Effective Museum Sightseeing Crowdedness Avoidance Algorithm Considering Exceptional Situations

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Abstract

As ubiquitous computing technology convergences into many industrial domains, most museums want to apply this technique to their domain. However, most ubiquitous museums merely provide the simplest service giving visitors only static information of artifact. To resolve limitations of the existing ubiquitous museums, we had proposed Visitor Preference based Museum Viewing Search Algorithm that provides the best path for visitors to reflect their preferences. However, since the Visitor Preference based Museum Viewing Search Algorithm did not consider abnormal situations that occur while visitors look at the exhibit. So when abnormal situations occur, the exhibition may cause congestion problems that may make visitors feel very uncomfortable. In this paper, we propose an efficient congestion avoidance algorithm to solve these problems. This algorithm automatically re-finds proper alternative paths for avoiding congestion resulting from the abnormal ones occurring during the museum viewing. The proposed algorithm improves comfortable museum viewing services by preventing congestion in advance when exceptional conditions occur. For the experiment of the proposed algorithm, we show that the algorithm can provide the best path to reduce the impact of museum sightseeing crowdedness well even in exceptional conditions.

Keywords: *Distributed systems, Ubiquitous computing, RFID, Greedy, Preference-based.*

1. Introduction

'Ubiquitous' is originated from a Latin word, and means 'anytime, anywhere' or 'everywhere' etc. The term was known to the general public, when Mark Weiser of Xerox Company introduced the concept of the 'Ubiquitous Computing' in 1988. Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user [1]. A ubiquitous network society is a society where it is possible to seamlessly connect "anytime, anywhere, by anything and anyone", and to exchange a wide range of information by means of accessible, affordable and user friendly devices and services [2].

The significantly increasing interest in the potential of ubiquitous computing technology leads to enormous related research and development activities being ongoing actively. Also currently in Korea, ubiquitous computing business is a kind of popular variety unfolding in public and private sectors. Although this trend advances related technology such as high performance, short-range wireless communication technologies, RFID, USN, and home network, initially, each technology independently

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is being applied and developed. However, all of these different technologies are being converged and then development of much more various ubiquitous services and technologies through this convergence is considerably accelerating.

Beyond the simple concept formulation phase, ubiquitous devices with development of ubiquitous computing technology are increasingly embodied in many areas such as u-City [3], u-Health [4], u-traffic [5], u-education, and u-distribution / logistics [6]. As ubiquitous computing technology converges into many industrial domains, this promising gear allows museum tour culture to be dramatically changing in terms of convenience and information richness. Using this technology, the existing museums may provide not only the ancient artifact's text-formed information but also many different kinds of information such as sound or media [7-9].

However, the most ubiquitous museums merely provide the simplest services that give visitors only static information about artifacts without fully utilizing smarter and high level of ubiquitous computing technology. In addition, the most ubiquitous museums provide several uniform paths to every visitor, not properly reflecting his or her accommodation and requirements.

To resolve limitations of the existing ubiquitous museums, we had proposed Visitor Preference based Museum Viewing Search Algorithm that provides the best path for visitors to reflect their preferences. However, since Visitor Preference based Museum Viewing Search Algorithm did not consider abnormal situations that may occur while visitors look at the exhibits. When abnormal situations occur such as resting somewhere privately, finding new interests and entering the exhibition that is not assumed to be in visitor’s selected path, the exhibition may be highly congested, making the visitors feel a big discomfort resulting from the crowded exhibition.

In this paper, we propose an efficient congestion control algorithm to solve these problems. This algorithm automatically re-finds proper alternative paths for avoiding congestion resulting from the abnormal ones occurring during the museum viewing. The proposed algorithm may significantly improve the level of comfort of museum viewing services by preventing congestion in advance when abnormal situations occur. When abnormal situations occur during the museum viewing, the proposed algorithm can detect these conditions and visitors continue doing their comfortable museum viewing by getting their proper new paths through our automatically re-finding path selection methods.

The remainder of this paper is organized as follows. In sections 2 and 3, we compare related work with ours and describe our visitor preference-based algorithm. Sections 4 and 5 introduce our congestion avoidance algorithm and show experimental results to verify effectiveness of our algorithms. Finally, section 5 summarizes this paper.

