

# Design and Development of Automated Schedule Adjustment Technology for Integrated Schedule Management System

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## ABSTRACT

In recent years, the Internet of Things technology has become widespread in response to changes in social trends such as a shortage of working population mainly in developed countries, globalization, and changes in consumer needs. As the number of devices connected to the Internet increases rapidly, various devices can be used to estimate and optimize people's schedule to increase time that people can freely use and improve quality of life. In this paper, we proposed automated schedule adjustment technology for integrated schedule management system. In automated schedule adjustment technology, schedule templates are used to calculate matching degree of user schedule and schedule template from the viewpoint of schedule sequence and time duration. We evaluated the proposed automated schedule adjustment technology for integrated schedule management system with an example user case of employee in a company and confirmed the automated schedule adjustment technology saves 520 minutes and make 52 hours time effective use.

## CCS CONCEPTS

• Information systems; • Information systems applications; • Decision support systems; • Data analytics;

## KEYWORDS

Integrated schedule management, Automated schedule adjustment, Data analysis

### ACM Reference Format:

Hideya Yoshiuchi. 2021. Design and Development of Automated Schedule Adjustment Technology for Integrated Schedule Management System. In *2021 6th International Conference on Cloud Computing and Internet of Things (CCIoT2021)*, September 22–24, 2021, Okinawa, Japan. ACM, New York, NY, USA, 6 pages. <https://doi.org/10.1145/3493287.3493288>

## 1 INTRODUCTION

In recent years, the Internet of Things (IoT) technology[1][2] has become widespread in response to changes in social trends such as a shortage of working population mainly in developed countries, globalization, and changes in consumer needs. As the number of devices connected to the Internet increases rapidly[3][4], various devices can be used to estimate and optimize people's schedule

[5][6] to increase time that people can freely use and improve quality of life. People have two activity fields. One is public places such as schools and companies where people act in collaboration with others, and the other is private places where they have a lot of free time, such as at home and on holidays, and users usually use all of them. People registers and manages his own schedules and activities of both places. The user's schedule changes from moment to moment, and it is often necessary to keep another person's time or make reservations for related equipments, facilities and services in order to determine the schedule. To increase people's free time, it is necessary to shorten the time required for schedule adjustment and management by automating the adjustment, reservation, and control of equipment, facilities, and services required to execute the schedule as much as possible.

In this paper, we propose automated schedule adjustment technology for integrated schedule management system that realizes schedule management and mutual coordination of people, goods, and services. The structure of this paper is as follows: chapter 2 shows rough explanation of integrated schedule management system. chapter 3 explains the proposed automated schedule adjustment technology for integrated schedule management system. In chapter 4 we will show evaluation result and chapter 5 is the conclusion and future work.

## 2 INTEGRATED SCHEDULE MANAGEMENT SYSTEM

This chapter describes the outline of the integrated schedule management system and the technical issues to be solved.

### 2.1 Overview of Integrated Schedule Management System

Figure 1 shows the conceptual architecture of the integrated schedule management system.

The integrated schedule management system collects data about users (people) through various kinds of sensors and devices, and estimates user behavior[7][8] in various locations such as homes, communities, and towns. According to the user's situation, and the estimated user behavior, the integrated schedule management system adjust user's schedule and suggests suitable services for executing the schedule. Data used for behavior estimation is acquired and accumulated through the data collection platform. Regarding the data management, original data was stored in temporal term for saving storage usage. The behavior estimation result data was stored in long term with proper post-processing such as anonymization. In order to adjust the schedule, the operation schedule of facilities and equipment and the schedule of external services are also managed. Based on the results of behavior estimation, services that are considered to be highly convenient for the user are estimated, and the schedule and resources for using the services

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CCIoT2021, September 22–24, 2021, Okinawa, Japan

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ACM ISBN 978-1-4503-8987-7/21/09...\$15.00

