A camera sensor network in the Yakima farm

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1 Introduction

It is hard work for the farmer to manage the state of all crops in a large-scale farm. The method of colleting photographs taken by setting up a large amount of camera and sending a wireless network is a technique of the efficiency improvement of this work. However, to collect images in a large-scale farm, a large capacity and a high-speed communication network are necessary.

2 Assumption environment

The situation of mounting the camera sensor network on the farm of Yakima that actually constructs the sensor network and collects temperature information is assumed. The sensor node called VikingX is used in this farm. The measured temperature information by VikingX using 902-928Mhz frequency band is transmitted to the Master. Master receives information from VikingX placed around and process the statistics. Communicate the camera sensor node by using WiFi. Because the image size should be able visually to confirm the state of trees, it is assumed the VGA size of about 30KB a piece. Table 1 shows specs of VikingX and WiFi. Fig. 1 shows the assumption environment of the farm.

Table 1: Node spec

	VikingX	WiFi
frequency	902-928Mhz	2.4-2.5Ghz
Tx range	few km	0-0.1km
nominal speed	230kbps	11Mbps
effective speed	approx. 80kbps	approx. 4Mbps
VGA picture/min	approx. 20p/m	approx. 1024p/m

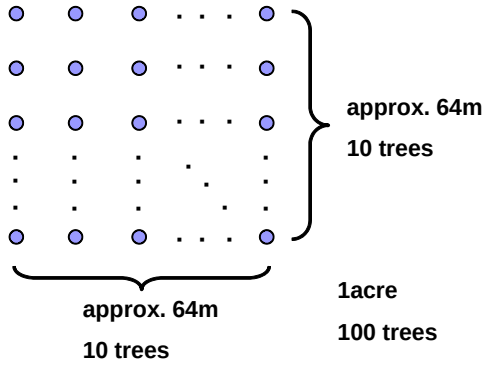

Fig. 1: Assumption environment

3 Optimal node composition

There are two important points when the camera sensor network is mounted on the farm. First of all, the image is delivered to Master as fast as possible. Secondarily, to benefit the reduction of the maintenance cost, power consumption is suppressed. If we use VikingX and WiFi, we consider whether to meet these requirements.

3.1 Only VikingX node

When all nodes are constructed with VikingX as shown in Fig. 2, we think. VikingX is very long the transmission distance, and can do almost all communications by one hop. Therefore, there is an advantage that the route to transmit the image to Master need not be constructed. Moreover, VikingX can mount an efficient camera because the sizes are larger than WiFi nodes. A necessary number of nodes can be decreased if a more suitable camera can be used. However, there is a problem that the cost rises to use a large amount of VikingX. Two or more nodes transmit VikingX to Master at the same time and the collision is occurred because the transmission rate is slow. It is necessary to stand by for a long time by the time the last node transmits when the transmission timing is moved for the collision avoidance.

3.2 Only WiFi node

When the network is constructed only with the WiFi node as shown in Fig. 3, we think. WiFi can decreases interference in Master as constructed only with VikingX because the transmission rate is fast. Moreover, it is possible to curb costs even if it sets it up in large quantities

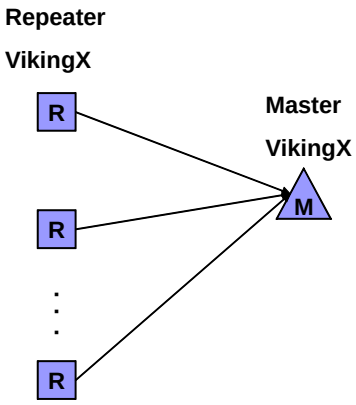

Fig. 2: Only VikingX

because the unit price of the node is cheap. However, to set up a large amount of node, maintenance becomes difficult. The necessity for the best route construction and the wastage rate of data are increased to have to relay the node of two or more times to deliver data to Master.

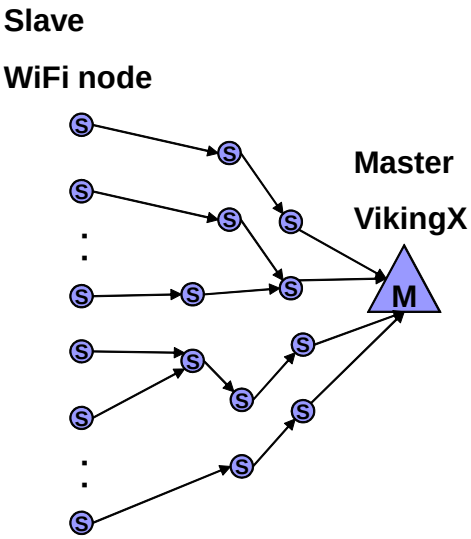

Fig. 3: Only WiFi

3.3 VikingX node + WiFi node (3 layer cluster)

We think about the model like Fig. 4 by whom VikingX is used together with WiFi. VikingX transmits the image data collected from the WiFi sensor node to Master. It curbs costs by using a large amount of WiFi node as sensor nodes. And, the time of the route construction can be saved by using VikingX that the long-distance communications is possible as a relay node. However, the communication congestion is occured so that the communication to Master may use VikingX.

