Energy-saving Location Estimation | Location-based Content Delivery | Customer Behavior Analysis

Technology Reports

Behavior Sensing Technology for O2O Marketing — Energy-saving Location Estimation, Flexible Information Delivery Control, Customer Behavior Visualization and Analysis —

Research Laboratories
Hiroyuki Sano
Teppei Konishi
Satoshi Kawasaki
Masakatsu Tsukamoto
Smart-life Planning Department
Masaru Maebatake †

O2O marketing services are gaining attention. These services promote sales and encourage people to visit actual shops based on customer location information acquired through smartphones. Issues with the O2O marketing service include how to combine high-accuracy user location estimation using various smartphone sensors with reduced power consumption, provide information delivery opportunity controls and perform marketing through analysis of customer behaviors.

*NTT DOCOMO has developed behavior sensing technology that estimates position using abstracted map information and provides flexible information delivery controls to respond to customer behaviors etc., and visualization for customer behavior analysis. Including some of these technologies in Air Stamp®*1 enables timely and energy-saving location-based information delivery and detailed customer behavior analysis.*

1. Introduction

Using the sensors built into smartphones enables provision of services linked to indoor/outdoor customer location information. These services can encourage shop visitation by delivering electronic coupons for shops in the customer's current vicinity to the customer's smartphone and deliver in-store product recommendations. Predicted to expand, the size of the market for these "Online to Offline" (O2O) marketing services*2 could reach approximately JPY 236 billion by 2020 [1].

O2O marketing services aim to encourage customer shop visitation, migration and purchase by providing interaction with store information, product information and coupons etc. With this technology, we believe it will be possible to more effectively achieve the objectives described above by providing content matched to customer preferences and needs, and matched to customer locations and their presence in areas in a timely manner.

† Currently Corporate Strategy & Planning Department

*1 **Air Stamp®:** A registered trademark of NTT DOCOMO, INC.

*2 **O2O marketing services:** Information services which aim to influence customer purchasing behaviors in actual stores by making use of interaction with information on the Internet.

As basic technology for providing O2O marketing services, NTT DOCOMO has developed a behavior sensing system that integrates developments for (1) energy-saving location estimation, (2) flexible information delivery controls, and (3) visual analysis of customer behaviors. This system has been included in the "Air Stamp" [2] location information platform provided by NTT DOCOMO. This article presents O2O marketing usage cases, and describes an overview of the behavior sensing system as well as examples of deploying it into Air Stamp.

2. Usage Cases

In providing O2O marketing using behavior sensing system, we assume the three usage cases of encouraging customer store visitation, migration and sales promotions in commercial facilities such as shopping malls, department stores and train station buildings in which there are many shops as well as shops such as supermarkets, home improvement centers and convenience stores. We assume that privately owned smartphones (hereinafter referred to as "terminals") will be the main destination for information delivery, although tablets on shopping carts in supermarkets or home improvement centers could also be targeted.

- Store visitation promotion: The system delivers information when customers are in the vicinity of commercial facilities or shops using outdoor location information. The system also provides customers with a welcome message upon entering a store, and delivers a survey upon leaving.
- Migration promotion: To get customers to visit more shops in commercial facilities or in-store points of sale, the system delivers information on shops and in-store points of sale they have not yet visited or shop and point of sale recommendations. Like a stamp rally, the system delivers a coupon when the customer has visited all designated shops.
- Sales promotions: Using indoor location data, the system delivers information matched to the point of sale or product display shelving. This involves replaying videos about products directly in front of product display shelving to attract customer attention, and displaying coupons available for use if the customer is at a point of sale for a certain amount of time, and is unsure about making a purchase.

Commercial facilities and shops can view visualizations of customer shop visitation behaviors and in-store movements to uncover issues, and go through the "Plan Do Check Act" (PDCA) cycle*3 to consider measures (plan), enact them (do), measure results (check), and improve content and timing of delivered information (act) to maximize effectiveness of measures etc.