<https://doi.org/10.1145/3493287.3493288>

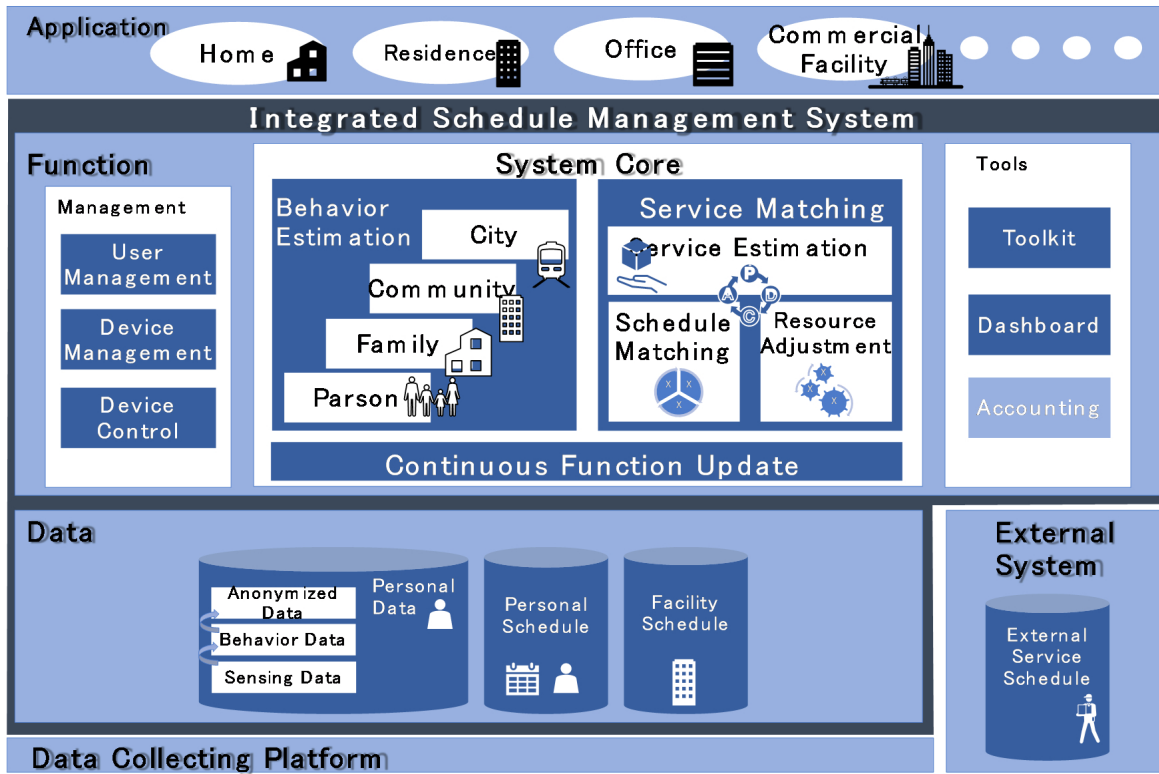


Figure 1: Conceptual Architecture of Integrated Schedule Management System

are automatically adjusted to increase the disposable time of the user and improve the quality of life. The purpose of developing the integrated schedule management system is to improve the people's quality of life (QoL). The results of behavior estimation and service recommendation are accumulated in the integrated schedule management system. By learning recommendation result, it is possible to improve the satisfaction level of service recommendation and continuously expand functions.

## 2.2 Technical Issues of Integrated Schedule Management System

When a users manage their schedule, they may use multiple schedule management systems at the same time. For example, it is reasonable for company employees to use different systems for the company and private schedule management. In such a case, it is necessary to synchronize the data of multiple schedule management systems. Service recommendation based on user behavior estimation are basically done based on individual behavior history. For effective data learning, we need to reduce the amount of data and devise so that appropriate service recommendation can be made in a short learning period.

## 3 AUTOMATED SCHEDULE ADJUSTMENT TECHNOLOGY

This chapter shows the results of examining the integrated schedule automatic adjustment technology for integrated schedule management system

### 3.1 System Architecture

Figure 2 shows the system architecture of the integrated schedule management system equipped with the automated schedule adjustment technology.

This system consists of the following elements.

