Consideration of Constraints in Communication Terminal Devices Due to an Installed Environment of Sensor Networks

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***Abstract*— Sensors are used to obtain information from a controlled target. We need to review terminal devices needed for a wireless system considered when constructing the sensor networks. This is a study of communication conditions and constraints of the terminal devices from the installed applied environments of the sensor. This will help us review some of the expected applications and limitations before mass installation of the device.**

Keywords— sensor network; installed environment; constraints in communication

I. INTRODUCTION

When we try to control something, we need to gather environmental information of the surrounding area including that object. In other words, a sensing system that observes the space where the control target is must be ready, and the control system must be operated based on the acquired information. The sensing system is an initial requisite to control.

When we consider sensor networks for diverse data collection, we consider wide coverages and scalable wired and wireless systems. Normally wireless systems are being deployed in a variety of environments and are growing in demand. We must consider the configuration conditions of the sensor network and the requirements for the wireless communication terminal equipment used in this network.

The method of constructing the wide area wireless system used for data transfer from these sensors can be roughly divided into two groups. These are a method of constructing a dedicated communication network, and a cooperation policy with a mobile communication network. In this cooperation method there is a direct wireless connection structure and an indirect wireless connection structure. The indirect connection is via a relay and a gateway. Next-generation mobile communication system sees the increased demand for this wireless service. And they have defined 5G which has the three technology categories, which include this as the one category. This definition has been done to include the market needs.

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If this wireless network is studied in the 5G area, it will be advantageous for communication compatibility and for a various device embodiment solution. And it will be advantageous in terms of revitalizing the related industries. Major services of the 5G system are expected to be around the three technologies, which are expressed as Capacity Enhancement, Ultra-high reliability & Low Latency, and Massive Connectivity. This large capacity transmission service considers high data rate in dense and mobile environments for such as Ultra high-resolution screen, Hologram, and Virtual / Augmented Reality. The ultra-high reliability / low latency services consider low latency for such as for tactile internet, remote-control robot. The massive connectivity services consider such as for remote sensors / actuators, smart city-home, IoT, etc. [1]. The Massive Machine-Type Communications (MTC) is attracting attention as a means to observe by wireless sensors and to control actuators at low power and low cost.

These low cost devices based on low-power operation, should be operated at low power and may be able to connect to a long distance. Therefore, it is necessary to realize low price by simplified data transmission method and narrow-band wireless technology. In addition, the communication device must be operated stably for a long time even in a coarse environment where a sensor is installed. This paper reviewed the constraints with component of the sensor network and drew requirements for the wireless communication terminal devices used by this network, and with the related power. It also reviewed how to utilize the vast amounts of data acquired from the sensor network.

II. COMMUNICATION SYSTEM FOR SENSOR NETWORK

In the next generation wireless system, the proportion of machine type communications will be increased more than human type communications with existing portable user terminals. Looking at machine type communications (MTC) usage scenarios, we can divide into two areas. One is a massive connected MTC type focused on a low cost and low power. Another type is a low latency-oriented communication focusing on a mission which requires high reliability.

The function of a massive connected MTC is considered as a means of low-speed data transfer for meter reading of electricity, gas, water meters and the like. And this MTC can be a more simplified type for some simple sensor connecting.
The usage will also grow in suburban and rural areas. Among others, metering, city or building lights management, and environment monitoring represent prominent examples of services in a smart city. The aggregation of all these services leads to very high density devices, which combines different communications and interworking frameworks which has very different characteristics. Depending on a specific use cases, very low cost devices with very high battery life may be required. Many user hopes the battery life is increased significantly: at least 5 days for a smartphone, and up to 10 years for a low-cost MTC device.

Because the massive connected MTC device must reduce the power consumption of the device by considering the characteristics of the usage scenario, a variety of approaches are being explored for low-power operation. To this end, a scheme including simple connection procedures based on narrowband radio wave and reducing the signaling overhead is being studied. Furthermore, the wireless congestion which come from attempting to access at a same time by many devices should be considered. Strictly this is congestions in a case of that multiple sensors installed at a same area try to transmit immediately the detected environmental changed value.

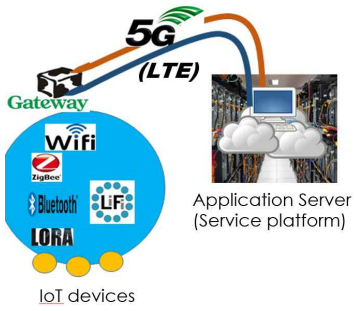

Fig. 1. RAN-based sensor network configuration diagram

As shown in Figure 1, the method to construct the wide area wireless system to transfer the data from these sensors can be the linkage with the mobile communication network. The wireless network structure that connects a remote sensor or actuator using MTC technology includes not only a direct access but also an indirect access.
The indirect access is a relayed connection using M2M function and the other connection is a construct of heterogeneous network by a GW (gateway). Basic requirements for M2M are Energy efficiency, low cost, low signaling overhead, long battery life time.
In this figure, the indirect traffics from devices in the proximity is accumulated in a local node before being sent to a radio node with base station functionality.
The accumulation point at the indirect access can be either a relay, a service dedicated GW, a smart phone connecting personal electronic devices, or a dynamically selected device acting temporarily as the group/cluster head. This indirect connection is similar to which the mobile user equipment (UE) processes the GW function to connect the wearable device. This figure shows the capillary-like structure.