3. Behavior Sensing System

3.1 System Configuration

To realize a system to handle the aforementioned usage cases, functions for (1) energy-saving location estimation, (2) flexible information delivery control and (3) customer visitation behavior and in-store movement visual analysis are required. We developed a behavior sensing system to provide and integrate these three functions. **Figure 1** describes an overview of the system.

(1) Energy-saving location estimation functions (Fig. 1 (1)): To estimate terminal location, the system generally acquires values from various sensors in terminals such as GPS, Wi-Fi®*4, Bluetooth® Low Energy (BLE)*5 and makes various computations on the values acquired to convert them to location information. Conventionally, because a system has to do location estimation regularly and often by sensor scanning to continually determine customer indoor/outdoor location or presence, and determine detailed customer positioning at the level of in-store product display shelving and the time that customers are present in an area, there is an issue with increased load on the customer's terminal battery. Therefore, since

*3 **PDCA cycle:** A method of ensuring smooth running of business. The PDCA cycle entails repeatedly and continually running through the four steps of (1) Plan (planning), (2) Do (performing), (3) Check (measuring results) and (4) Act (making improvements).

*4 **Wi-Fi®:** A registered trademark of the Wi-Fi Alliance.

*5 **BLE:** An extension of the Bluetooth short-range radio communications specifications, added in Bluetooth version 4.0, and characterized by its low-power communications. Bluetooth is a registered trademark of Bluetooth SIG Inc. in the United States.

