A STUDY FOR SUITABLE SPECIFICATION OF MEDICAL USE RFID

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Abstract: Most of medical accidents around the patients are depending on misidentification of human or medical articles. The accidents can be reduced, if information about the human and medical articles are managed automatically. RFID (Radio Frequency IDentification) tag can be identified automatically, since the tag is using wireless communication for identification. It is effective medium to reduce the medical accidents. However, a specification of medical use RFID as a communication medium is not discussed. In this paper, the problems for realization of the tag and suitable specification of the tag are discussed.

Introduction

The number of medical accidents has recently been increasing. Most of the accidents around the patients are depended on misidentification of human or medical articles. For example, patient A was identified as patient B in a surgical room. The accidents can be reduced, if information about the human and medical articles are managed automatically. Nowadays, Bar code is one of effective medium to manage the human and medical articles. However, the bar code cannot be identified automatically, since the code is printed matter. On the other hand, RFID (Radio Frequency IDentification) tag can be identified automatically, since the tag is using wireless communication for identification. It is effective medium to reduce the medical accidents. However, a specification of medical use RFID as a communication medium is not discussed. There are several problems around the medical use RFID[1]. In this paper, the problems for realization of the tag and suitable specification of the tag are discussed.

Principle of RFID

Principle of RFID is shown in Figure 1. RFID is a sort of beacon system. If RFID tag approaches to reader antenna, tag receives a signal from the reader. The signal inquires to tag about its ID and some property information. In most of RFID tag, electrical energy of the signal is charged to small capacitor in tag circuit. Battery less operation is possible in most of RFID tag, since the energy for reply has been charged in the capacitor. On the other hand, RFID tag reply to reader about its ID and property information only one time. The reader completes identification with receiving the reply signal.

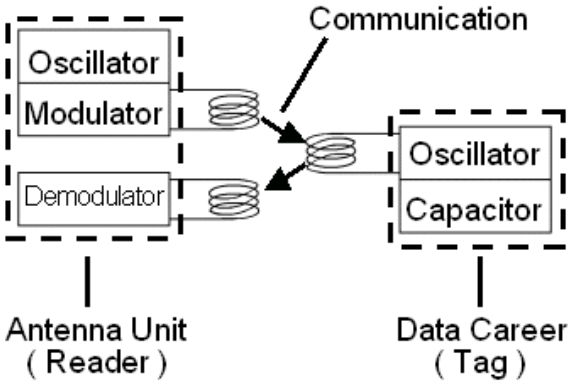

Figure 1: Principle of RFID

In generally, communication distance is small, since the output power is low level. However, the characteristic can be improved by design of tag circuit and its antenna. For example, spread of antenna area, spread of diameter of antenna wire and tuning of Q in circuit are effective improvement.

There are some frequency bands for RFID. They are LF band, SW band, UHF band, microwave band and so on. However, there are several problems in each frequency band.

Most of RFID tag cannot be identified near by metal materials. To improve the characteristic, anti metal tag is also developed. There are several metal material in the medical environment. It is considered that the tag is useful in the environment. However, the communication distance of the anti metal RFID tag is shorter than the normal type tag. Improvement of extension in its coverage area is an assignment of anti metal tag.

Tag circuit can be designed small in size, since the circuit is simple. The circuit is constructed by a receiver unit, oscillator unit, antenna and capacitor. All of them can be made by integrated circuit (IC) technology. Smallest tag is designed 0.4mm square in size by Hitachi, Japan. The tag is called myu (μ) chip. Antenna is also molded in the size. Its size is small enough to put in tablet or capsule. But, the myu chip do not corresponded to metal material. Myu chip on a finger is shown in Figure 2.

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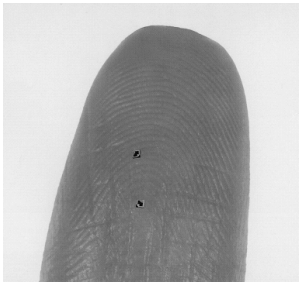

Figure 2:
Myu chip by Hitachi

Medical Accident and Human Error

AT medical care site, the general principle is established that the patient environment is safe, except for in hospital infections such as MRSA. Because of this situation, there has been no positive effort to improve the safety of the patient environment. Recently, some hospitals have been testing incident reports in an effort to prevent accidents. However, depending on the cases, the problems arise that the effort many be connected directly to individual labor evaluations and has not been developed to stage of nationwide execution. At present, the number of patients continues to increase gradually, while the number of nurses involved in nursing procedures is not increasing, but is actually tending to decrease.

