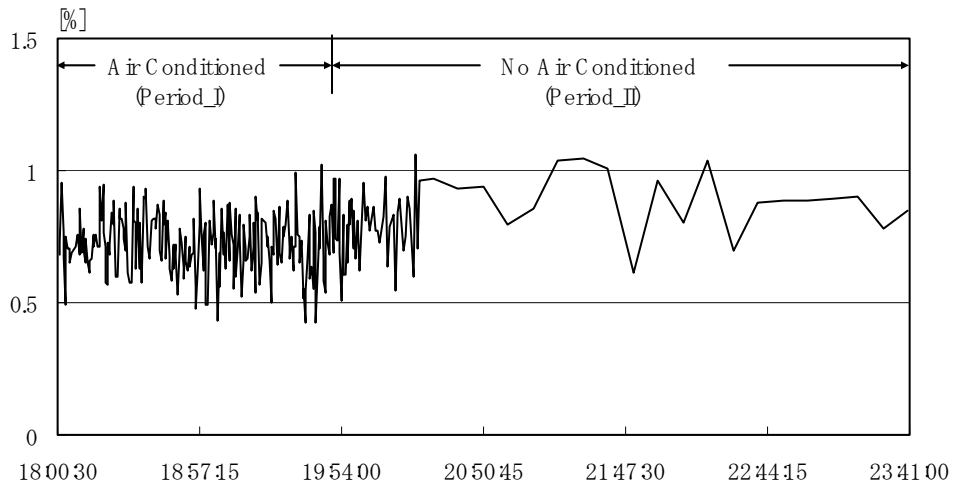

Fig.5. Series of Differences of Data Measured in Regular and Irregular Mode

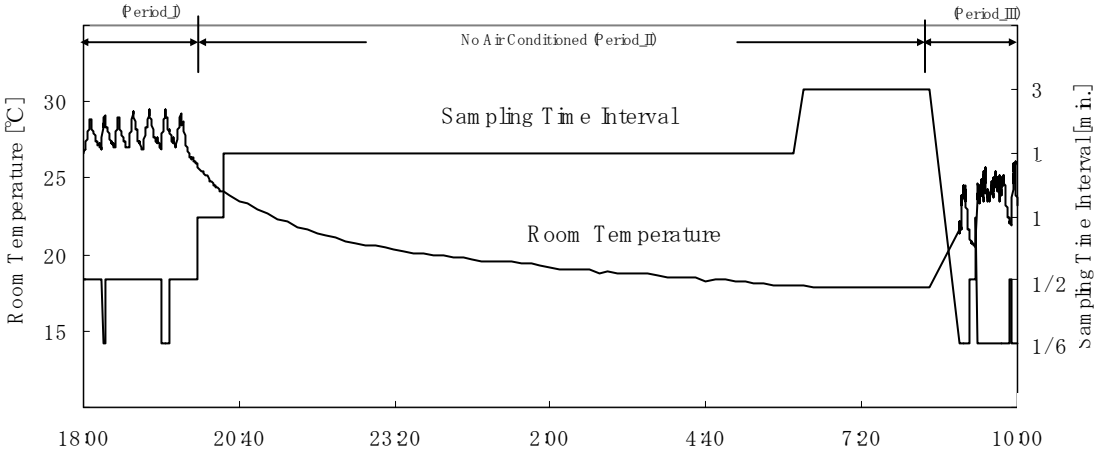

Fig.6. Measurement Results of Room Temperature and Sampling Time Interval in Irregular Mode

5. Conclusions

Telemetry system is the useful system for environment measurement, plant monitoring, navigation system and security system. Autonomous sensing node and the networking are key technologies to construct effective telemetry system. This paper described the fundamental system construction, four kinds of operation mode and some experiments in Regular and Irregular mode. And it has been shown that Irregular mode is effective and necessary for an autonomous operation of sensing node. The advance subjects are on a system construction of local area network by the autonomous sensing node and a data communication between the LAN and a host system.

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