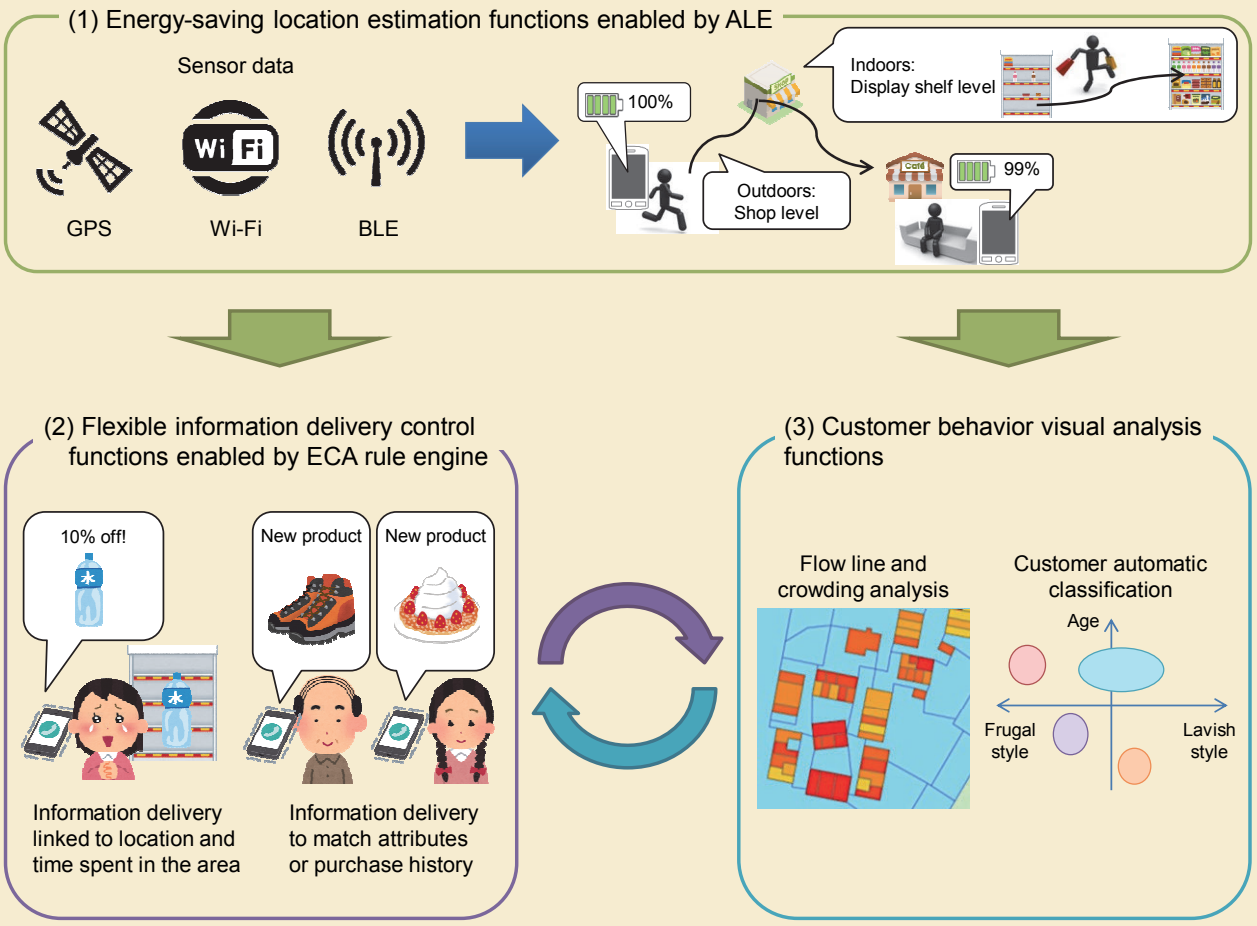


Figure 1 Overview of behavior sensing system

customers may spend several hours shopping in a commercial facility, the amount of power consumed by the terminal during that time must be reduced. However in general, it is possible to lengthen the interval that data is acquired from sensors to lower power consumption but location estimation accuracy will be lower as a result due to a trade off between power consumption and estimation accuracy [3]. To solve this issue, we developed a location estimation engine, called "Abstract Location Engine (ALE)." It runs on the terminal, and combines energy saving with location estimation accuracy at the product display shelving level in-store, and at the shop level outdoors. ALE achieves this using an abstracted map with a node and link configuration (described later) to compensate for location estimation errors caused by more infrequent acquisition of values from sensors, and performs path interpolation.

(2) Flexible information delivery control functions (Fig. 1 (2)): For flexible information delivery, the system requires functions to analyze customer attributes such as age and gender available from store membership card registrations, and purchasing history acquired from store Point-Of-Sale (POS) information to deliver information to each customer tailored to their needs and preferences, and linked with their location or presence in an area. Further, the system has to be able to handle demands from commercial facilities and shops to quickly perform new measures or change the content or timing of delivered information while measuring the effectiveness of measures. These demands can be met with Event Condition Action (ECA) rules. ECA rules consist of event, condition and action statements to control information delivery discussed in the aforementioned usage cases. An ECA rule engine runs on the terminal to execute the ECA rules, and compares the stated delivery rules with terminal states such as location data, time data and application operation logs to perform operations such as displaying content or notifying a server when specified conditions are met. Because ECA rules set in the server are immediately reflected in the application, it is possible to quickly handle new measures or change measures without updating the terminal application.

(3) Customer behavior visual analysis functions (Fig. 1 (3)): To study measures and measure effectiveness, the system requires functions to visualize customer store visitation and in-store behaviors such as flow lines and crowding. The customer behavior visual analysis functions include functions for real-time display of basic information such as numbers of customers who visited shops, numbers of repeat visitations and the time that customers were present based on specified dates, times or demographic attributes*6, as well as analysis based on automatic customer classification using individual flow lines, crowding conditions and flow patterns.

These three functions are described in details as follows.

3.2 Energy-saving Location Estimation Functions Enabled by ALE

1) ALE Overview

ALE is incorporated into applications running on the user's terminal to estimate the location of the terminal using the combined values of various sensors such as GPS, Wi-Fi and BLE.

