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Invited Paper

Monitoring System for Network devices with Mobile Robots

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Abstract. In universities, network devices of users often become unavailable because of the carelessness of users. For this reason, network administrators of the university have to go to the users' room and to solve problems at the users' rooms where network troubles happen because the network devices do not support monitor protocols such as SNMP. Even if the network devices have the abilities of monitoring protocols, the monitoring system is unavailable at the time of the network troubles, because of many network devices. Solving failures of the network devices in the users' room is a heavy work for network administrators of the university because the administrators have to move on the large campus of the University to go to the users' room. Moreover, the network administrators must manage many devices in campus networks. This paper proposes a method, which collects the states of the network devices in campus networks to reduce the burden of the network administrators. This method uses the monitor devices, which are attached to the network devices. Mobile robots collect information of the network devices by patrolling by the monitor devices. This paper describes the system, which is implemented by using cleaning robots and small computers and reports the results of the experiments of the proposed system at the Saitama University.

1. Introduction

In Japan, many universities provide a network to users such as faculty members and students for education and study. In universities, "Information Technology Center" take a role in network management. A small number of network administrators operates the network despite many users. Network administrators have to take charge of many tasks alone. For this reason, the per capita workload of the network administrators is increasing. In fact, support service of users such as help desk is big burdens of network administrators. Users freely connect network devices such as Broadband routers, Ethernet switches and media converters to the network of the university by the discretion of users. Therefore, users cause many network troubles. For example, network troubles are "Loop" of Ethernet switches, and "DHCP spoofing" by broadband routers.

Besides, users have many kinds of network devices. The users' network devices have no functions of network managements to reduce production cost. Many network devices of users do not have abilities of monitoring protocols such as Simple Network Management Protocol (SNMP) [1]. For this reason, the monitoring system for network devices is not available for network trouble of users. Network Administrators of the University has to check the state of network devices on the users' room for a solution to network troubles.

Therefore, we consider a method to reduce a burden on network administrator and to support the activity of the network administrator. The method paid attention to the network administrator's behavior in which solve network troubles. The network administrator checks the state of the network device visually. We propose a system, which reduces workloads of network administrators, by checking a state of network devices of users through a web camera in conjunction with a small computer and automatically determining whether network devices is normal state or abnormal state

by image processing technology. Mobile robots collect information of network devices by going around the periphery of the monitoring devices.

2. Proposal Methods

The purpose of our study is to monitor network environment of users. Our method enables to alleviate burdens of Network administrators. Our proposal method has two elements. The first element is to refer states of network devices by image processing technology. For example, a media converter of Fig1 has four indicators. The indicator of each state shows the state of power lamp, the state of optical fiber cable connection, the state of Ethernet port connection, and the state of Ethernet port link speed.

Fig1. Normal State of a Media Converter.

In the case of a normal state of the media converter, this indicator distinguishes these into four categories.

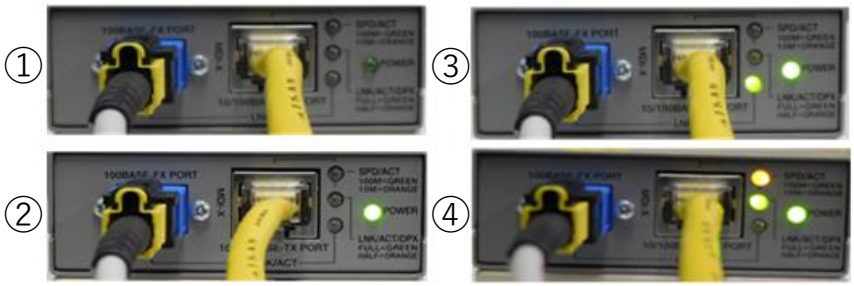

Fig2. Abnormal State of the Media Converter.

Fig2 shows the abnormal state of the media converter. Image of ① shows on the power source the media converter. Image of ② shows no connection to optical fiber cable and LAN cable with the power supply. Image of ③ shows state of optical fiber cable connection only. Image of ④ shows state of Ethernet cable connection only. These different images enable to recognize whether network devices are normal state or abnormal state. These procedures are using OpenCV such as image processing library. Fig3 shows the image processing proceedings.

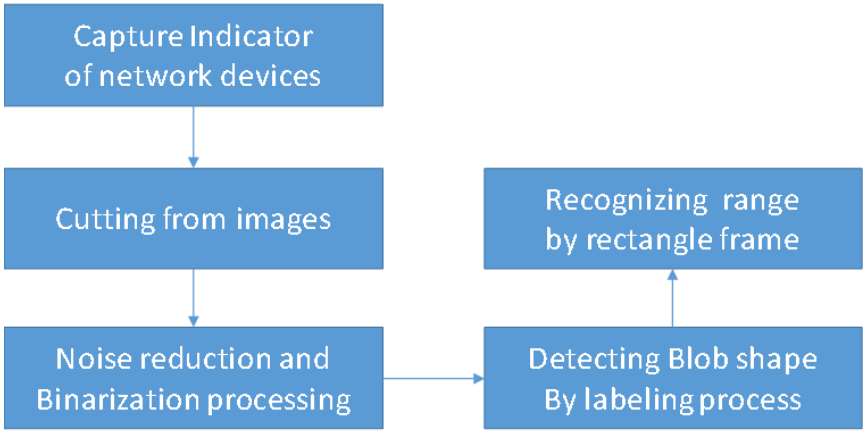

Fig3. The Proceeding of Image Processing.