2. Related Work

The National Museum of Korea services PDA image guidance system [10]. PDA image guidance system is a mobile service. PDA image guidance system is a new concept museum guidance system which provides visitor`s current position and information about optimized, but uniform viewing movement as well as simply information about exhibits to visitors through mobile device (PDA). When visitors who rent PDAs stand in front of artifacts and exhibits, the PDA image guidance system provides information about artifacts and exhibits by video and audio through information interchange infrared sensors of mobile devices and infrared generator installed artifacts.

However, if you wear a PDA around your neck during 1-2 hours, your neck will be tired because of considerable size and weight. In addition, since font size is very small, visitors may feel uncomfortable to use.

The Louvre museum provides a multimedia guide service through PDA [11]. The multimedia guide service provides information about exhibits by museum staffs in more than seven languages such as French, English, German, Spanish, Italian, Japanese, Korean, etc.

To use the multimedia guide service, visitors enter artifact's ID on the right or left side of the corresponding artifact. Then visitors may hear information about artifacts. The multimedia guide service provides a variety of information about their authors and copyright information as well as information of exhibits. Also visitors freely enjoy the exhibits by selecting their favorite tour courses according to theme, duration, and the difficulty.

However, the multimedia guide service causes the problem that the exhibitions are seriously congested or are crowded by visitors in popular and famous exhibitions only by providing several uniform courses.

The National Science Museum operates u-museum services using Mobile RFID technology [12, 13]. Visitors can utilize U-museum services by inputting their basic information, name, telephone number, e-mail, etc, after visitors has leased dongles in mobile RFID terminal rental at the museum entrance. Visitors place their phones close to exhibits and can obtain a variety of multimedia information though the exhibits or their web servers. Visitors can hear the narration about description of exhibits by earphones and see description of exhibits using mobile phones.

U-museum services have many advantages that visitors provide comfortable service by their mobile phones. But u-museum services are being limited only in some forms of the provided static services.

The Seoul Museum of History provides the u-exhibit guidance system [14]. The u-exhibit guidance system guides a variety of facilities as well as provides information about exhibits. The u-exhibit guidance system is linked to the museum website, providing richer museum information with its visitors. The u-exhibit guidance system provides automatically description of exhibits and artifacts in a variety of forms, flash video, photos, text, voice, etc, and the exhibition guides without visitor`s special operation using ubiquitous sensors. In addition, the u-exhibit guidance system can provide detailed and professional information about exhibits through touch screen, so visitors are easy to acquire the desired information.

However, although a variety of ubiquitous technologies being applicable for enabling visitors to much more easily access and be immersed in the ubiquitous museum according to their interests, but the u-exhibit guidance system only provides uniform and static types of information. In addition, PMP is too big and heavy, so visitors experience inconvenience.

3. Visitor Preference based Museum Viewing Search Algorithm

In this algorithm, greedy algorithm is used to find appropriate paths based on users' preferences [15]-[16]. Figure 1 shows the algorithmic description of the visitor preference based algorithm.

```
Begin
  get arrayofPreferRoom from its visitor's mobile terminal ;
  calculate arrayofWgt by distance between every pair of rooms in
            arrayofPreferRoom ;
  change arrayofWgt into arrayofPreferWgt by Prefer_Const ;
  while ( arrayofPreferRooms is not empty)
   if (there is only one room r1 in arrayofPreferRooms)
     append r1 into  recommendedPath ;
     adjust visitorTotalTourTime with tourTime of r1 ;
     remove r1 from arrayofPreferRooms ;
   else
     find one room r1 with the minimum weight value in arrayofPreferWgt ;
     if (r1.MAX_Visitors > r1.Current_Visitors + 1)
       change arrayofPreferWgt based on r1's attributes ;
    else
       append r1 into  recommendedPath ;
       adjust visitorTotalTourTime with tourTime of r1 ;
       remove r1 from arrayofPreferRooms ;
       adjust arrayofPreferWgt with the rooms still remaining in
            arrayofPreferRooms ;
  return  recommendedPath ;
End
```