(1) Node and link configuration

ALE corrects location estimation errors due to infrequent sensor value acquisition and noise in measured sensor values using map information abstracted with the node and link configuration, and then outputs results of location estimation in abstracted units called "nodes."

The abstracted map used by ALE displays areas for location estimation such as shops or commercial facilities as a graph structure with nodes and links. An example of an abstracted map of a commercial facility converted into nodes and links is shown in **Figure 2**.

- Setting nodes

O2O marketing service providers set locations where it is desirable to acquire information such as in front of shelving displaying sale items or at intersections in aisles as nodes in the abstracted map. The aforementioned information includes user behaviors such as passing traffic or presence in areas. There are two types of nodes, indoor nodes and outdoor nodes. User presence in outdoor nodes is determined from GPS positioning. At indoor nodes where GPS radio waves are unavailable, user presence is determined from the signal strength of short-distance radio communication devices such as Wi-Fi access points

*6 **Demographic attributes:** Information from population statistics used to characterize customers. These include attributes such as gender, age, job and number of persons in the family unit.

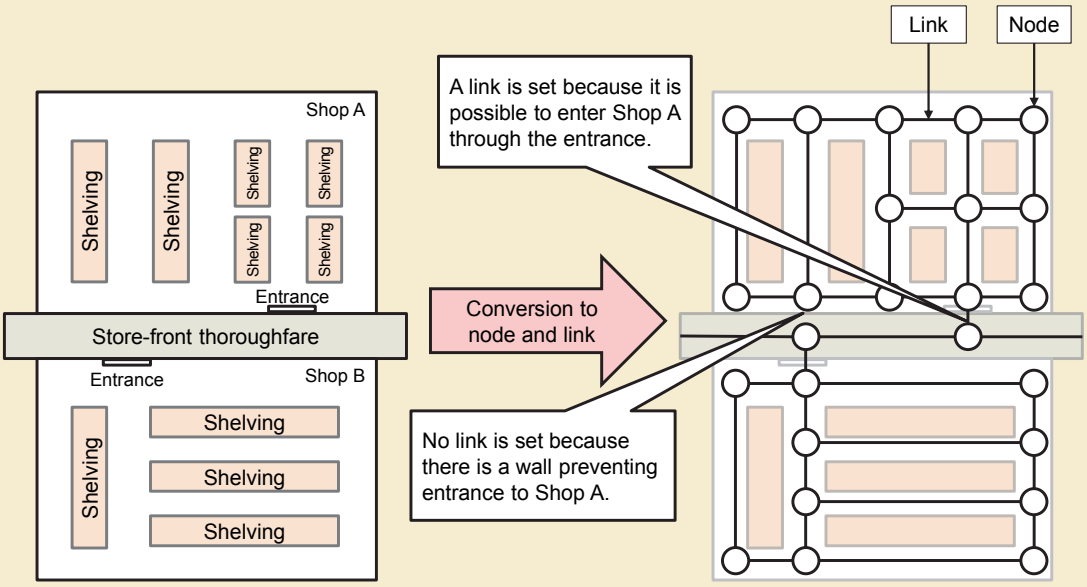


Figure 2 Example of abstracted map with node and link configuration

and BLE tags set up in the area.

- Setting links

The links in the abstracted map represent aisles, and are only set for routes between nodes through which people can physically and directly move. For example, as shown in Fig. 2, there is no direct route between Shop A and Shop B, which means the only passage is through the nodes in the thoroughfare in front of the shops. Hence, there are no direct links connecting nodes in Shop A with those in Shop B. Instead, there is a link connecting Shop A entrance with the thoroughfare in front of the shops, and a link connecting the thoroughfare in front of the shops with the Shop B entrance. There are also weights set for links. These weights represent the cost required for people to move node to node, where the larger the weight, the longer the time it takes to move. An example of a weight value could be the direct physical distance between the centers of nodes. These weights are used to correct location estimations, as described below.