In the situation, there is little possibility of preventing human error. Some hospitals use wristband type nametag attached to the patient. In some hospitals, bar code labels are attached to bottles of medicines and the other medical articles. However, these tags and labels may not function as expected. In an accident at Yokohama City University Hospital, a file containing individual information about the patient was placed near the patient. The body of the patient bore traces of past treatment inherent to the disease. The accident occurred because all such information was over looked. Thus, it seems necessary to support the work of medical professionals by using a system that automatically identifies patients, medicines and related medical articles.

Some hospitals have introduced a bar code system for patient identification. In such a system, a reader is moved close to the bar code on the wristband type nametag of the patient, and reading the bar code identifies the patient. It may seem that patient safety is improved and nurse workloads are reduced in this way, but it should be noted that new procedure requiring that a special equipment which has not previously existed at the nursing site must be operated. It is sensible that the patient is identified by the information system, but there remains considerable room for improvement.

In the brief of the author that in the introduction of information equipment into this area, it is not enough to realize functional requirements: there should also be an effort to reduce human error. An example is the hands-free approach, that is, if reducing human intervention, accidents, supports a nursing procedure due to human error may be prevented. A present, information technology is finding wider applications in

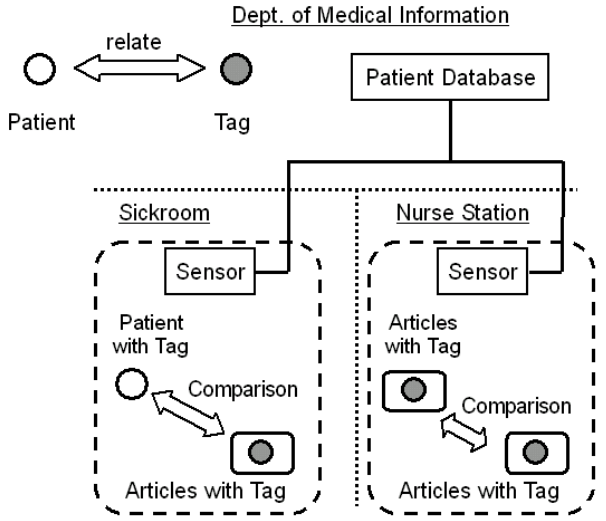

Figure 3: One of supposed system

handling medicines and medical articles. If such a system is realized, it will be easy to identify patients and medical articles in daily procedure, which will contribute to improvement of the patient safety assurance.

An example of supposed system is shown in Figure 3. In order to attach tags to patients and articles such as transfusion packs and syringes, the tags must be small and inexpensive. In order to monitor the matching continuously, battery-less operation should be employed. If the tags satisfying these conditions are recognized without using an additional procedure, the state of matching can be monitored automatically. If such a system is realized, errors in medical prescriptions and incorrect transfusions will be avoided.

Problems in Medical Use RFID

RFID is effective system to maintain the safety level of medical environment. RFID tag is small in size in generally. Hands-free operation and automatic identification are possible in the medical use RFID system. However, there are also following several problems to apply the system to medical environment[2)].

(a). Characteristic for metal articles
(b) Suitable frequency band
(c) Method for identification
(d). Suitable coverage area
(e) Running cost

(a). Characteristic for Metal Articles

Most of RFID Tag cannot be identified to attach the metal articles. In the case of normal type RFID tag, It is not able to reply, since magnetic flux is reduced by the metal material of the articles. Therefore, small metal articles like as mosquito and some forceps cannot be identified. Examples of metal articles in medical environment are shown in Figure 4. Anti metal tag is also provided. However, the communication distance

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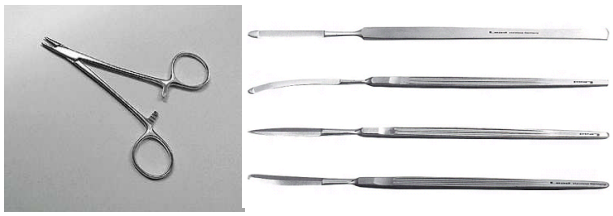