Figure 1. Pseudo code of visitor preference based algorithm

After obtaining a list of exhibition rooms with attributes of the corresponding visitor's preference he or she is trying to view, steps of this algorithm for setting the weight value of each room are as follows. First, visitors' preferences and distance to each exhibition room they attempt to travel are used to set its weight value. The initial weight value of each room is calculated based on movement time from this exhibition to every other one in a list of rooms selected. Then, this algorithm makes a second-step weight value of each room by combining its initial weight value with attributes of visitor's preference. In here, the attributes include the priority of each room and the minimum and the maximum movement times input on the visitor's mobile device he or she can tolerate to see much more interesting exhibits and artifacts even though there are some others near from his or her current location.

Next, this algorithm retrieves one or more than one room with the lowest preference-reflected weight value. If multiple rooms are searched, the nearest one from visitor's current location is selected. Afterwards, the total number of visitors including itself who are currently or will be sightseeing that room is calculated. If the number is greater than the maximum number of visitors this room can accommodate without feeling inconvenient about their viewing of the room, the next candidate would be found after setting the weight value to the infinite and recalculating the weight values of the other remaining rooms. Otherwise, the selected room would be added in the path recommended to the corresponding visitor and the weight values of the others are re-adjusted by considering the visitor's estimated viewing time of the room. Then, this procedure stated above will be repeated until the full path for the visitor is completely found. If there remain only the rooms in the list where their respective maximum numbers of visitors are currently staying, the maximum numbers would be adjusted by reflecting the number of visitors not finding their full path, but trying to see them.

Let us explain how our visitor preference based algorithm searches the museum viewing path suitable for a visitor using figures 2 and 3 shown. In this example, the number of rooms traveled by three visitors A, B, C is eleven. It is assumed the maximum capacity of each room is two persons. As shown in figure 2(a), visitors A's and B's full paths determined by the algorithm are room 1->2->3->4->7->11->10->6->9->8->5 and room 1->5->8->9->10->6->2->3->7->4->11 respectively, and the two persons are both staying in room 1. In this situation, another visitor C is trying to view eleven rooms based on his or her preference. The algorithm recommends room 8 as the first room on visitor C's expected itinerary to him or her by considering C's preference and the condition that both visitors A and B are currently in room 1. After iterating the same procedure explained earlier to find the next 5 rooms visitor C will view in order, a partial path for C is made like in figure 2(b) with A's and B's locations expected. If room 2 has the highest priority among the remaining rooms on C's itinerary and the movement time from room 6 to room 2 is between the minimum and the maximum movement times input for viewing his or her preferred exhibits and artifacts, room 2 may be chosen rather than room 5, the nearest from room 6, like in figure 3(a). Figure 3(b) shows the full path for visitor C the algorithm recommends after completing its entire process based on C's preference-related attributes.