(2) Location correction using node and link information

Using this node and link information, ALE suppresses the degradation of location estimation performance. The time required to transition between nodes is calculated using the link weights and average speed of movements of people. ALE compares node transitions results with positioning results to determine whether there are any abnormalities with the location estimation results and hence prevents erroneous location estimation results from being output.

(3) Node interpolation

There is a higher chance of events occurring in which user presence at nodes cannot be detected with ALE due to the longer sensor value acquisition interval to lower power consumption. Hence, when ALE detects a node transition that is not a possible direct transition on the link configuration, its node interpolation function provides a supplement by predicting the optimal path based on the link structure.

2) ALE Evaluation Experiments

As described above, while saving energy, ALE performs the above location correction and node interpolation using abstracted map information to accurately estimate location at the shelving level indoors and at the shop level outdoors. In testing performed in FY 2014, we installed ALE in a commercial facility application and performed experiments to evaluate power consumption. We confirmed that it contributes to an approximate 36% to 40% power consumption reduction, and that the location estimation performance is hardly degraded at all even when the sensor value acquisition interval is doubled.

3.3 Flexible Information Delivery Control Functions Enabled by ECA Rule Engine

1) ECA Rule Engine Overview

An overview of the ECA rule engine is shown in **Figure 3**. As a function that runs on the terminal, this interprets and executes an eXtensible Markup Language (XML)*7 file that contains the ECA rules describing the event, condition and action statements. As shown in **Table 1**, events such as changes to ALE location estimations or terminal screen display are used as opportunities to execute ECA rules.

Figure 4 shows the flow of ECA rule processing. When a change occurs, the ECA rule engine checks whether

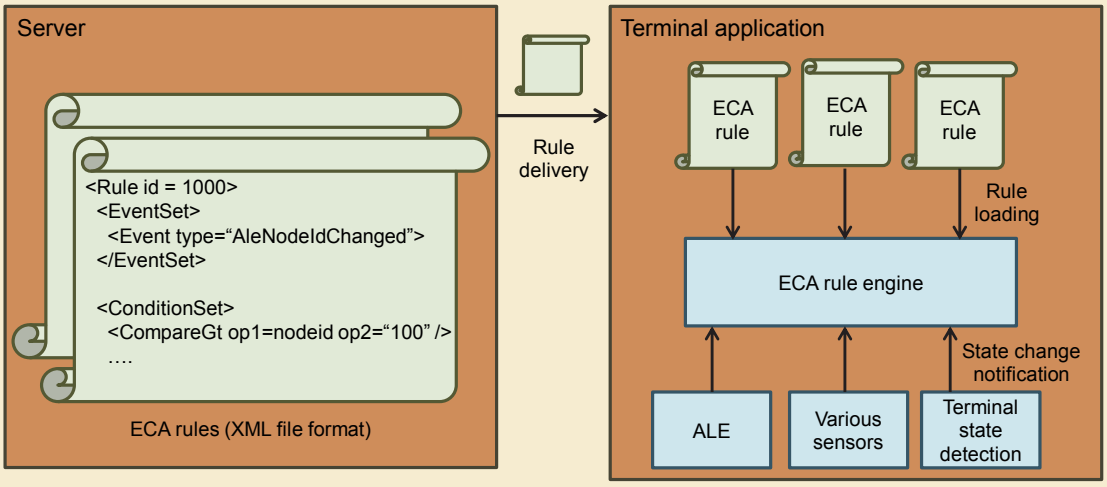


Figure 3 ECA rule engine overview

Table 1 ECA rule engine event list

Event list (partial)
Screen change notification
Screen unlock
Change to node estimated by ALE
Enter/leave registered area (region)
GPS-acquired coordinate change

*7 **XML:** A markup language for describing the meaning and structure of text and data advocated by the World Wide Web Consortium (W3C). It can be expanded, and users can specify their own unique tags.