By the procedures of Fig3, the indicator of media converter enable to recognize such as Fig4.

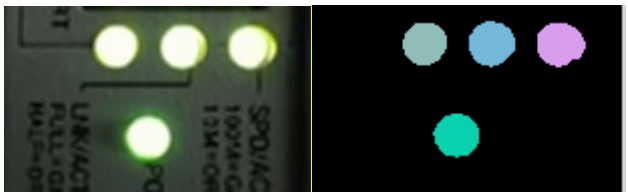

Fig4. Detect indicator of media converters by labeling process.
（Left: Original Image, Right: Recognition Image）

The small computer monitors theses proceedings of image processing as monitoring equipment. The surveillance equipment fit to network devices with attachment. The second element is to gather information of the monitor devices by mobile robots. Using procedures of image processing in the previous section enable to monitor the state of network devices. However, to support that network administrator consider from monitored data, the system needs to grasp the state of network devices by gathering and analyzing data from monitoring equipment. We consider two methods for countermeasure. One of the methods is to use a network, which managed network devices of monitoring object. However, this approach has the problem which data of surveillance equipment is unable to be data transmission in the case of network trouble of the monitoring object. Another one of methods is to use special circuits for monitoring equipment. For example, communication network as specific circuits selects mobile network such as the 3G network. This method is the highest cost and needs to prepare the circuit for each monitoring equipment.

In the case of many monitoring equipments, system management requires the significant cost. Accordingly, we propose a method, which collects information on monitor equipment in campus networks with patrolling around monitoring equipment by mobile robots. We have been a part of contribution in services of cloud robotics; the system name is Remote Open Campus (ROCS) [2]. ROCS is a remote campus guidance service using mobile navigation robots, and remote users controlled mobile robots located in the campus via a server on the Internet. About this knowledge, our research enables to grasp the state of network devices without moving network administrators to users' room on the campus.

In our research, a mobile robot design is based on an iRobot Roomba of cleaning robot (Fig5). The robot controls by Raspberry Pi. The robot is on laser range finder and 3D depth camera. This research uses Robot Operation System (ROS) [3] as robot framework.

Fig5 Mobile Robot design.

3. Related Works

About our research, some research has discussions in a field of the investigation of Data Center Management. Research about monitoring for network devices and servers using mobile robots and image processing. There have been many attempts to research by IBM group [3, 4]. In the data center, mobile robots collect environment information about the temperature and humidity indoors [5, 6]. These researches have focused on controlling air conditioning, which can further reduce power consumption in a data center. To grasp heat spots into a data center, energy improving the utilization efficiency of energy.

In server room of the data center, the free range is narrow and restrictive. In contrast, our challenges on research are difficult to patrol user's environment by mobile robots, because the environment is a variety of patterns.

Some research is different from our research. John et al. [7] proposed a system that monitors some indicators of blade servers by patrolling mobile robots. However, his research is deferent from our research, because his research aims to chase assets in the data center. In fact, because of a long bar mounted mobile robot in research, mobile robot control in case of patrolling's hard. Network communication between monitoring equipment and mobile robots is similar to Wireless Sensor Network.

Numerous researches have been done, especially in the Mobile Wireless Sensor Network fields. Already, many types of researches have methods supporting communication between Wireless Sensor by mobile robots [8]. However, these researches assume the reduction of mobile robots' energy.

Our research using method is Data Mule [9, 10]. In our research, Mobile robots collect information on monitoring equipment, because monitoring equipment is not necessarily communication for each other. To our knowledge, there are no recent studies that present a method to reduce the burden of the network administrators by monitoring network environment of users. Our research is a new contribution in research of network management.

4. Implement System

Fig3 shows an example of implement system based on our method. The system consists of monitoring equipment, mobile robots and monitoring central information server. The system implements by two part as below.

1. The monitoring equipment installs to rooms, which used network devices of the monitored object.
2. Mobile robots travel at corridor on the room installed monitoring equipment.

The system has three procedures as below.

A. The connection between monitoring equipment and mobile robots constitute ad-hoc network by wireless.

B. To create environment maps by SLAM（Simultaneous Localization and Mapping）, mobile robots with laser range finder travel at corridor on the room by remote control.