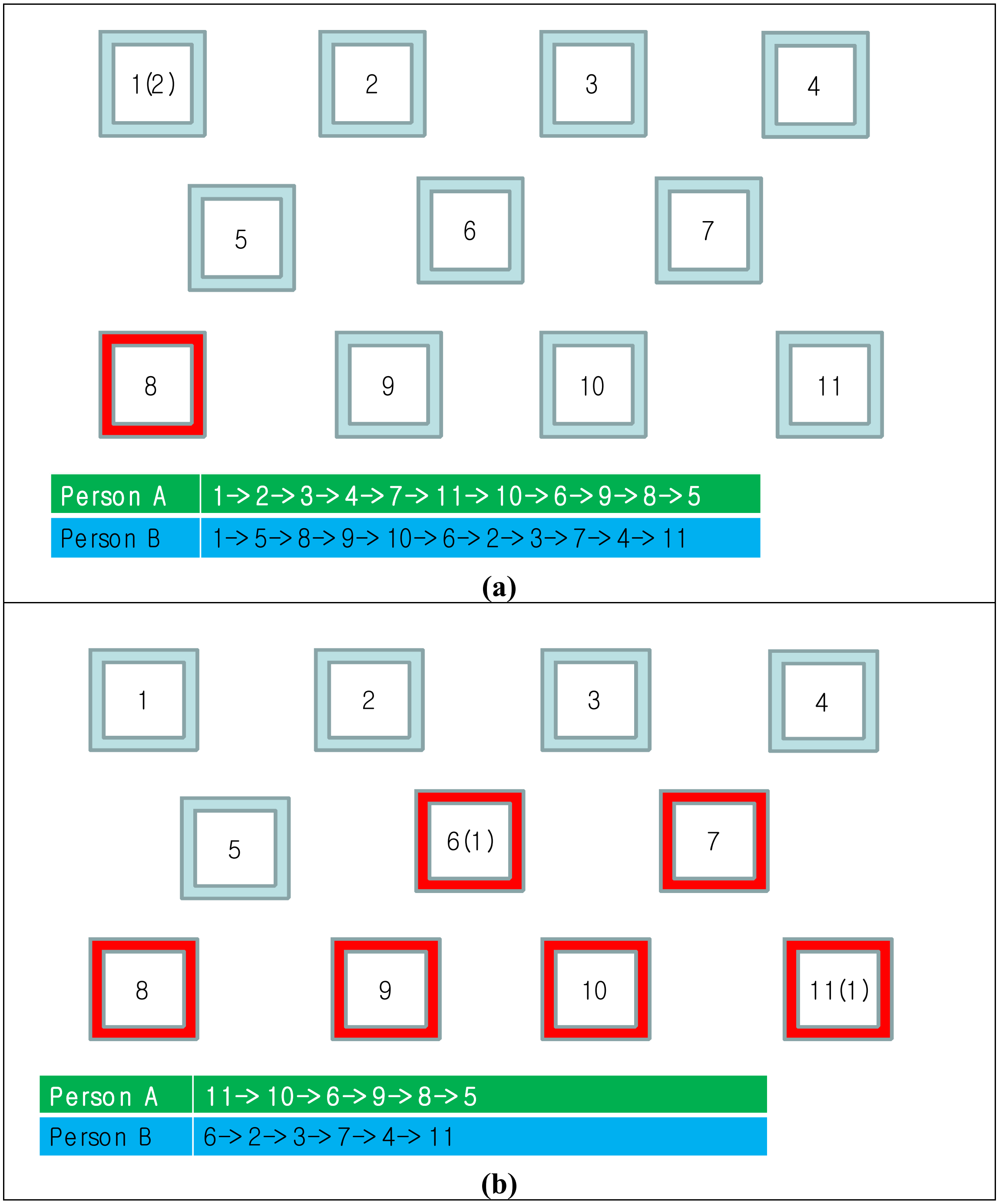

Figure 2. An example scenario of visitor preference based algorithm

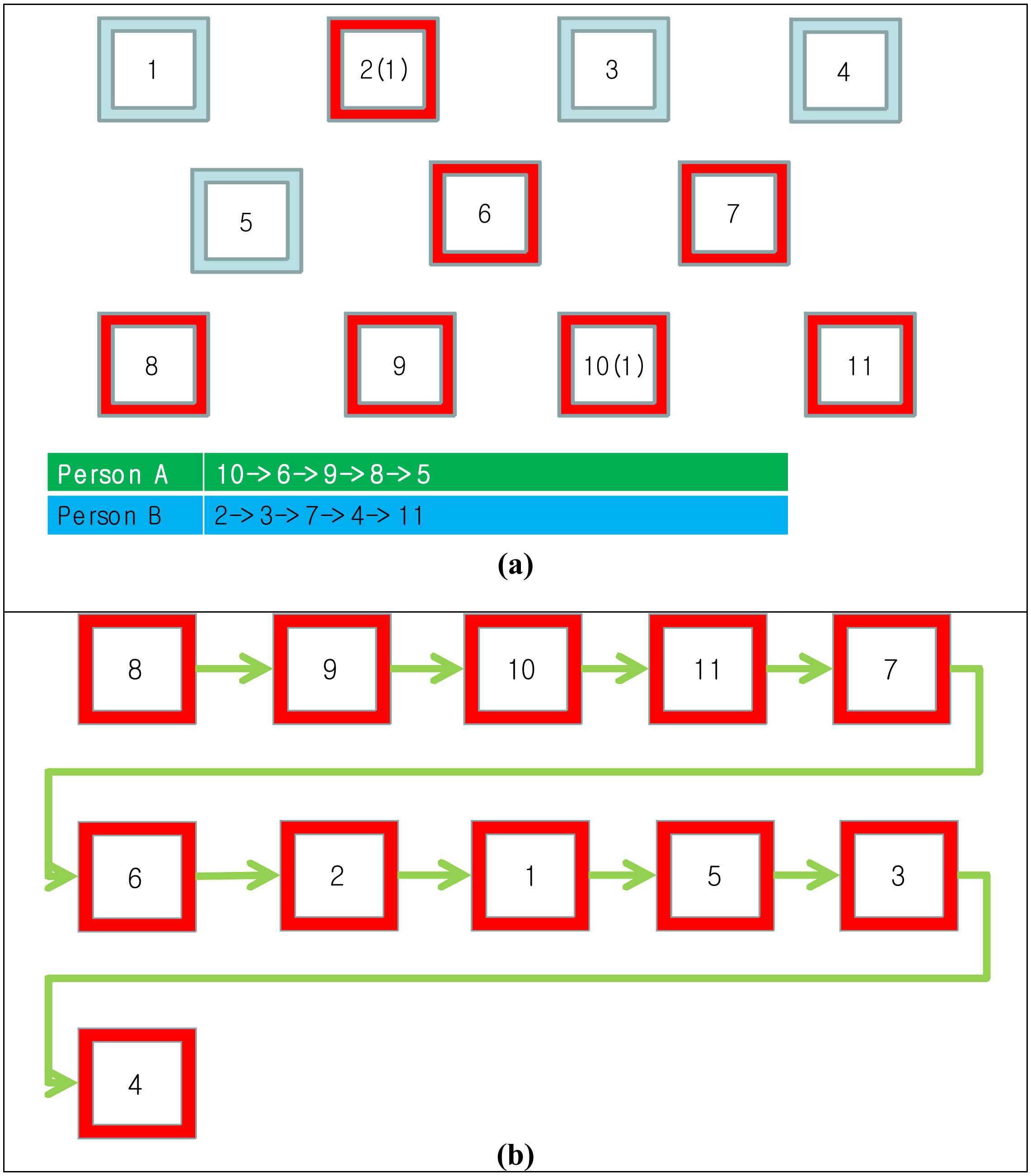

Figure 3. An example scenario of visitor preference based algorithm (cont'd)

4. Congestion Control Algorithm

If visitors can take a break during the museum viewing, it makes time differentiation between algorithm providing entering time and visitor's actual entering time for the exhibition which causes congestion of the exhibition. And this congestion may occur in any exhibition by visitor's unexpected behaviors like: they could find new interests on their way, be confused about the exhibition, and enter the wrong room.

To solve this problem, we attach a sensor on entrance of each room in order to monitor that visitors are coming in and out of the room [17]. If the unexpected behavior occurs, it causes huge differentiation between the time given by Visitor Preference based Museum Viewing Search Algorithm and actual visitor’s entering time. We analyze and then provide alternative, but proper paths for the corresponding visitors. By this process, we enable visitors to continue their viewing comfortably on the fly regardless of their unexpected behaviors.

Also, if a visitor enters the exhibition that is not in the recommended path, our system will notify visitors of this situation and set the exhibition to the next starting point for them in order to re-find their proper path. After that, we provide the re-selected path to the visitor, which makes him or her enjoy the rest of their viewing without feeling inconvenience.

If visitors find some new interests, they can request re-finding their appropriate paths considering their interests.

Figure 4 shows how our system may handle abnormal situations appropriately during visitor’s museum viewing.