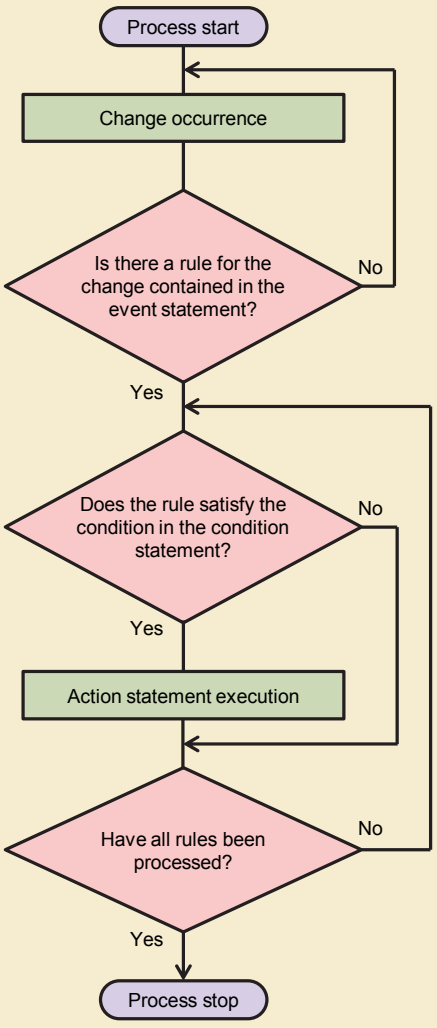


Figure 4 ECA rule process flow

the change is an event described by the event statements in the ECA rules. Events that correspond to ECA rules are determined by the conditional statements described in **Table 2**. Conditions are determined not only as current conditions by comparing with node IDs estimated by ALE or terminal status, but also compared to variables set for other ECA rule actions and so forth so that comparisons with past conditions are also possible. When conditions are satisfied, the processing described in the action statement is performed. Action statements specify identifiers for content to be displayed, and can be used to provide information to suit conditions. Apart from displaying specified content, actions such as notifying a server of shop visitation events or setting conditional variables for numbers of visitations can be specified, as shown in **Table 3**.

ECA rules are highly versatile like a kind of programming language. The ECA rule engine has a mechanism to acquire ECA rules from a server and synchronize them. Service providers can describe ECA rules for campaign measures and deliver them to terminals so that they can immediately implement measures without updating or redistributing applications. They also can perform different measures for individual users by switching ECA rules to be delivered for user IDs.

2) Usage Cases

We describe two usage cases for ECA rules.

- In the first usage case, a user is unsure about making a purchase from a product display shelf and a discount coupon is delivered to prompt the user to make a decisive purchase. This is achieved by describing an ALE estimated node change in the event statement, presence at the node for the product display shelving longer than a specified amount of time in the condition statement, and coupon content display in the action statement.
- In the second usage case, a special coupon is delivered when a user visits all specified shops, as

Table 2 ECA rule engine condition list

Condition list (partial)
A variable and specified constant are equal
A variable is lower than specified constant
Two specified variables are equal
All specified conditions are satisfied
At least one specified condition is satisfied

Table 3 ECA rule engine action list

Action list (partial)
Content display
Server notification
Enable/disable specified ECA rule
Region registration
Set value to variable

in a stamp rally. In ECA rules, when it is determined that a specified shop has been visited from ALE location estimation, the state of whether there was a visit to the shop is retained by the action statement, which writes a special variable. Then, in the condition statement, it is possible to control special coupon delivery by determining whether all specified shops have been visited.

3.4 Customer Behavior Visual Analysis Functions

These functions include functions for real-time display of basic information such as numbers of customers who visited a shop, numbers of repeat visitations and the time that customers were present based on specified dates, times and demographic attributes, as well as the following three special functions.

