Designing a Attendance System Based on Physical and Virtual Services Using the Internet of Things

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Abstract

A number of learning systems have been developed in recent years to provide secure attendance systems for blended learning; however, most have not been very successful. Furthermore, alongside increasing the level of awareness of the need to deploy interoperable physical and virtual learning services for each university that supports the idea of blended learning, there exists an immediate need for the establishment of clear standards and guidelines for the successful integration of all physical and virtual attendance systems that relate to blended learning services. The importance and motivation for designing a new attendance system based on the Internet of Things that supports blended learning at Taif University in Saudi Arabia is discussed in this paper with respect to three perspectives: security, which includes identity; the Internet of Things, comprising physical and virtual objects; and blended learning, containing Blackboard system. Not many systems abide guidelines for all of these perspectives; thus, the proposed system aims to change this and provide its users with attendance and the ability to access their physical and virtual learning services in a secure and usable way.

1. Introduction

The Internet of Things (IoT) is a new concept which has been gaining freedom thanks to advances in telecommunications such as the development of identity management systems and learning systems integrated into countless electronic devices, ranging from mobile devices, to vehicles, appliances and more [17]. The idea of the Internet of Things is to put together all these devices into the World Wide Web, which can be managed from the web and in turn, provide information in real time and also allowing interaction with people who use it.

The Internet of Things plays an significant role in learning processes in formal and informal education dating from the electronic learning (e-learning), blended learning (b-learning), mobile learning (m-learning) up to ubiquitous learning (u-learning) [4], [16]. Resources in learning centres are limited, and the necessity of record-keeping has played a central role in the functionality of universities. Therefore, universities are joining the IoT revolution for monitoring attendance, or evaluating students..etc [20]. It is also implicated in general security and identity. However, the biggest advance is thought to be in u-learning, including information sharing across multiple physical and virtual platforms, and enabling students to have full-time access to educational tools and packages [23].

The potential of using the Internet of Things for supporting blended learning is reflected in increasing access to learning content and collaborative learning environments supported by computers anytime, and anywhere. It also allows the right combination of virtual and physical spaces. The purpose of the Internet of Things in supporting blended learning is basically improving learning processes. It is trying to adapt learning resources to different contexts of use.

This paper proposes a system that allows students to attend all physical and virtual learning services at Taif University by using a set of physical objects in the surrounding environment. Each of these objects has one (or more) associated virtual objects which provides information allowing the student to attend different learning services and reach a learning achievement, in terms of how they work, how it can be used, etc.

This paper is organized as follows: *Section II* presents background and a literature review that relates to the three research perspectives which are blended learning, security, and the Internet of things. In *Section III* the research gap and question are presented. Then, the proposed attendance system that would conform to the standards of these three research perspectives for different users and sectors is described in detail in *Section IV*. Finally, *Section V* ends the paper with a summary and suggestions for future work.

2. Background and Literature Review

2.1. Blended learning

Blended learning is the term given to formal education programmes where learning is partially delivered via online tools [7]. This is in contrast to traditional learning, which is delivered solely through face-to-face contact combined with

independent study. Blended learning differs in that computer-mediated activities are included in the learning package.

The degree to which the human and online contact is balanced varies from institution to institution [14]. At its most basic, students will have access to portals that direct them to learning resources such as websites and journal articles. At its most complex, blended learning can involve online assessments and graded learning packages that monitor student progress and adapt in response to their individual needs.

Blended learning has been in existence since the popularisation of the computer. The potential of the computer as a learning device was apparent as early as the 1960s, and early models such as the Programmed Logic for Automatic Teaching Operations (PLATO) system was one of the earliest teaching tools. Significant acceleration was achieved following the invention of the CD-ROM, which allowed progress tracking and interactive learning [8]. The natural follow on to this was the use of interactive learning through the World Wide Web, giving students a truly globalised learning experience.

2.1.1. Blended Learning Tools. There have been several blended learning packages developed. One of the first was the Khan Academy developed by Salman Khan in 2006, the site comprises video tutorials in subjects from art history to cosmology, and along with micro lectures features hundreds of thousands of practice problems that can be accessed through a personalised learning dashboard [9]. The popularity of the Khan Academy, which has been translated into 23 languages (with the micro lectures translated into 65) and is accessed by more than 120 million students per annum, has shown that students are eager and willing to engage with blended learning and online tools [11].