- **Integrated Schedule Management Server**  
A server that centrally manages user schedules. When a user manages his / her own schedule using multiple Schedule Management Servers, the integrated schedule management server acquires schedule information from each schedule management server and merges them.
- **Behavior Estimation Server**  
A server that has a function to estimate user behavior by collecting information related to user behavior from each user behavior scene and performing data analysis. The user's action scenes include, for example, offices, facilities, moving by vehicle, home, etc., and the information available in each scene can be recorded in the office by elevators and cameras, and in the future, robots. If you are on the move, you can use GPS data and transportation history, and if you are at home, you can use IoT home appliances.
- **Schedule Adjustment Server**  
Search for services that are likely to be used by users from the results of user behavior estimation and past schedule history, propose schedules, and adjust the schedules of related parties, devices, and services required to execute the schedules.

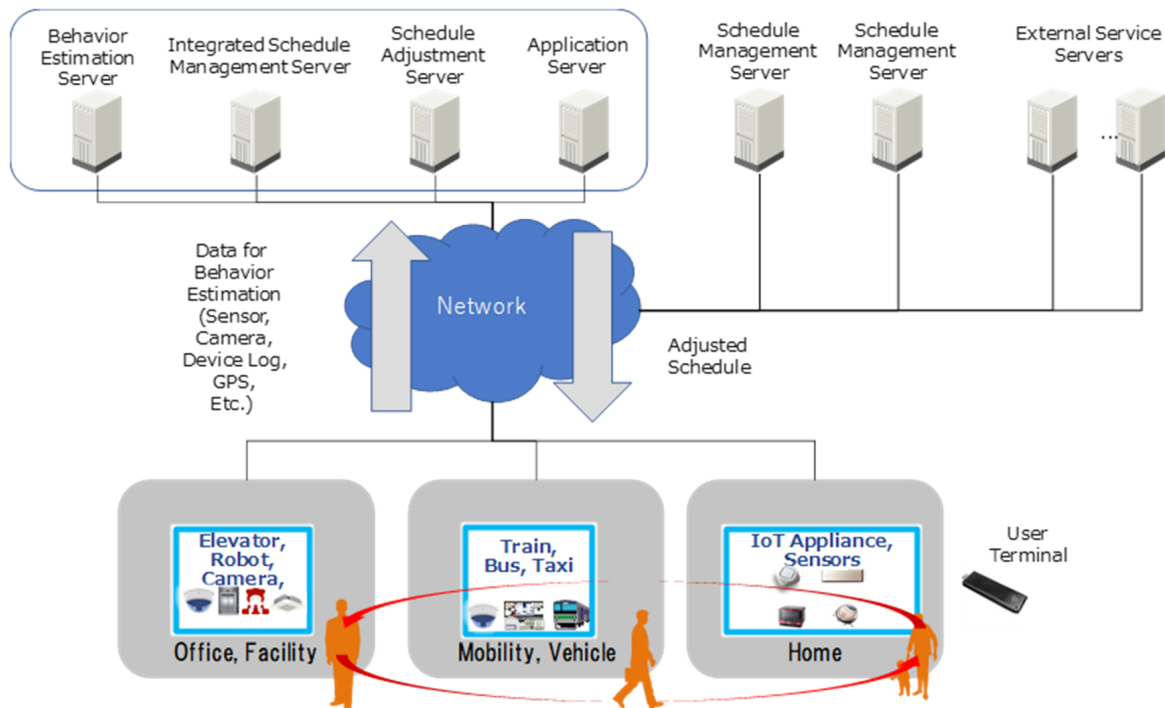


Figure 2: System Architecture of Integrated Schedule Management System with Integrated Automatic Schedule Adjustment

- **Application Server**  
Processing such as device control and service reservation is performed as processing necessary for executing various services.
- **External Service Server**  
A group of servers that provide various existing services in the real world. The servers are located out of the integrated schedule management system and managed by various organizations
- **User Terminal**  
It is used when the user uses the functions of the integrated schedule management system. The user terminal realizes functions such as display and editing of integrated schedule, confirmation and acceptance of service proposal results
- **Sensors**  
Sensors are installed on-site for the purpose of grasping the situation and automating device control in each scene where the user acts. Collected various data with sensors are directly or indirectly sent to the integrated schedule management system
- **Service equipments and apparatus**  
Equipment required to execute the service. In buildings such as offices and commercial facilities, there are elevators (Elevators), surveillance cameras (Cameras), and robots (Robots). Vehicles such as trains, buses, and taxis can be regarded as the essential apparatus for transportation services. At home, various IoT home appliances (IoT Appliances) are service devices.