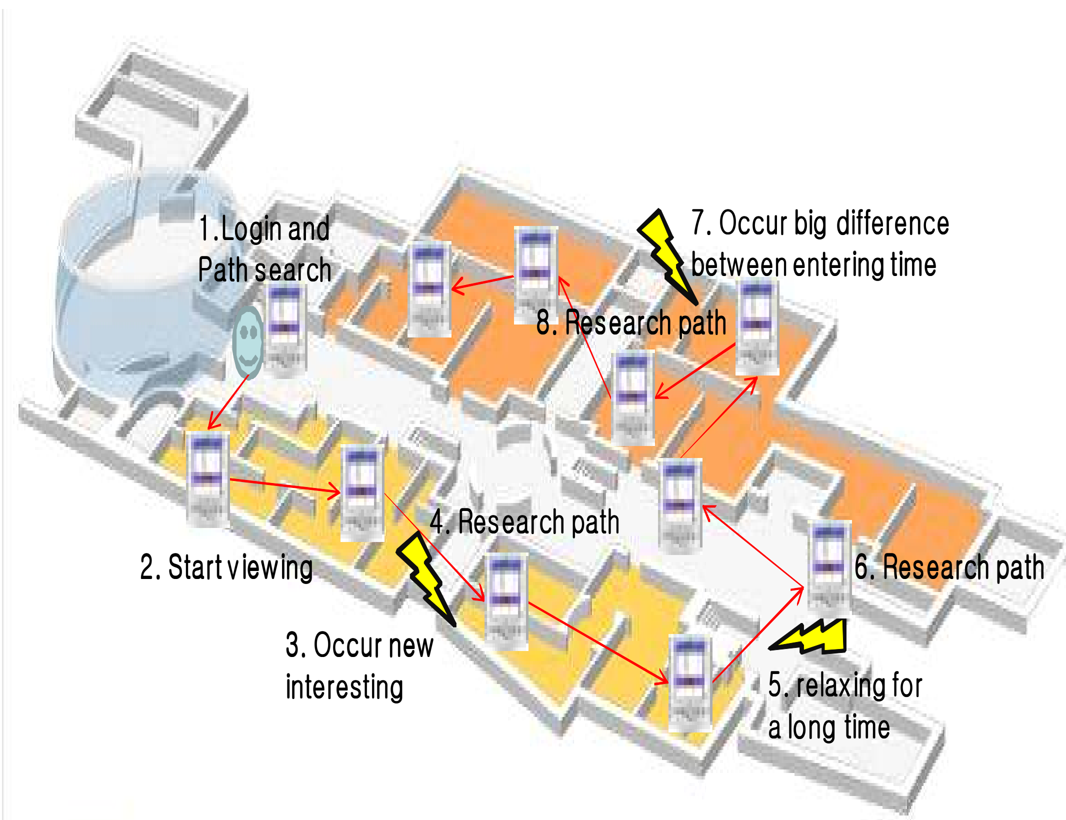

Figure 4. An example scenario of abnormal situation

5. Experiments

Experiments are performed to evaluate how effectively the proposed congestion control algorithm can help visitors do their comfortable viewing even in abnormal situations. Our performance evaluation environment is as follows.

Table 1. Performance Evaluation Environment

Classification	Description
Operating System	Windows XP Service Pack3
Implementation Language	C#
CPU	Intel® Core™ 2 Duo CPU E8300 @ 2.83GHz
Memory	2GB

For this, experimental conditions are set as follows: Experiments were carried out by emulating the situation that visitors should enter into the museum within at least every five minutes. In our experiment, one minute of visitor's actual viewing is translated into one second in simulation time. Under the assumption mention earlier, visitors entering the museum are randomly generated up to 100 persons. It is assumed that each exhibition is held only at one room. In here, the maximum number of visitors each exhibition may accommodate without making them feel discomfort resulting from congestion is set up to 10 persons. The number of exhibitions is set to 43.

The initial experimental procedure for each visitor entering the museum is following. First, he or she randomly selects from at least 5 to up to 43 exhibitions he or she wants to see. Then, his or her phone sends the list of rooms selected to our system server. Next, it gets back visitor's appropriate path from the server after the server has analyzed with the selection information through our congestion control algorithm. In order to find out the degree of congestion that occurs during the museum viewing, the number of visitors in each exhibition is checked every 10 minutes intervals from the time of the first entrance into the exhibition to the time of the last exit out of the exhibition after all visitors have finished their viewing with or without our congestion control algorithm.

