Analysis of Office Activity Levels Using IoT Sensors and How to Use it to Get the Best from Corporate Real Estate

Recent years have seen growing interest in initiatives aimed at reducing facility management costs and improving employee productivity that involve the installation of IoT sensors in offices and the analysis of how facilities are used and the behaviors of office staff. This article describes the ideas behind a project in which the headquarters building of Hitachi Solutions, Ltd. and Hitachi's @Terrace innovation room were equipped with IoT sensors designed for such facilities, and also work aimed at the future optimization of corporate real estate.

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1. Introduction

The usual routine for office workers in the past was to arrive at work at the designated time, work at their designated desk, and attend meetings at designated locations. Now, however, the spread of flexible working practices means that the way staff spend their time in the office has become more diverse, with people able to choose for themselves when and where to work.

This greater diversity in how staff spend their time at the office brings with it new challenges. These can be broadly split into two issues.

The first relates to office space. To cater for a variety of different working practices, action is needed to transform office spaces with fixed uses into spaces that can change purpose dynamically. Examples include adopting free-addressing in place of the past practice of each employee having their own desk, and the provision of places where people can gather informally for meetings. The challenge that comes with making dynamic use of space, however, is that management and administration become more complex than when spaces had fixed uses.

The other issue relates to staff management and support. Among the new challenges are how to support better communication and how to handle attendance management for employees with flexible working practices.

One approach to resolving these issues that has attracted attention is to use Internet of Things (IoT) sensors to collect information on things like how facilities are used and how staff behave in the office, and to utilize it in various solutions.

2. IoT Sensor Solution for Office Facilities

The method used to monitor how office facilities are used and the behaviors of office staff was an IoT sensor solution from the US company Enlighted, Inc. that is already used at more than 200 building or other facilities across 11 different countries.

The IoT sensor solution is made up of the sensors for acquiring information and a cloud service that provides visualization of that information (see **Figure 1**).

The feature of the IoT sensor used is that the same device can collect data on temperature, humidity, and whether people are present (using infrared), with data transfer by Bluetooth Low Energy (BLE), a low-power communication mode of the Bluetooth* wireless communication technology. Used in conjunction with BLE beacons, the sensors can identify individuals and objects and track their movements in real time. The positioning accuracy is in the range of 1 to 2 m when installed on the ceiling at 3-m intervals to form a mesh configuration.

The information acquired by the IoT sensors and BLE beacons can be visualized using the cloud service in a variety of forms. One example is to plot the number of detections by the infrared sensors that detect when people are present along a time axis. This produces a heat map indicating the times when people are present and can be used to visualize the paths people follow and their use of facilities. Using BLE beacons to show people's movements not only indicates their location in real time but can also be used to display alerts when they enter particular areas or to track their past movements.

A strength of the solution is that it can consolidate this information across a number of different facilities to provide facility managers with the ability to analyze what is happening over a wider area than ever before.

*The Bluetooth word mark and logos are registered trademarks owned by Bluetooth SIG, Inc.

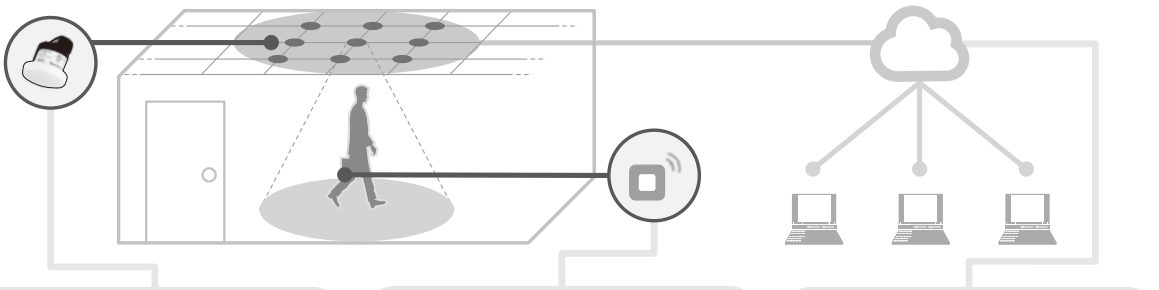
3. Trial Aimed at Analyzing Behavior in Office

3. 1 Trial Location

The trial was conducted by installing the Enlighted sensors in the headquarters building of Hitachi Solutions, Ltd. and at the @Terrace innovation room administered by Hitachi Urban Investment, Ltd., the group responsible for corporate real estate strategy at Hitachi, and by conducting various analyses.

Figure 1 — Overview of IoT Sensor Solution from Enlighted

The ceiling-mounted IoT sensor system sends information about the environment inside a building and the behavior of staff to the cloud. A cloud application provides information about how the facility is being used that is obtained by analyzing this data in a variety of ways.