One of the most popular systems amongst universities is the Blackboard [22]. Developed by Blackboard Inc., the Blackboard Learning System is Web-based server software. The aim of it is to integrate authentication protocols with existing student information systems. Along with a basic calendar function, Blackboard is often used by course tutors to post course information and handouts, to post information about students' grades along with feedback from their submissions, and to open discussion and chat spaces. Essentially, Blackboard operates as something between a student logbook and a personal educational guide [22].

The reasoning behind Blackboard was that the software could replace what so many universities were failing to provide: a personal tutor who could be on hand to monitor progress and ensure that students had access to everything that they needed [3]. The jump from the first stage of higher education – typically A-levels or Access Courses – to university sees students going from a fairly controlled environment to one where most have increasingly less contact time with course providers.

An alternative to Blackboard is Moodle [24]. This stands for Modular Object-Oriented Dynamic Learning Environment. Moodle has the benefit that it runs with many different systems, which is one of the core concerns of any kind of multi-platform device.

2.1.2. Blended Learning Issues. Sardessai and Kamat carried out a detailed case study into the use of Moodle [15]. They were specifically interested in whether students were actually using the site, and if so how often and whether they liked it. Sardessai and Kamat [15] found that ICT in education is of a considerable benefit, but that services such as Moodle made it much more user-friendly and practical. However, a drawback that was noted was that many faculty staff are not adept at translating their traditional methods into more modern ones, resulting in unequal distribution of skills across the learning arena.

Mahajan carried out an empirical study into how students wanted to learn, and found that it depended upon their primary learning zone [12]. Those who worked exclusively at home preferred e-learning; whilst those in normalised university departments preferred face-to-face. This division reveals that there is something of a dislocation between students and institutions.

Dunwell et al took the unique approach of looking at the potential for serious games to answer some of the multiple education problems that exist [5]. The study sought to investigate the emergent phenomenon that games used in blended approaches are ideal ways for difficult problems to be tackled. For Dunwell et al this posed the opportunity to integrate a serious game into an existing learning content management system (LCMS), and found that the result was an intuitively guided response [5].

The basic theory behind the Dunwell et al study was scaffolding [5]. This is an idea that was first put forwards by the psychologist Piaget, and which has formed the backbone of many educational curricula of the twentieth and twenty-first centuries. The core concept is that learning needs to be broken into manageable stages that are attainable by students. The question of pedagogy is pertinent in blended learning, but remains unanswered.

Yongxing investigated the issue of blended learning plans [21]. This worked on the basis that many further education providers put together blended learning plans without much thought as to efficacy. Yongxing notes that blended learning plans should be meticulously designed, but this raises multiple problems [21]. As Mahainan noted, it is still unknown precisely how students interact with online

learning portals, meaning that designing systems of use is inherently problematic [12].

One of the major challenges is security, according to Zhou et al [24]. Blackboard and Moodle are accessed via a username and password combination. However, passwords and login names can be easily shared amongst students, meaning that in theory anyone can be accessing the content with or in some cases without the knowledge of the legitimate service user [18].

In some cases this may simply mean that students studying at different universities share information in a non-legitimate way. In others it might mean that third parties are paid to enter the site and pose as the student [18]. In earlier years, tutors would easily be able to determine the identity of a student and ascertain whether or not their work was genuine due to features such as handwriting. The use of digital admissions that decrease the personality features of the students mean that in theory the work can be done by almost anyone.

Those who support blended learning state that student attitudes towards learning are improved, and that the overall communication experience between students and their tutors and peers is improved [11]. However, there are other core disadvantages. One of the most obvious ones is that students increasingly need to be computer literate in order to attend their courses. This is something that is unlikely to particularly affect the younger generation, but puts many mature students at a significant disadvantage [3].

2.2. Internet of Things

The Internet of Things (IoT) is the name given to embedded elements within the broader Internet. It is designed to go beyond machine to machine communications (M2M) in order to enable the fundamental interconnectedness of all things [20]. This is something designed with the evolution of smart technology in mind, particularly the future of smart objects. However, IoT is vast in its scope, and covers everything from biochip transponders to thermostat systems [20]. In short, any kind of communicable electronic device will be able to connect to the Internet.

