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Impact of Position Tracking on the Outpatient Navigation System

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***Abstract*— Reduction of waiting time of patients and idle time of doctors is one of the most important factors of outpatient ward management. Although conventional in-hospital outpatient navigation and re-scheduling systems free the patients from waiting rooms, the systems often cause additional idle times for the doctors and even several clinical incidents. This paper designed a new patient navigation and re-scheduling system equips position tracking. The authors introduced the system into Kyoto University Hospital. As a result, the system decreased more than 100 hours a day of wasted time and irritations of the patients and the clinical staffs. The results tell that the context-aware feature makes not only the system user friendly but also the users friendly.**

I. Introduction

Reduction of waiting time of patients and idle time of doctors has been a center of interest of the hospital management. Many foregoing researches have designed, analyzed and simulated appointing and scheduling systems for better performance of outpatient wards [1-7]. Especially in huge outpatient complex, which has multiple clinics and departments, pre-defined schedule is easily overridden by un-predicted laboratory, radiological tests, patient no-show, un-expected delay of related clinics, etc. Thus, automatic re-scheduling and messaging systems [8,9] are in use.

Although such in-hospital outpatient management systems enables clinical staffs to call patients into the rooms with single click of button, and free patients from waiting room, the systems often decrease performance of outpatient ward, and sometimes cause even clinical incidents.

The authors designed and implemented a new in-hospital outpatient navigation system, which equips the patients' position tracking function, into Kyoto University Hospital to overcome existing problems of the conventional systems. This paper presents the design and effect of the system.

II. Problems of the Navigation Systems

Figure 1 shows typical setup of the in-hospital outpatient navigation systems. The navigation system sets waiting cue for each clinics, and pushes patients into the cue along pre-defined schedule and several additional rules. When a doctor calls patient A in the waiting cue into the consultation room, patient B is pushed into the waiting cue. At this moment, the system sends corresponding messages to mobile terminals of patient A and B respectively.

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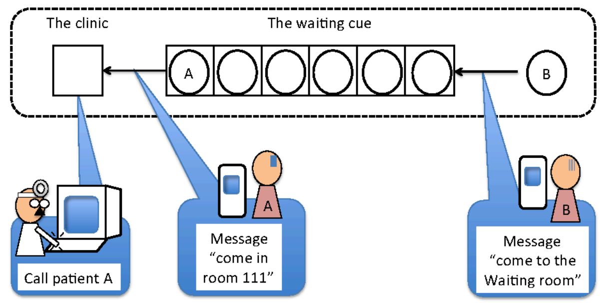

Figure 1. The typical setup of in-hospital outpatient navigation systems

Although the messaging function frees the patients from the waiting rooms, one-way (doctor-to-patient) messaging system often causes additional idle times for the doctors and additional troubles for both the clinical staffs and the patients. Once a doctor calls a patient not at the waiting room, the doctor need to wait for the patient's arrival for a while. If a doctor calls a patient in another department, such as laboratory or radiology section, a clinical staff nearby the patient needs to call the doctor to tell the condition. Those waiting times and additional communications result in not only decrease of total performance of outpatient department but also increase irritation of clinical staffs and patients. Especially, to see another patient jumping into the consultation room directly from the outside of the waiting room where you are won't make you feel better.

In worst case, a doctor may call a patient who has two appointments at the same day for different clinics and waited in front of the other clinic with earlier appointment. It forces the doctor to wait for a while and the patient to rush to the clinic. As a fact, Kyoto University Hospital, which introduced a conventional navigation system in 2000, experienced several incidents that the patients rushing to another clinic fell down and had some additional aid.

To overcome such problems, the system needs to know and tell the conditions of the patients.

III. System Design

A. Patient Position Tracking

Recently, various Real-time location systems (RTLS) [10,11] are available on the market. However, the absolute positions on global coordinates given by the conventional RTLS are not appropriate for context-based application as discussed in the authors' previous work [12]. As the context aware system needs logical positions such as "around the waiting room near the consultation room A", the absolute position need to be interpreted. Thus, the location sensor should tell proximity to a certain referral positions. The authors introduced proximity sensor utilizing the inquiry process of Bluetooth designed by Naya et al [13].