C. Mobile robots automatically patrol according to the environment maps. For sending an alert message about the state of the network troubles network administrator, mobile robots send to servers the information collected.

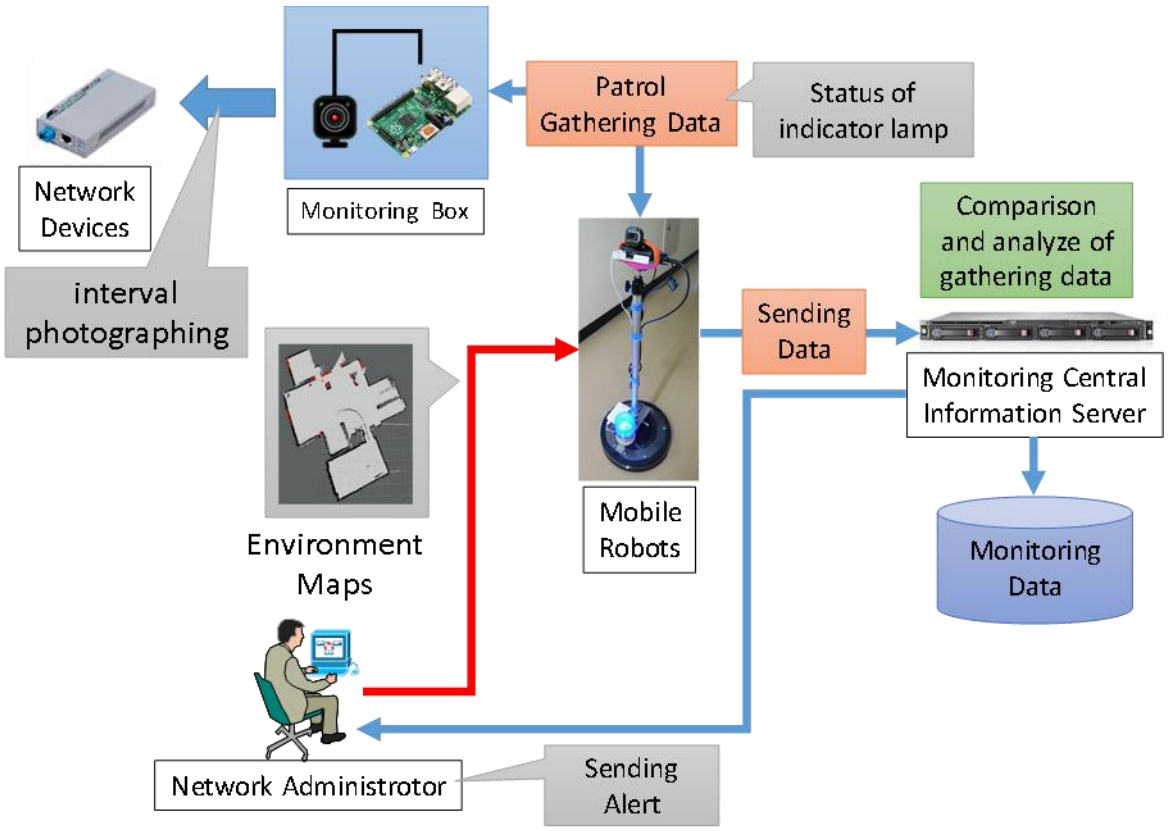

Fig6. Monitoring system architecture based on our method.

5. Results of Preliminary Experiments

We conduct a preliminary experiment with the system implemented methods of the previous section. In the preliminary experiment, monitoring device as subjects of the experiment is media converters at Saitama University in Japan. This experiment aims surveys correctly detect a positional relationship between mobile robots and monitoring equipment, using RSSI（Received Signal Strength Indicator）, Bluetooth Beacons, and Image Makers. In the case of use Image Makers, Image recognition processing succeeds or not. Moreover, Image Makers are enhanced, preventing erroneous recognition when identifying an image of the maker. Bluetooth Beacons use the same frequency band of 2.4 GHz as wireless LAN. Therefore, communication by Bluetooth Beacons happens to jam, because of the variety of short-range wireless LAN. In contrast, RSSI is varied widely, but RSSI enables to detect position correctly.

6. Future Works

In the future work, we challenge two issues using RSSI. The first issue is to send to mobile robots notification for the position of monitoring equipment and communication traffic using RSSI. The second issue is to mobile robots decide to communicate monitoring equipment by using strong signal based on RSSI. We consider these algorithms and implement proposal system.

Moreover, we consider that a plurality of mobile robots cooperates to patrol into the large campus of the University.

7. Conclusion

In this paper, we proposed a method and implemented the system for reducing network administrators.
To preliminary experimental results, it was found that RSSI is the best solution for checking the position of monitoring equipment. Additional work is required for addressing these issues. This work applies to the monitoring system of automation in other fields of research.

8. Acknowledgement

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