(1) Individual flow line visualization: Chronological analysis of flow line characteristics of individuals
(2) Crowding level visualization: Analysis of user presence in areas by each gender/age group/date and time/flow line pattern
(3) Visualization of flow line pattern characteristics: Automatic analysis of flow line patterns

The following describes usage examples of these functions.

(1) Visualization of individual flow lines enables understanding of the paths that customers follow from entering a store until leaving it, and their reaction to delivered information. For example, this makes it possible to compare individual customer paths before and after delivering information on certain point of sale specials upon store entry or around points of sale.
(2) Visualization of crowding enables display of customer presence at nodes as a heat map on the store map in which areas with many customers present are displayed in red and areas with few customers are displayed in blue. Taking into account these traffic conditions, this function enables planning, holding and measuring effectiveness of point of sale events on certain days of the week or at certain time slots, repositioning staff

to handle crowding at cash registers, and evaluation of the changing amounts of time that customers are present in areas.

(3) Visualization of the characteristics of flow line patterns entails classification of user flow lines using document classification technology, and display of them with Word clouds*8. Documents are classified according to the frequency of occurrence of words in the document. The names of products on display at each node are associated with each node in advance, a node names log with each store visit is viewed as a document, and node names in a document are viewed as words, and Latent Dirichlet Allocation (LDA)*9 is used to classify flow lines into clusters. **Figure 5** shows the automatically generated cluster 2 for flow lines of a user who frequently presents at nodes where there are side dishes, bread, fried foods and bento boxes, and displays these points of sale in the upper right of the heat map in red, indicating a high presence of the user. This means measures such as sales promotions to appeal in particular to cluster 2 customers at the points of sale in the upper right, prompting them to visit other areas that they do not visit much, or changes to store layout could be studied based on this analysis.

4. Implementation Technology into Air Stamp

We have included the behavior sensing system ALE in the "Air Stamp" location information platform provided by NTT DOCOMO. Air Stamp has been designed for shops such as supermarkets or restaurants, and commercial facilities to develop services converging the real with the Internet by linking location information so that coupons, and information about events and building directions can be delivered to users based on smartphone location estimations.

This behavior sensing technology enables well-timed and energy-saving location-based information delivery and detailed analysis of customer behaviors. As shown in **Figure 6** (a), on shelving displaying a range of different products, information delivery pin-pointed for certain products on the display is possible in front of the shelving. In addition, as shown in the train station example in Fig. 6 (b), corrections can be made for flow lines that cannot actually exist in commercial facilities to raise the accuracy of customer movement analysis. We are proceeding with studies on the release of Air Stamp supporting these