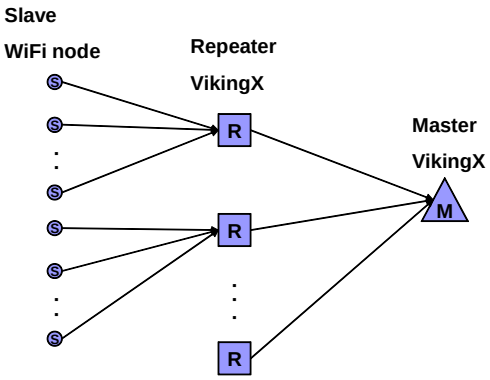

Fig. 4: VikingX node + WiFi node (3 layer cluster)

3.4 VikingX node + WiFi node (4 layer cluster)

We think about a model different from the using together described in the last paragraph. It is a problem the congestion of the communication to use VikingX that the transmission rate is slow when communicating with Master in the last model. Therefore, this problem is solved by using the WiFi node in the vicinity of Master as a relay node as shown Fig. 5 between Master and VikingX. It becomes possible to communicate several VikingX that the transmission rate is slow at the same time, and the communication to Master can be sped up. Moreover, it is a problem in the battery exhaustion of a node frequently to increase the maintenance cost.

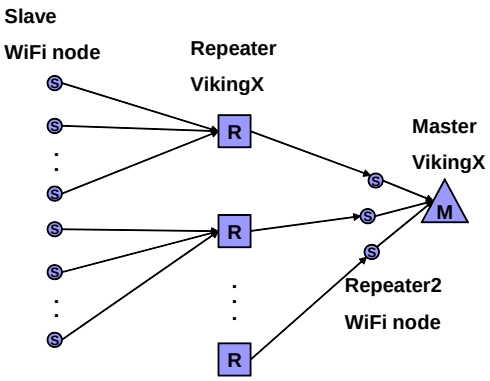

Fig. 5: VikingX node + WiFi node (4 layer cluster)

3.5 VikingX node + WiFi node (Multiple Master)

In the relay assistance with vicinity WiFi node described in the last paragraph, the maintenance cost of the neighbor node is a problem. Therefore, this problem is solved by

installing several receivers in the Master as shown in Fig. 6. The Master node can receive the image data sent from several VikingX at the same time.

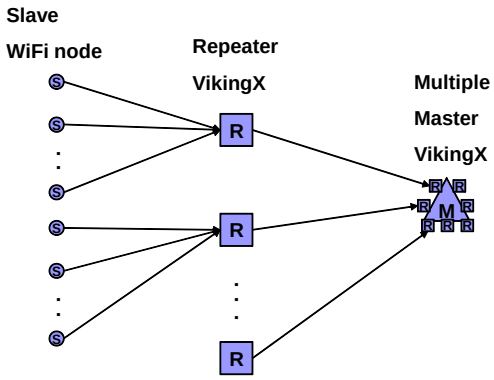

Fig. 6: VikingX node + WiFi node (Multiple Master)

3.6 Discussion

The method that has been devised here is summarized in Table 2. The maintenance cost increases as shown in the above-mentioned though the case to use only the WiFi node can curb costs most. VikingX+WiFi (4 layer cluster) and VikingX+WiFi (MultipleMaster) that a high-speed communication is possible are suitable in the large-scale farm with curb costs.

4 Data collection

In the composition in which VikingX is used together with WiFi, we think whether an efficient communication can be done. First of all, we think about time zone. Power consumption is suppressed by putting the node as a lot as possible into the state of the sleep at nighttime because the image after the sun drops is not suitable assuming that the state of tree is confirmed. It only has to do the transmission completion by using VikingX that is a low-speed communication because this time zone need not newly take the photograph by the dawn. The WiFi node takes sleep after transmitting the image taken at the end of durations of sunshine to VikingX. Because farmer want to collect a lot of images in daytime, it is desirable to use the node that can be used as a lot as possible. Therefore, you should do the communication with VikingX+WiFi (4 layer cluster) in daytime, and use only VikingX at night.

The priority of each area is set from the state of trees the day before in daytime. The image data is transmitted without sending again. Therefore, a high communication of reliability is requested as much as possible as for the image of the area where priority is high. When transmitting from VikingX to relay WiFi node, several nodes receive this communication. The node that receives successfully sets sent to Master and the improvement of the arrival rate is aimed at. When another reception success WiFi node intercepts the transmission of the neighbore WiFi node, own transmission to Master is discontinued. Moreover, sensor WiFi node of the area where priority is high improves the data arrival speed by the concurrent transmission of several VikingX in the positive transmission if it is possible excluding Repeater in own area. Sensor WiFi node takes the sleep after transmitting the image data to VikingX until the following transmission begins.

The node takes the sleep after the sensor node transmits the last image data of that day to VikingX at nighttime. The relay node in the vicinity of Master is put into the state of the sleep, and only the communication between VikingX and Master is done. When the image data of the area where priority is high is not received, the demand of sending again is done from Master. VikingX turn into the sleep after all communications end, too. Master analyzes the color by using Autonisys from the received image, and displays the ranking of color information. The farmer will change priority based on the information and the image the next day.

Table 2: Qualitative evaluation

	merit	demerit
Only VikingX	• The route construction is unnecessary • Reduction in number of nodes	• High cost • The communication is crowded in the vicinity of Master
Only WiFi	• Low cost • High-speed communication	• Maintenance is difficult • The route construction to Master is indispensable • Large power consumption
VikingX + WiFi (3 layer cluster)	• Medium cost • Reduction in number of hops	• The communication is crowded in the vicinity of Master
VikingX + WiFi (4 layer cluster)	• Medium cost • Reduction in number of hops • High-speed communication	• Increase in power consumption in the vicinity of Master
VikingX + WiFi (Multiple Master)	• Medium cost • Reduction in number of hops • Maintenance is easy	