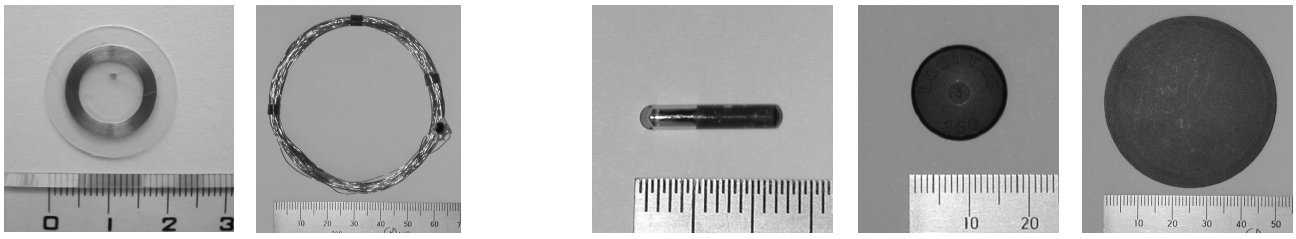
Figure 4: Examples of metal articles in medical environment

is small in the anti metal tag.

The communication distance is evaluated by an experiment. In the experiment, five tags are evaluated. Two types are normal tag. Their diameters are 20mm and 60mm. Three types are anti metal tags. Their diameter is 3mm, 15mm and 50mm. The Tags used in the experiment are shown in Figure 5. In the first step of the experiment, communication distance is measured for each tag. In the second step, steel disk was attached to each tag. The steel disk is 100mm in diameter and 10mm in thickness. After the treatment, communication distance is measured. Result of the experiment is shown in Figure 6. In the figure, horizontal axis shows type of tags. Vertical axis shows communication distance. The distance of each tag is normalized by result of first step experiment. In the figure, it is distinct that the communication distance is reduced to attach the steel disk to the tags. Especially, in the case of 20mm normal tag, communication and identification is impossible. On the other hand, 3mm anti metal tag keeps 91 percent of communication distance. However, the absolute value of each communication distance is small. Improvement of the distance for anti metal tags is indispensable. The absolute distance can be extended by improvement of tag circuit. Especially, tuning of Q in resonance circuit (tank circuit) is effective. By the improvement, some of metal articles will be identified. The metal articles like as mosquito attached improved anti metal tag can be detected, if it is left in patient's body. The safety level rises by using the improved anti metal tag

(b). Suitable Frequency Band

Some frequency bands are provided for RFID system. There are 125/135 kHz band, 13.56MHz band, 433MHz band, 800/900 MHz band and 2.45GHz band. These each band is managed under law in each country. The frequency map for Europe, Japan and US is shown in Figure 7. Most of frequency band are similarly in three areas. However, in 800/900 MHz band, situations are not same. In Europe and Japan, this band is not useful for RFID, since most of the band used another communications like as mobile phone. In only US, 800/900 MHz band is useful for RFID. The tag for the frequency band is not used in worldwide. The frequency convert is indispensable, if the tag used at outside of the area. For example, a tag that is attached to medical article in US, is not identified in Europe and



(a). 20mm Tag (b). 60mm Tag (c). 3mm Glass Tag (d). 15mm Tag (e). 50mm Tag

Normal Tag Group Anti Metal Tag Group

Figure 5: Tags used in the experiment

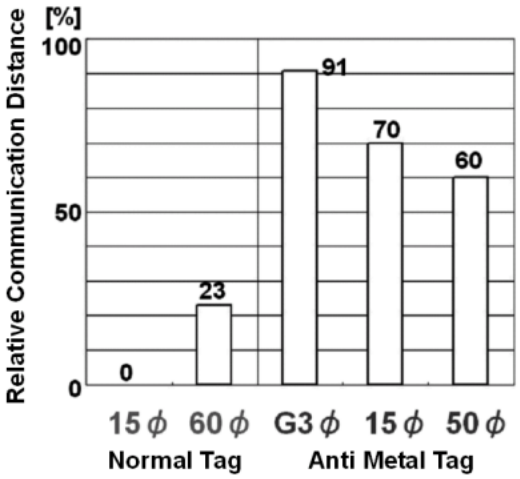


Figure 6: Performance of anti metal tag[2)]