Figure 2 shows the developed system. The system mounts Bluetooth beacon developed by Takebishi at the each waiting room, and tracks positions of patient terminals of the in-hospital outpatient navigation system of Panasonic Healthcare. The obtained positions are provided to the patient terminals and the hospital information system (HIS). Thus, the patients can see where they are and to where they should go as shown in figure 3. At the same time, the doctors can check whether the next patient waiting in the neighboring waiting room on the HIS terminal. As a result, the doctor can call a patient at the waiting room and avoid waiting. When doctor want to call a patient who is not at the waiting room, the doctor can send message "please come to waiting room near room 310" to the patient's terminal in advance.

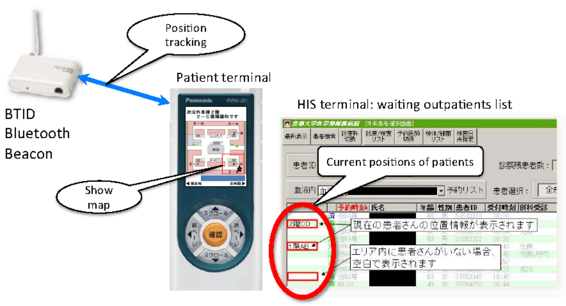

Figure 2. The conceptual design of the proposed system

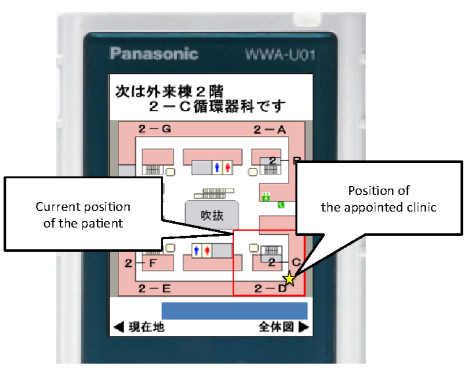

Figure 3. The snapshot of the patient terminal display

B. *Schedule management*

The obtained positions can be used for the on-the-fly re-scheduling. Figure 4 shows the basic status transition and the waiting cue.

The system sets two waiting cues for one consultation room, the outer and inner waiting room. The system calls a patient into the outer waiting cue N (pre-defined) minutes before the appointment, if the waiting cue is not full.

When the inner waiting cue is not full, the system calls the patient in the outer waiting cue into the inner waiting cue. If the patient is not at the outer or inner waiting room at the moment, the system send just one message "please come to the outer waiting room as your turn is coming" and wait until the patient comes back to the place. It means that the messages to call the patient back to the outer waiting room for the patient in "no-show" status is automatically suppressed.

Once the patient agreed (click "yes I'm coming") to come to the inner waiting room, and the patient is at the inner waiting room or the consultation room, the patient is "locked" and all the message generated by the system won't be sent to the patient till the appointed consultation is done. Of course, the system delivers any messages sent by the staffs to the patient's terminal at any time.

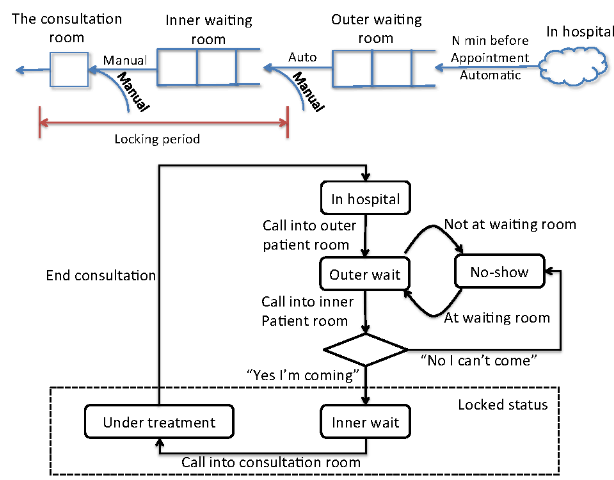

Figure 4. The waiting cue and status transition

IV. INTRODUCTION TO THE HOSPITAL

The authors introduced the developed system to Kyoto University Hospital. The system is replaced from the previous system during "the golden week", a holiday week in May 2011. As the Kyoto University Hospital receives about 2,800 outpatients a day by about 33 departments in a four-floored building, 3000 patient terminals and 100 beacon antennas were introduced to the hospital.

The clinical staffs warmly accepted the idea of patient position tracking. The fact that the IT management section got enormous amount of claims when the position tracking system had stopped just one month after cutover tells how the staffs depend on the system.

The authors estimated the time saving of the developed system.

The authors measured the number of messages to call patient back to the outer waiting room including suppressed messages for the patients in "no-show" status. If no position tracking system were given, the doctors would call the patients into the consultation rooms and be forced to wait for several minutes. The average of 25 business days between July 25 and September 12 was 328.8 messages per day. Assuming the doctors wait five minutes for each attempts, the total waiting time becomes about 27.4 hours per day.