(1) Environmental information acquisition

IoT sensors mounted on the ceiling or under desks record temperature, brightness, and the presence of people. The sensors are able to communicate using BLE.

(2) Positioning

Used in conjunction with BLE beacons, the sensors can track the locations of individuals and objects in real time. The system achieves high positioning accuracy under standard conditions (1 to 2 m).

(3) Results presentation

The collected data is stored in the cloud where it is analyzed in a variety of ways. Analysis results can be viewed from a browser.

BLE: Bluetooth Low Energy IoT: Internet of Things

3. 2

Trial and Results

(1) Area Occupancy and Utilization

@Terrace is a co-working office that provides spaces for a variety of different ways of working. It is divided into seven areas: the Work Lounge for relaxation or informal meetings, the Presentation Room equipped with a large screen, the Solo Work Space where PCs are available, the Project Work Space equipped with a circular desk and sofa to provide a space for focused discussion, the Huddle Space that can adapt flexibly to meetings of different numbers of people, the Meeting Booth that can accommodate a number of people, and the Concentration Space that is divided up into separate rooms where users can work by themselves (see **Figure 2**).

Figure 3 shows the occupancy and utilization analysis results for the seven different areas. The results are presented as a map of utilization percentages across all areas and also as detailed numbers for each area.

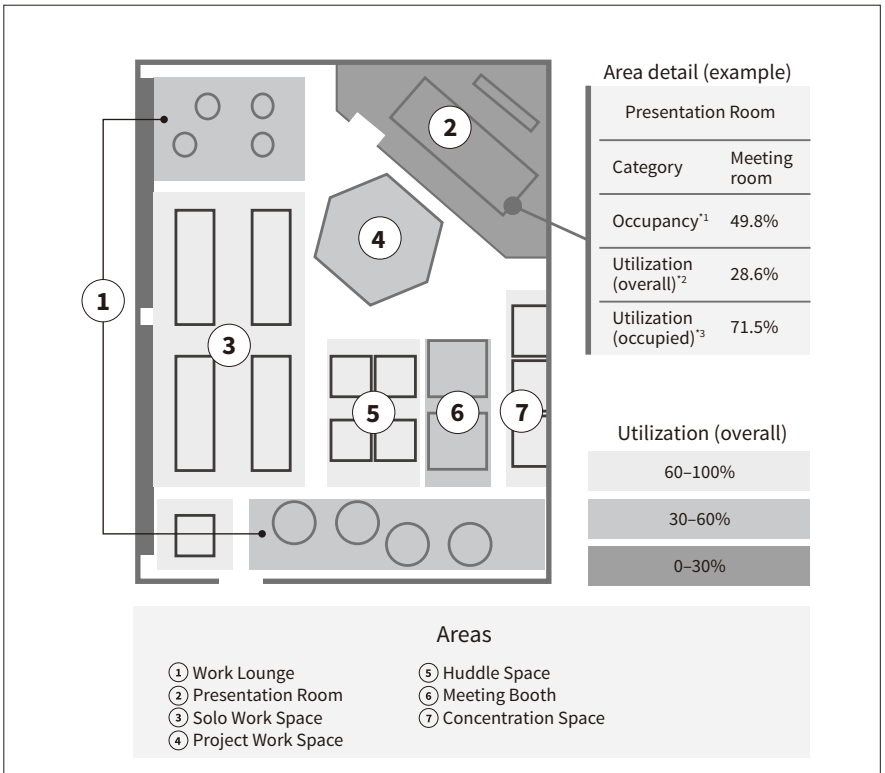
The trial looked at the results for use of the Solo Work Space (for individual use) during working hours from 9 AM to 6 PM. The occupancy, indicating the percentage of time the area was in use, was more than 90%, while the figure for utilization (occupied), indicating the percentage of the space that was used, was more than 70%. This shows that good use is being made of @Terrace as a satellite office. The occupancy of the Presentation Room used for team discussions was higher than expected at about 50%. Furthermore, the utilization (occupied) result of about 70% indicates that a large proportion of the Presentation Room

Figure 2 — @Terrace Interior

Made up of spaces to suit various different ways of working, @Terrace is a place where users can try out new work styles.

Figure 3 — Occupancy and Utilization of @Terrace Areas

The screen showing the occupancy and utilization of each space provides a breakdown of how each one is being used, indicating that the spaces are being used in the way the building operator envisaged.