Figure 5 shows the effectiveness of our congestion control algorithm applied in an abnormal situation. In this figure, the x-axis represents the room number for each exhibition and the y-axis, the highest number of visitors entering the exhibition measured every ten minutes. When our algorithm isn't applied, a lot of exhibition rooms are seriously congested, having one and half times more than the affordable number of visitors recommended for each room. However, with our proposed congestion control algorithm, the number of rooms having each more than ten persons decreased dramatically. In this case, the reason a few places have more than 10 persons even after executing our algorithm, is that, among all the exhibition rooms, some are very interesting spots and some others, unpopular ones. So, from these results, we can see that our congestion control algorithm are very effective when unexpected behaviors occur to provide high quality of comfort in museum viewing for visitors.

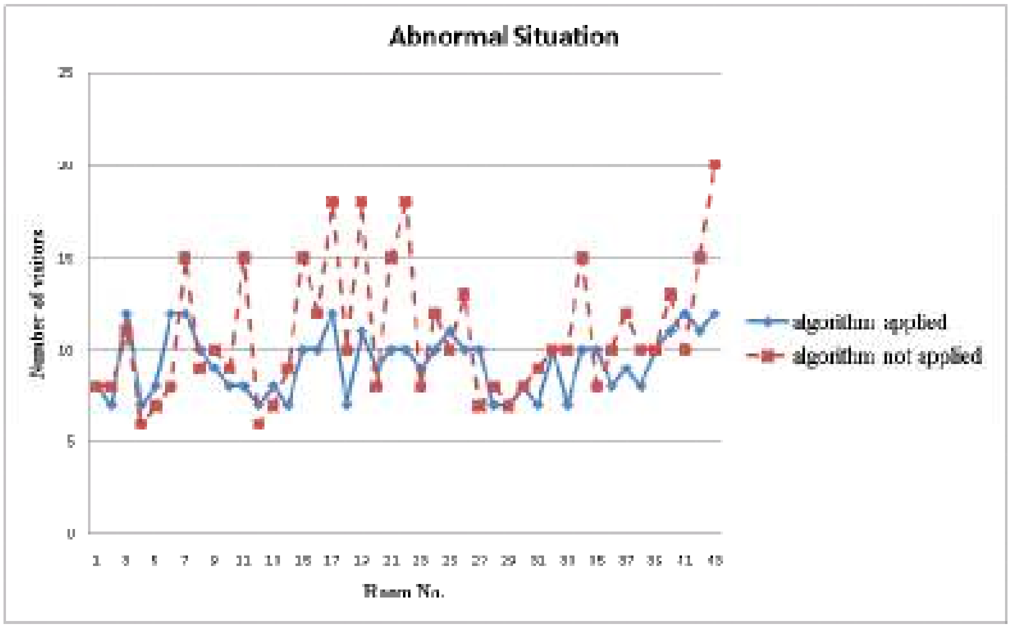

Figure 5. The highest number of visitors entering each exhibition measured every ten minutes

6. Conclusion

As ubiquitous computing technology converges into many industrial domains, this promising gear allows museum tour culture to be dramatically changing in terms of convenience and information richness.

However, most ubiquitous museums merely provide the simplest forms of services giving visitors only uniform and static information of artifact, not fully utilizing smarter and high level of ubiquitous computing technology. In addition, the convenience of visitors is not reflected properly to their viewing. It allows them to follow several uniform paths, which makes them feel a big discomfort resulting from crowded exhibition.

To resolve limitations of the existing ubiquitous museums, we had proposed Visitor Preference based Museum Viewing Search Algorithm that provides the best path for visitors to reflect their preferences. However, since the Visitor Preference based Museum Viewing Search Algorithm did not consider their unexpected behaviors like finding new interests during their viewing, relaxing suddenly and privately during viewing, etc.,.

In this paper, we proposed an efficient congestion control algorithm. The algorithm helps visitors to have a more comfortable viewing by preventing congestion that could be caused by their unexpected behaviors

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