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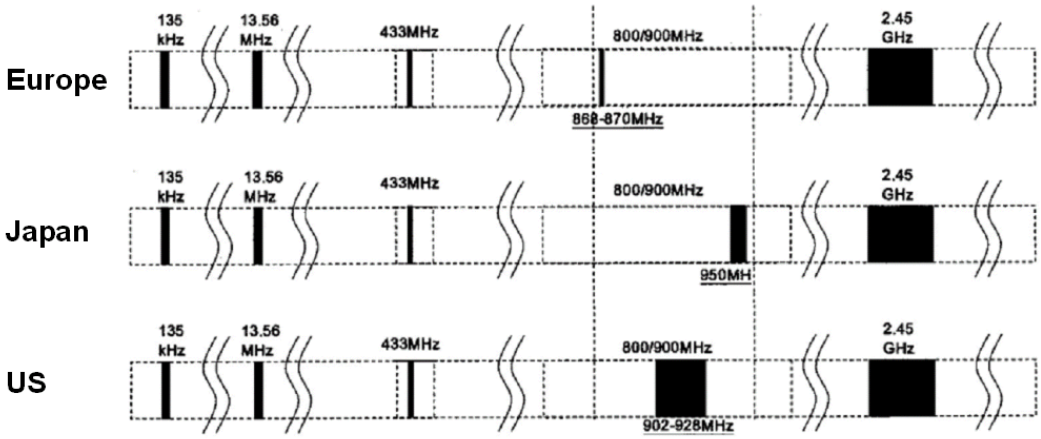

Figure 7: Frequency map for RFID

Japan. For realization of effective medical use RFID tag, the band has to be united in the world.

Another frequency bands also have some problems. For example, 13.56MHz band is SW band. The ionosphere effects SW band communication. Amateur communication band is also located 433 MHz band. The equipments may affect RFID communication, since the equipments may construct by hand made. 2.45 GHz band is also used by microwave oven and several wireless systems for PC. Their signals may affect RFID communication. On the other hand, 125/135 kHz band is allocated only to marine wireless communications and other limited uses, adverse effects or incorrect operation due to electromagnetic noise can be largely avoided using the frequency band. The tags to be attached to the patient and the medical articles should be small in size. Small antenna with high efficiency is difficult to realize in the low-frequency band like as 125/135 kHz due to the long wavelength in generally. The suitable frequency band has to be selected for each application in medical environment.

(c). Method for Identification

Bar code cannot be identified automatically, since the code is printed matter. Bar code reader has to be close to the object to read the code. However, In the RFID, identification information is sent by wireless communications. Hands-free automatic identification can be carried out, if the reader antenna is located suitable position. Automatic identification of the tag is effective, since human error is removed.

However, manual identification like a treatment with intentionally confirmation is also effective. For example, it is considered that the manual check of procedure in providing of medicine is indispensable. When a nurse is engaged in treatment such as administering medicine in the ward, the carried articles are placed near the antenna of the bed side RFID reader, and the reader is operated, for example by pressing a foot switch located under the bed. The reader compares the RFID tag on the wristband of the patient and the tag information of the medicine in the identification range. If a tag that does not satisfy the dependency relation is found, an alarm signal is emitted.

(d). Suitable Coverage Area

Coverage areas of the RFID reader have to maintain the suitable level in each application. Its characteristic depends on reader output power and design of antenna. In generally, the reader of high output power has broad coverage. Broad coverage area is also realized by using effective reader antenna.

In a small coverage RFID reader, an object that is located far from the reader is not identified. However, misidentification of some unrelated objects is prevented using small coverage reader, since the identification area is narrow. An example of antenna characteristic for small coverage reader is shown in Figure 8. The antenna is designed for desktop identification system for medicine in our laboratory. Its coverage area is less than 300mm in diameter. Its communication distance is also limited 130 mm. This type characteristic is suitable for manual identification for RFID tag. In the type of antenna, misidentification can be prevented.

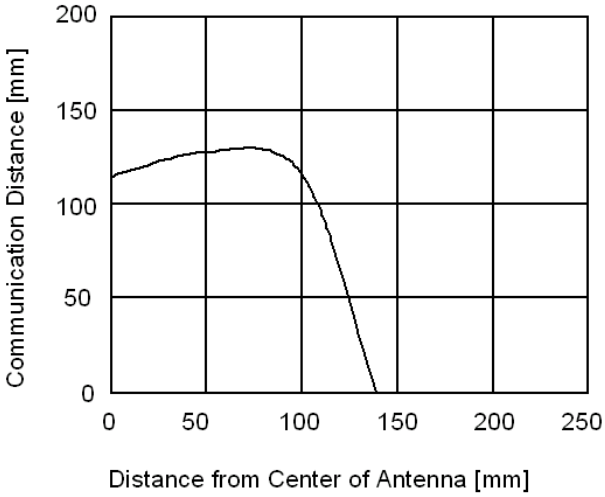

Figure 8: Characteristic of small coverage RFID reader antenna[3)]