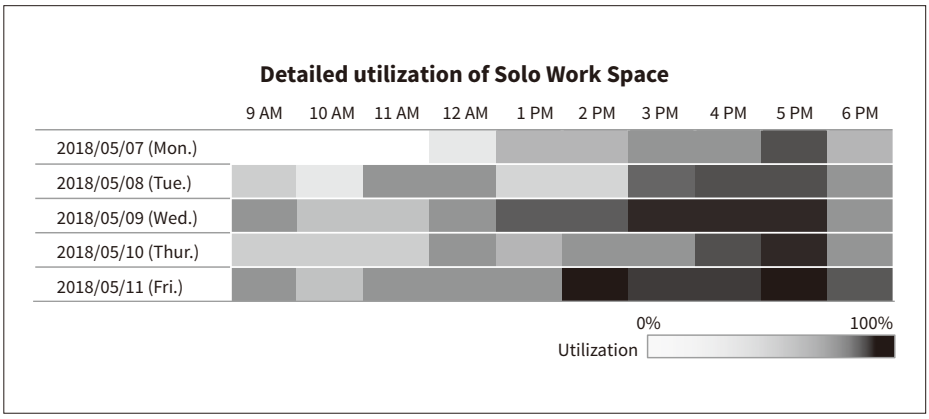
Notes

*1: The proportion of time the space was in use over a specified time period. A space is assumed to be in use if at least one person is present.

*2: The proportion of the space that was used within the target area within the specified time period.

*3: The proportion of the space that was used within the target area over the specified time period and during those times the target area was in use.

Figure 4 — Percentage Utilization of @Terrace at Different Times of Day
The graph provides a detailed view of space utilization. This includes using color intensity to indicate times of high use.



area is used, which was interpreted as meaning that the room is being used by a number of people at a time, as intended. This demonstrates that @Terrace is being used as venue for vibrant team discussions.

The trial also looked at the utilization across different times of the day (see **Figure 4**). The results show high utilization on Wednesday and Friday afternoon, with utilization generally low in the morning, especially so on Monday mornings. This also demonstrated that the facilities are insufficient for the number of users on certain days of the week and times of day. As events are regularly held at the facility, this also suggests there is potential for measures such as holding these at times or days of the week when use is low so as to smooth utilization.

The analysis did not use BLE beacons, only sensors for detecting the presence of people. The trial also included visual counts of the number of people present, with the analysis results being checked to confirm that they were consistent with these counts. From this it was concluded that sensors for detecting the presence of people are sufficient for determining the occupancy and utilization of a facility.

(2) Estimating extent to which facility is in use

@Terrace is used as a co-working office for Hitachi employees and is available without an advance reservation. As the facility has become more frequently used, however, users have started to complain about not knowing how busy it will be prior to arriving. Accordingly, steps were taken to use the sensors for detecting the presence of people to estimate the extent to which the facility is in use.

The first method considered was to estimate usage from the proportion of sensors in the office that were detecting the presence of people. Unfortunately, the results did not provide a good indication compared to a visual assessment. An investigation found that the reason for this was that using the number of sensors currently detecting people as an indicator overestimates the actual number of people present because people moving around inside the facility are detected by multiple sensors (see **Figure 5**).

Accordingly, an alternative method was adopted whereby the extent to which the facility is in use is estimated by statistical processing of changes in sensor information over a fixed period of time. The intention is to also look at incorporating additional information to predict facility use in the future.

Figure 5 — Problems with Indicating Extent of Use
A problem that arose when showing how heavily the facility is being used was that people moving about were detected by multiple sensors, resulting in an overestimation.