### 3.2 Integrated Schedule Automatic Adjustment Technology

As one method of realizing the service proposal based on the behavior estimation, which is the basic function of the integrated schedule management system, the service recommendation based on the user's past behavior history can be considered. For service recommendation based on behavior history, we need to collect and learn user's past behavior history data. The past behavior history can be obtained as the past schedule data, but it is necessary to acquire the schedule data for a sufficient period in order to improve the quality of the service proposal by learning. For users who newly start using the service, it is highly likely that the quality of the service proposal will not reach the level expected by the user. Therefore, instead of obtaining a typical pattern of the schedule history that is retrieved by data analysis and learning, general and typical schedule templates are prepared in advance. These templates are used for matching with the user's future schedule to make schedule proposal that might be useful to a user. By introducing a schedule template, it is possible to automatically generate a schedule that does not depend on the user's past action history.

Figure 3 shows an example of a schedule template. A schedule template consists of several elements. One is schedule type for schedule item to define event or action for a user. Each event item has its duration and the time interval from one schedule item to the next. In this example, a meeting with a duration of 1 hour is the first schedule item. 30 minutes later there is a movement with a duration of 1 hour and 30 minutes, and 30 minutes later a meeting with a duration of 1 hour and 30 minutes is set.



Figure 3: Example of Schedule Template

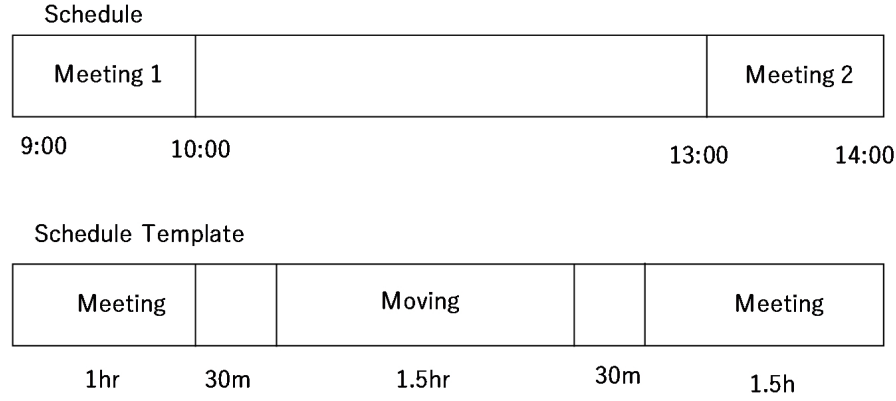


Figure 4: Schedule Template Matching

Schedule adjustment is a process that compares the user's schedule information with the schedule template, calculates the degree of matching between the template and the user schedule, and proposes a service proposal that is not registered in the schedule of a user based on the schedule template with a high degree of matching. The calculation of the matching degree between the user's schedule and the schedule template begins with the selection of the schedule to be compared and the selection of the schedule template. In calculating the matching degree between the schedule and the schedule template, first procedure is checking the sequence correspondence between the schedule and template.

Figure 4 is a schematic diagram of the correspondence between schedules and templates. In the example of Figure 4, both the schedule and the schedule template contain two meetings. The schedule template contains movements between meetings, but the schedule does not include movements, so the sequence match in this case corresponds to two of the three schedule template elements. In this case, sequence matching degree is calculated as two-thirds, that is, about 67%. First judgment of matching degree is done by the threshold value set by the system for the calculated sequence match. If the sequence match degree is less than the threshold, the schedule and template are considered to have less relationship and processing is terminated. If the sequence matching degree exceeds the threshold, the matched schedule and schedule template elements calculate the time length matching degree. In the example of Figure 4, the meeting 1 (Meeting1) from 9 o'clock in the schedule corresponds to the one-hour meeting at the beginning of the schedule template. In addition, the meeting 2 (Meeting2) from 13:00 during the schedule and the 1 hour 30 minute meeting at the end of the schedule