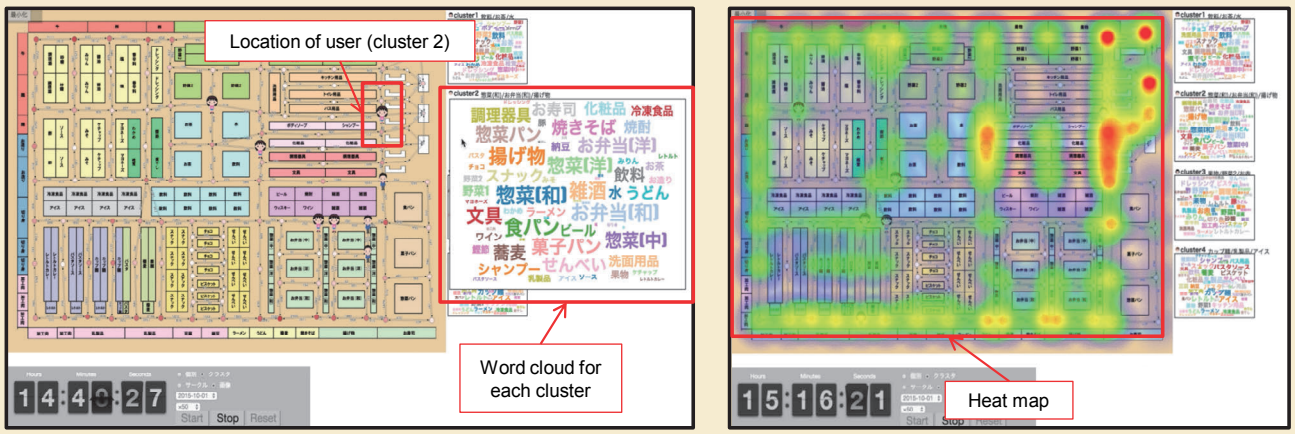
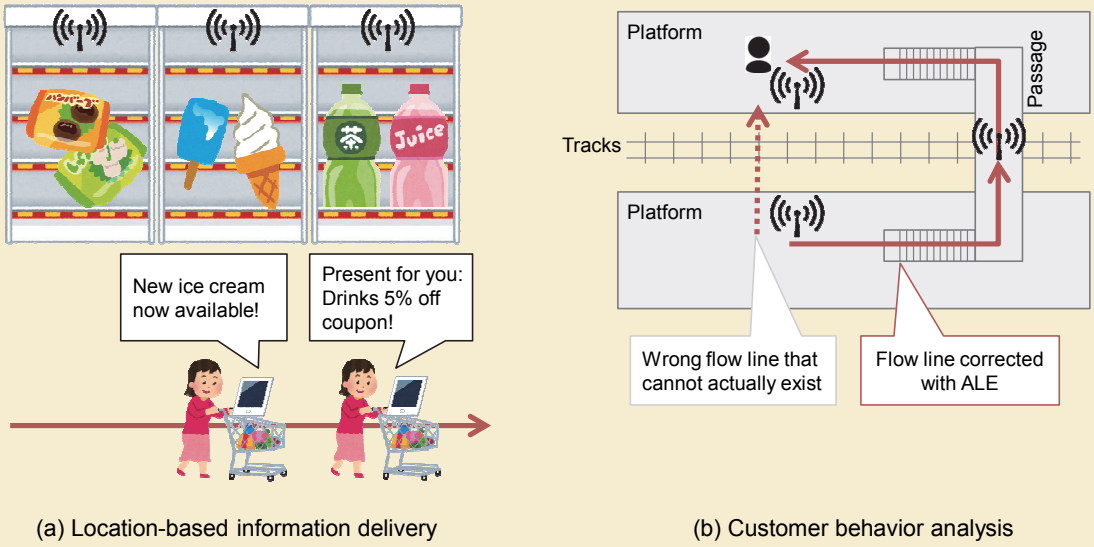


Figure 5 Customer behavior visualization and analysis functions

*8 **Word cloud:** A visualization method in which the size of words expresses the frequency of their appearance. The larger the characters, the more frequent the appearance of the word.

*9 **LDA:** A machine learning technique that classifies documentation based on the topics related to words that appear in the documentation.



(a) Location-based information delivery

(b) Customer behavior analysis

Figure 6 Location-based information delivery (a) and more accurate customer behavior analysis (b) using this behavior sensing technology

functions.

5. Conclusion

This article has described behavior sensing technologies that integrate functions required for O2O marketing services, and an overview of the system. Using this system, commercial facilities and shops will be able to quickly implement the PDCA cycle for various measures.

We plan to incorporate knowledge and data gained from the results of deploying Air Stamp services in various commercial facilities and shops into customer behavior analysis and use it to study how to make system operations more efficient.

References

[1] Seed Planning Inc.: "Current state of O2O business and future directions, 2013," 2013 (In Japanese).
[2] Air Stamp Web site. http://www.airstamp.jp
[3] H. Liu, H. Darabi, P. Banerjee and J. Liu: "Survey of Wireless Indoor Positioning Techniques and Systems," IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS - PART C: APPLICATIONS AND REVIEWS, Vol.37, No.6, pp.1067-1080, Nov. 2007.