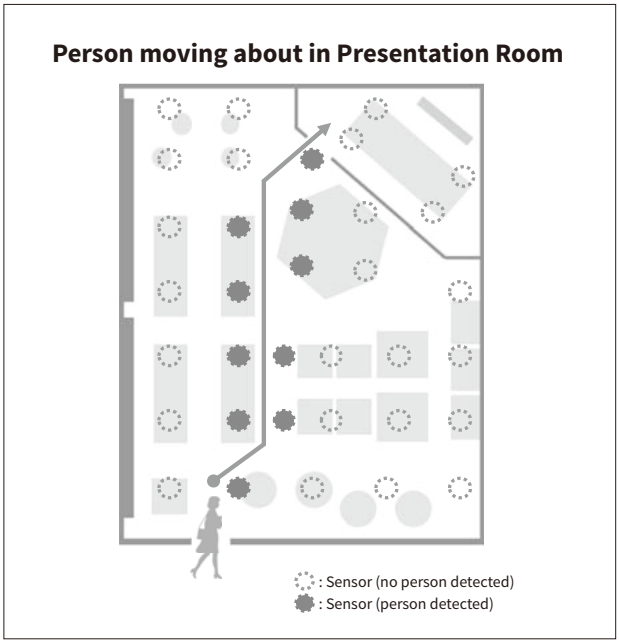
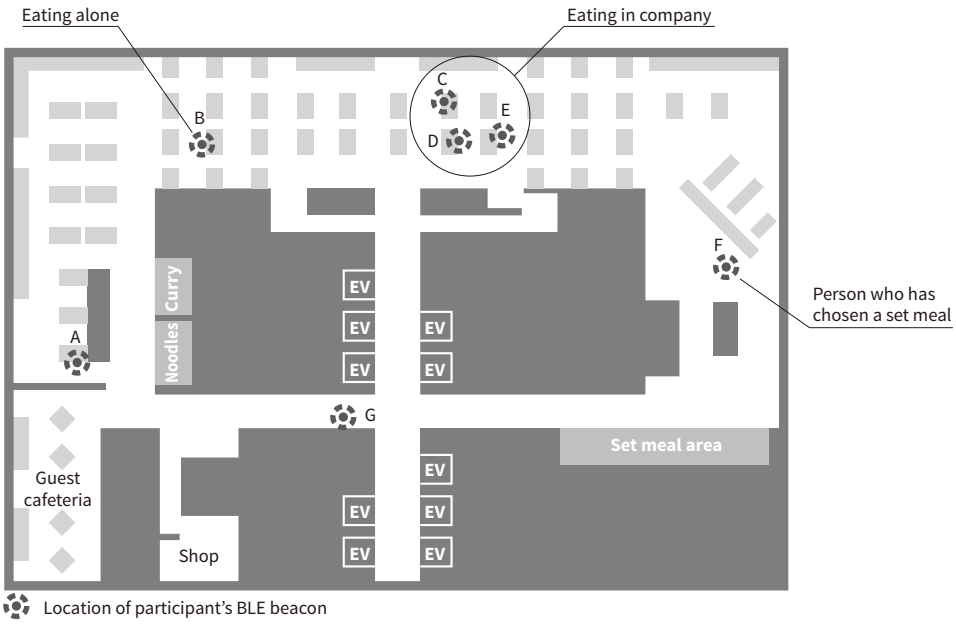


Figure 6 — Behavior of Trial Participants at Cafeteria

Who staff participating in the trial were eating lunch with and their meal choices were determined by plotting their positions on a map of the cafeteria in real time.



EV: elevator

(3) Attendance management and identification of where staff are working

The IoT sensors were installed at two entrances, certain meeting rooms, the cafeteria and some of the office floors at the headquarters building of Hitachi Solutions. Used together with BLE beacons, the sensors provide a way to determine when the BLE beacons are present at particular locations. Accordingly, the trial looked at whether attendance management, and the identification of where staff are working and who they are working with, could be done by having some of the staff wear BLE beacons and analyzing the resulting location information.

The first step was to verify whether the times when staff enter or exit the building could be determined based on communications between the BLE beacons and the IoT sensors at the entrances. A week-long trial in which BLE beacons were worn by 20 staff found that such movements were correctly detected most of the time, but that misdetections also occurred several times. Additional testing determined that, in certain rare cases, signals were being picked up from the BLE beacons worn by staff using a restaurant adjacent to the office building. As a countermeasure, instead of treating the last time the signal is detected as being the time of leaving the building, statistical processing was performed on time-series data, such as collating signals over a period of time and combining this with signal information from the office floors to use as the basis for identifying movements. It was found that, for this case, building entry and exit could be detected with 100% accuracy.

The next step was to analyze what staff do in the cafeteria. This involved obtaining information about the lunching habits of the staff wearing BLE beacons and identifying who they were eating with (see **Figure 6**).

The results of the trial indicated that it was possible to estimate a person's choice of lunch meal (whether they had the curry or set meal, etc.) based on their time spent and sequence of movements to different locations. The results also showed that who people were eating lunch with could also be estimated based on their relative positions and their starting to move at similar times.

The results of the trial indicated the potential for analyzing and determining the behaviors of individual users to provide detailed feedback by combining information about time, place, and surrounding people and objects obtained by the IoT sensor solution.

4. Conclusions

The trial described in this article demonstrated that the IoT sensor can be used to determine how a facility is being used and for staff attendance management and behavior analysis.

Hitachi Solutions also plans to collaborate with Hitachi Urban Investment on the development of new solutions using its W Innovation consulting service that combines work style and workplace reform (see **Figure 7**). Through this solution, Hitachi intends to combine information about workplace and staff obtained by IoT sensors with facilities management applications such as meeting room reservations or air conditioning control and human resource solutions such as attendance management and project management, both to get the best from corporate real estate, including office arrangement and operating costs, and to create more comfortable working environments.

Figure 7 — W Innovation Logo

W Innovation is a consulting service supplied by Hitachi Urban Investment, Ltd. based on its own experience of implementing "(Work Style × Work Place) Reform."

W INNOVATION
働き方改革 × オフィス改革

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