template are also supported. Since the time lengths of the meeting 1 and the schedule template are both one-hour meetings, the lengths are completely the same, and the degree of matching can be calculated as 100%. On the other hand, the length of the meeting 2 and the last meeting of the schedule template are 1 hour and 1 hour and 30 minutes, respectively, and the degree of agreement in this case is the value obtained by dividing 1 hour by 1 hour and 30 minutes, that is, about 67%. For the time length matching degree, the average value of the each time length matching degree between the corresponding schedule and the schedule template is adopted. In the example of Figure 4, the average value of 100% and 67%, that is, 83.5% is the time length matching degree.

The process of adjusting the schedule according to the degree of schedule agreement is carried out according to the following procedure.

1. Select one schedule template
2. Starting from one of the user schedules, select a number of schedules equal to the number of elements in the schedule template selected in the previous stage from the starting schedule in succession.
3. Calculate the sequence matching degree between the selected schedule and the schedule template
4. If the calculated sequence matching degree is less than the threshold specified by the system, the schedule adjustment process is not performed and another schedule is tried.
5. If the calculated sequence matching degree is larger than or equal to the specified threshold, the system calculates time length matching degree between the schedule and template.
6. If the time length matching degree is larger than the threshold defined by system, schedule adjustment proposal item is created.

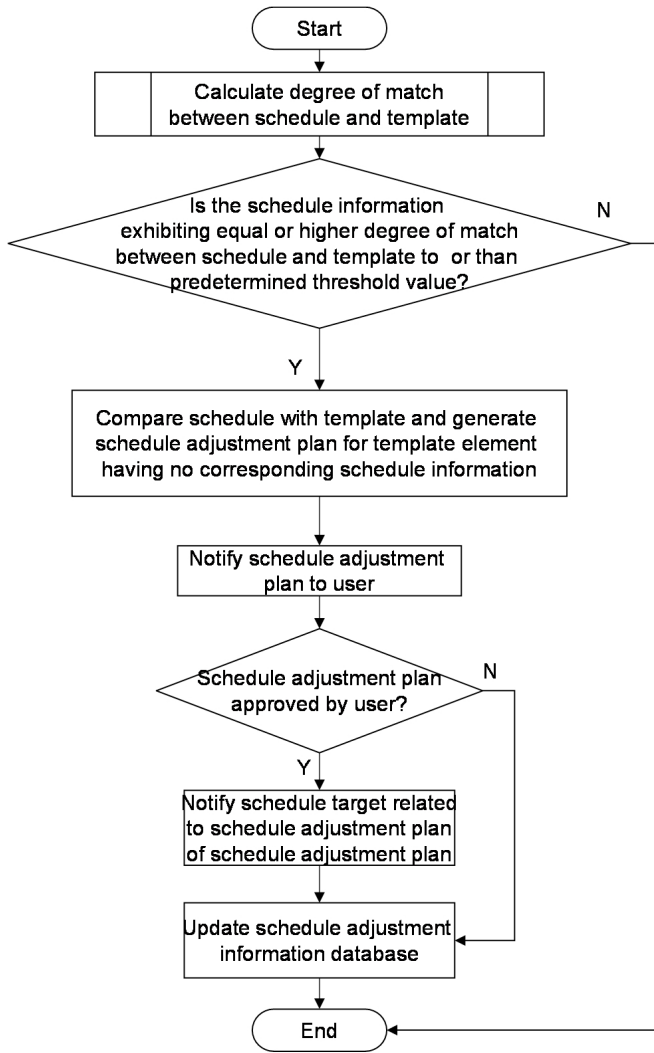


Figure 5: Flowchart of Schedule Adjustment

In the example of Figure 4, there is no schedule information corresponding to "Moving" of the schedule template component, so this is treated as a schedule adjustment item. When the system creates schedule adjustment item, it will consider the duration of the schedule, time interval, location, etc.

7. After creating the schedule adjustment plan, the schedule adjustment server notifies the target user of the created schedule adjustment items.

8. The user who receives the schedule adjustment items decides whether to approve the schedule adjustment items based on the validity of the content. If the schedule adjustment items are approved by the user, the integrated schedule management server update the user's schedule.