The authors measured the number of suppressed messages for the patients in "locked" status. If no patient locking function were given, the staff would communicate to tell the situation and waste some time. The average of 25 business days in the same period was 1472 messages per day.

Assuming the staffs waste three minutes for each messages, the total wasted time becomes 74.2 hours per day. Even two-third of the messages were ignored, still 24.5 hours would be required.

V. Discussions

The introduction of position tracking for better patient on-the-fly re-scheduling and navigation was quite effective. The evaluation results and experiences after introduction of the system confirm the effectiveness of the approach.

Even 27.4 hours per day reduction sounds over estimation, it becomes 42.4 seconds per patient as the hospital received 2328.4 patients per day in average during the sampling period. Thus, the estimation seems realistic enough. Even it is pile of small wasted time, it becomes 101 hours a day. It is just as old saying “Many a little makes a mickle.”

The best effect the hospital got by the system is reduction of the staffs’ and the patients’ irritations. A lot of clinical staffs welcomed the new function and some staffs changed management of their own outpatient clinics. Although there are several troubles caused by the patients cheating as they are in front of the clinics by leaving their terminal while they are out, outpatient clinic looks more peaceful than before. Thus, the context aware information system is to make user friendly as well as is itself user friendly.

VI. Conclusions

This paper developed the in-hospital outpatient re-scheduling and navigation system equips position-tracking function. The system tracks the positions of patient terminals by proximity sensors based on Bluetooth inquiry process to tell whether the patient is at the neighboring waiting rooms or not. The positions are utilized not only as the supporting information for the doctors to manage their own clinics, but also as the context information to define system’s behavior.

The introduction of the system to the Kyoto University Hospital confirmed the effectiveness of the developed system. The system decrease the doctors’ and the patients’ irritations as well as wasted times.

The context aware system is not just the user-friendly system. By providing information to make users attentive, the context aware system makes user friendly.

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References

[1] R.B. Fetter, J.D. Thompson, “Patients’ waiting time and doctors’ idle time in outpatient setting,” *Health Serv. Res.*, vol.1, no.1, pp.66-90, 1966.

[2] J.F. Rockart, P.B. Hofman, “Physician and patient behavior under different scheduling systems in a hospital outpatient department,” *Medical Care*, vol.7, no.6, pp.463-70, 1969.

[3] J. Vissers, “Selecting a suitable appointment system in an outpatient setting,” *Medical Care*, vol.17, no,12, pp.1207-20, 1979.

[4] J. Vissers, J. Wijngaard, “The outpatient appointment system: design of a simulation study,” *Euro. J. Operational Res.*, vol.3, issue 6, pp.459-63, 1979.

[5] S. Vemuri, “Simulated analysis of patient waiting time in an outpatient pharmacy,” *Am. J. Health-Sys. Pharm.*, vol.13, pp.347-54, 1993.

[6] P.R. Harper, H.M. Gamlin, “Reduced outpatient waiting times with improved appointment scheduling: a simulation modeling approach,” *OR Spectrum*, vol. 25, no, 2, pp.207-22, 2003.

[7] T. Cayirli, E. Veral, “Outpatient scheduling in health care: a review of literature,” Production and Operations Management, vol.12, issue 4, pp.519-49, 2003.

[8] Green IT Promotion Council, “Outpatient guide solutions remote medical care / electronic karte fujitsu limited,” (visited Mar 11 2012) http://www.greenit-bestpractice.jp/product/detail.php?pcid=33&pid=328&language=e

[9] Panasonic news portal, “Panasonic’s comprehensive solutions for entire hospitals: solutions for the reception desk: in-hospital navigation system for outpatients,” http://news.panasonic.net/archives/2010/1227_3337.html, Dec 27 2010.

[10] Ekahau, (Visited Mar 11 2012) http://www.ekahau.com/.

[11] AeroScout, (Visited Mar 11 2012) http://www.aeroscout.com/.

[12] T. Takemura, T. Kuroda, N. Kume et al, “System Value Analysis of Multipoint Distribution of Realtime Locating System in Hospital,” *J. eHealth Tech. App.*, vol.6, no.2, pp.124-127, 2008.

[13] F. Naya, H. Noma, R. Ohmura, K. Kogure. “Bluetooth-based indoor proximity sensing for nursing context awareness,” *IEEE Int. Symp. Wearable Comp*, pp.212-31, 2005.