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On the other hand, large coverage reader is also necessary. Especially, in the case of hands free and automatic operation, the system is required long-range characteristic. Using broad coverage reader can solve it. An example of antenna characteristic for broad coverage reader is shown in Figure 9. The antenna is designed in our laboratory for automatic patient identification in surgical room. The RFID reader is same to case of figure 8. This antenna is set around the surgical light. The distance between antenna and patient is over 800 mm. In the figure, communication distance is maintained over 1200 mm in the center of the antenna. The patient on a surgical table can be identified using the system. This type of antenna is suitable in the situation. However, it is necessary to notice misidentification of unrelated objects.

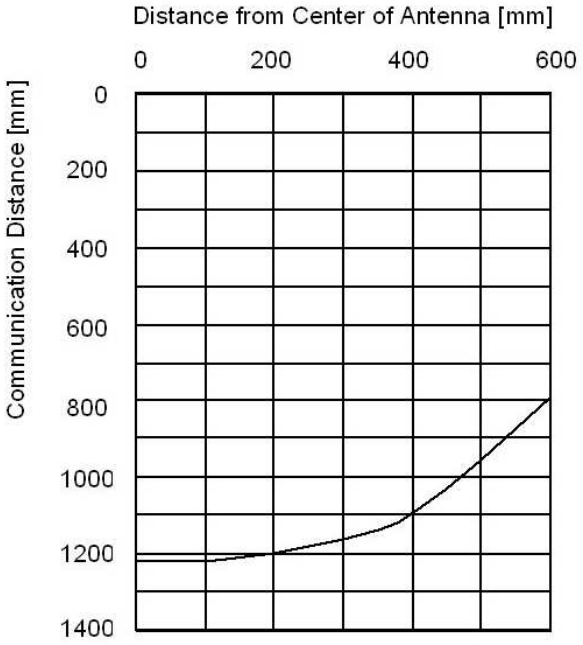

Figure 9: Characteristic of large coverage RFID reader antenna[4)]

(e). Running Cost

Bar code is printed matter. Therefore, it can be printed by ordinary PC printer. It is generally considered that RFID tag is more expensive than other information medium such as the bar code. However, the cost of RFID tags is reducing in present. For example, cost of myu chip for 2.45 GHz is approx. 5 US cent. Another tag for 13.56 MHz is approx. 1 US $.

On the other hand, it is supposed that an inpatient consume approx. 20 tags related medicine (tablets and capsules) and some types medical articles in every day. In the same way, each outpatients also consume approx. 5 tags in every day. Total amount of consumed tags are calculated approx. 31,000 in one large sized hospital in every day. In Japan, it is considered that the 30,000,000 tags are consumed in domestic all medical facilities in every day. Its amount is calculated 11,000,000,000 per year. It is enough amount to reduce its cost. For example, total publication of each major newspaper in Japan is 10,000,000 in daily. Author supposes final cost of tags are fixed 2 US cent for myu chip and 20 – 50 US cent for another tags. It is not expensive to maintain the safety of the patient.

Discussion

Anti metal tag is useful for application in medical environment. Small communication distance of the tag can be improved by suitable design of Q in the tag circuit. 125kHz band and 2.4GHz band are recommended for medical environment. In 125kHz band, confliction between another wireless communications can be reduced, since small number of communications is located in the band. The tag circuit can be made small in size to choice the 2.4GHz band. In Japan, 0.4mm sized tag is realized. The tag can be included in each tablets or capsules. Automatically identification is recommended in most of medical environment. Supervisor in each environment should manage manual identification of the tag. Small and large coverage area RFID system is able to realize. However, suitable system has to be used in suitable purpose. The cost of tag can be reduced, if large number of tag is used. In Japan, over 10^7 tablets or capsules are consumed in every day.

Conclusions

If the medical use RFID system is realized, matching between patients and medical articles will be automatically checked regardless of proficiency or number of nurses. The increase in workload which is inevitable in the application of the system is expected to be relatively small. From such a viewpoint, the medical use RFID system is an effective means in the present situation, where no essential improvement such as substantial increase in nurse staffing is likely. Most of RFID tags are small size and weight, and will not disturb the daily life of the patient, even if it is attached to the wristband or some other part of the body.

However, it is necessary to discuss the principal factors of RFID as wireless communication medium. Without the discussion, medical use RFID system cannot be effective safety management system.

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