Figure 5 shows flowchart of schedule adjustment explained above.

As for schedule adjustment, there are some features to be mentioned. One is automation of schedule operation. In some cases,

users need to reserve schedule related equipment or facilities. For example, if new meeting is added to user schedule as the result of schedule adjustment, user need to prepare meeting room. If meeting room reservation is operated by outer system, schedule adjustment will automatically reserve proper meeting room for dedicated schedule adjustment. Another feature is error handling for avoiding impossible schedule execution. For example, if schedule adjustment just add new schedule without taking care duration of location change, schedule might be impossible one. Typical case is movement for business trip. If one user move from his office to customer office, we have to take care how long it takes for moving by car or train. If the user cannot keep enough time for movement, schedule adjustment system should remind that users can not keep enough time for location change and schedule adjustment might be impossible one.

## 4 EVALUATION

This section shows evaluation results of the automated schedule adjustment technology for integrated schedule management system.

The key point of the automated schedule adjustment technology is to maintain a typical schedule template on the system and realize automatic schedule adjustment even without learning. In order to improve the quality of schedule adjustment, it is important to prepare a large number of schedule templates with high application rate to a large number of users with various lifestyles. In order to prepare useful schedule template set, it is necessary to properly design the number of schedule elements included in the template. As for calculation of matching between the user's schedule and the schedule template, firstly we should determine the threshold value for sequence matching degree, then consider the time length matching. The degree of sequence matching is affected by the number of schedule elements included in one template. As for various schedules that are basic element of users' schedule, such as company meetings and gym exercises, its duration time is around 30-minute or hourly units. In many cases, it is considered that there are not many users who manage schedules to register many short-term schedules in a day. Therefore, we assumed that the number of schedule elements included in one schedule template is 3 or 4 which is applied with high frequency in practical use. Regarding the threshold of sequence matching degree, it is reasonable to set the value more than 50%. If the number of schedule elements in one schedule template is 3 or 4, 2 and 3 schedule item matching is necessary to satisfy more than 50% of sequence matching degree respectively.

Based on the above assumptions, the schedule is automatically adjusted after considering the degree of time length. The following conditions must be satisfied for the automatic adjustment to succeed.

1. The number of schedules required for the schedule template matching is registered as a daily schedule.
2. The sequence match and time length match between user's schedule and the schedule template are both above the default threshold.
3. The user approves the proposed schedule adjustment result for automatic adjustment.

User behavior patterns vary according to age, occupation, and gender. Here we consider a man who works five weekdays as an example. Since there are 52 weeks in a year, the number of days on Saturday and Sunday is 104. In Japan, there are 16 national holidays, so 120 days are holidays and 245 days are weekdays. Holidays are rest days, and there are many occasional appointments such as completing tasks that cannot be done on weekdays and enjoying entertainment. For this reason, it seems relatively difficult to automatically adjust the holiday schedule using templates.

On the other hand, weekday schedules consist of regular business meeting, which is almost fixed and repeated schedules. Templates may be effectively applied to such appointments. Assuming that there are two schedule proposals generated by automated schedule adjustment in a week, and one proposal is approved and one is rejected by a user. If we assume schedule adjustment with schedule template is executed once in a week and the time required for schedule adjustment is 10 minutes, As a result, 520 minutes (10 x 52) are saved for schedule adjustment. If the duration time of one proposed schedule by automated schedule adjustment is 1 hour, 52 hours time are effectively used as a result of schedule adjustment.

## 5 CONCLUSION

In this paper, we proposed automated schedule adjustment technology for integrated schedule management system. In automated schedule adjustment technology, schedule templates are defined and schedule adjustment is done by checking of matching degree between user's schedule and schedule template from the viewpoint of sequence matching and time length matching.

We evaluated the proposed automated schedule adjustment technology for integrated schedule management system with an example user case of employee in a company and confirmed the

automated schedule adjustment technology saves 520 minutes and make 52 hours time effective use.

For the future work, we will implement the automated schedule adjustment technology and integrated schedule management system, and collect data through experimental environment to verify the effect of the proposed technology.

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