III. CONSTRAINTS IN WIRELESS DEVICE FOR SENSOR NETWORKS

There are some large commercial batteries for these MTCs but the economics of the massive connected MTC should be considered. A low-cost, low-power device may be considered to be a low-power model that uses commercial AA batteries for 10 years [2]. In here there is a voltage loss when the energy of a battery is connected to an external device, due to the internal characteristics of the battery. As shown in Fig. 2, the resistance component (R) in the battery is shown in a simple equivalent model [3]. From the point of view of battery-operated devices, the actual operating voltage (V) should be considered. When the voltage at which the opened terminal is denoted by E, power losses in rechargeable battery can be evaluated by equation 3 shown in Fig.2. The loss in a discharging process is shown in equation 4.

$$\text{Charging voltage:} \quad V = E + R \cdot I_{charge} \tag{1}$$

$$\text{Discharging voltage:} \quad V = E - R \cdot I_{discharge} \tag{2}$$

$$\text{Voltage loss:} \quad V_{\Delta} \cong 2 \cdot R \cdot I_{(charge\_discharge)} \tag{3}$$

$$\text{Power loss:} \quad P \cong R \cdot I^{2}_{discharge} \tag{4}$$

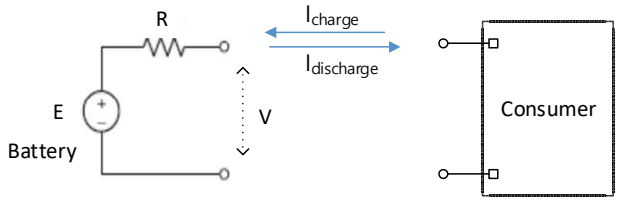

Fig. 2. Voltage scheme of battery

In this case, the R represents the resistance component in the battery. The R value has not only fixed characteristics but also variable characteristics depending on discharge time. In the case of rechargeable batteries as shown in the figure below, the voltage drop is not large during the period of use because of characteristics on discharge time. As shown in Fig. 3, the rechargeable battery shows the characteristics that the output voltage is maintained regardless of the elapse of the discharge time for a certain period of time. When other types of battery are used, the output voltage becomes weaker depending on the discharge characteristics over time.
Due to these characteristics of the battery, the capacity tends not to be expressed numerically. The dry batteries will be used pervasively for the massive connected MTC applications due to

their low price, but internal circuit of the device have to be stable in this voltage range which come from the voltage attenuation.

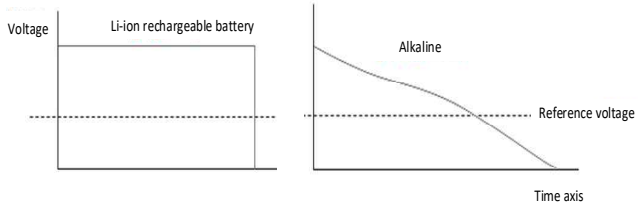

Fig. 3. Voltage scheme of battery

Because the battery cell is related to the chemical reaction, it is affected by temperature and is based on storage and use at room temperature. the battery is still discharging even when not in use. There is a case of leakage when the battery is stored for a long time or is slowly discharged due to low power consumption. In addition, when the battery is short-circuited, the temperature may rapidly rise due to a rapid chemical reaction. Care must be taken when using these products because there are many commercial products including those that had been improved these characteristics or not [4].

Connected IoT devices are becoming more functionally rich, not only in capabilities, but in the data they generate and transmit. If low-power and low-cost technologies are pervasively applied when wirelessly connecting a large number of widely distributed sensors or actuators, the IoT devices for sensor network will be proliferated. There is a need for a way to manage and effectively utilize a myriad of installed devices through such connections. Next generation sensor network must provide up- and down-scaling connectivity solutions for tens of billions of devices since it is expected that there will be more connected devices per one human user of communications systems for human interaction.

Considering the large data collected from this, the existing management technology will reach the limit. As the number of wireless connection devices increases, a more advanced technology is required. They can be integrated into the cloud platform to provide support for control and management. Cloud services have evolved into various infrastructure and wired and wireless network configuration stages through software sharing stages at the level of storage and computation processing [5]. Therefore, a combination of such physical space and virtual space is required.

As these devices blend seamlessly into our daily lives, it's vital that developers secure and protect the data in these devices from being stolen or manipulated.

The data obtained here can be used for machine learning and optimal control can be achieved through this. This method often uses reinforcement learning through time series data. Variables related to energy demand and supply are affected by user policy. They have very complex dynamic correlations. Deep reinforcement learning AI technology using Deep Q-network (DQN) is considered to be effective in determining demand and supply control policy in such environment [6].

IV. CONCLUSIONS

This paper reviewed the communication conditions and wireless terminal devices in an installed environment of sensors. This has a connection with some anticipated applications and massive deployments of a sensor. Sensors are used to obtain the information from a control target. This is necessary to operate for a long time in an installed location and the operation is applied unattended. These sensors often want to be connected to a wireless system. In the wireless system, the wireless congestion problem due to multiple concurrent connection attempts by many devices should be considered. And the power constraints of the device should be studied. Since a huge amount of data is acquired from the wireless connected sensors, it is necessary to use efficient data usage technology.

ACKNOWLEDGMENT

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