2.2.1. Internet of Things Technologies for Supporting Blended Learning. Schools and universities are joining the IoT revolution. Resources in learning centres are finite, and the necessity of record-keeping has played a central role in the functionality of universities. The IoT plays an obvious role in elements such as monitoring attendance, calculating trends and patterns, and locating inefficiencies [20]. It is also implicated in general security. However, the biggest advance is thought to be in mobile learning, enabling students to have full-time access to educational tools and packages [23]. This includes information sharing across multiple platforms.

2.2.2. Security and Identity Problems in the Internet of Things. There are multiple criticisms concerning the IoT. These include questions about the moral role that technology plays in human lives, particularly in terms of personal control. Technology shifts people towards particular patterns and habits, reducing their autonomy and shifting power to corporations focused on financial gain. For the education system, this effectively means that the controlling agents are not the academic professionals, but the organisations that control the tools they use [10].

Security challenges are particularly profound. It has become increasingly clear that systems are vulnerable to cyber attacks, and these are predicted to become physical in the future [19]. In theory, students could stage physical cyber attacks on their universities; or universities could be prevented from functioning by an outside threat. It is well known that data can be stolen and sold, and the IoT is recognized as being one of the richest sources of data.

3. Research Gap and Question

As stated in the preceding section, there exist numerous issues and unaddressed areas that can provide a basis for improving an attendance system based on the Internet of Things for supporting blended learning With this in mind, this research shall focus mainly on the following aspects since most negligence in the existing attendance systems has been felt in these regards: blended learning, which includes the Blackboard system; the Internet of Things, involving physical and virtual objects; and security, including identity.

There is limited literature examining the importance of the Internet of Things and security dimensions with respect to blended learning systems. There is no literature known to the researcher that considers the attendance systems for physical and virtual places at Universities from users' viewpoints. There is also limited literature which examines the facets important to users including blended learning along with security measures. Hence, this research will demonstrate that the integration of physical and virtual attendance systems for supporting blended learning, as based on the proposed model, are effective in terms of conforming to the standards of universal attendance systems for different users and sectors with a focus on the theory and practice sides for the three research perspectives. Based on this research overview and research gap the following main research question is proposed:

'In both physical and virtual attendance systems for supporting blended learning at Taif University, how can secure and accessible attendance systems based on the Internet of Things be designed?'.

Fig.1 shows the research gap in terms of these main aspects of research:

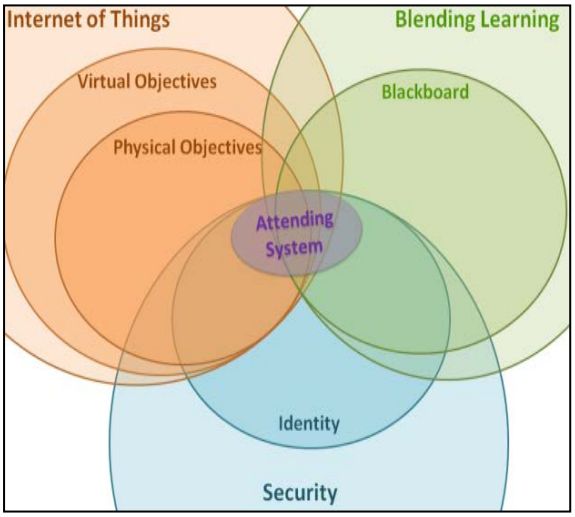

Figure 1: Research Gap

4. Proposed Attendance System

The preceding section discussed some of the different theories, frameworks and models that have been used in the implementation of different systems with the aim of introducing the concept of attendance systems based on the Internet of Things for supporting blended learning in various countries.

It is common practice for learning services at Taif University to ask for student ID cards or usernames and passwords for verification whilst the university gateway expects users to scan their fingerprints at the gate to allow them to enter the university. This practice is followed in physical spaces and will give the same results if the services are moved to an online platform. Owing to these limitations, a new system has been proposed in this paper that provides interoperability between physical and virtual spaces, alongside the option to prove one's identity with any type of identity document or biometric for supporting blended learning at Taif University.

The foundation of the proposed system has been inspired by three main factors: previous implementations, frameworks, and theories related to the respective research domain. Figure 2 includes the sources of inspiration for the proposed system:

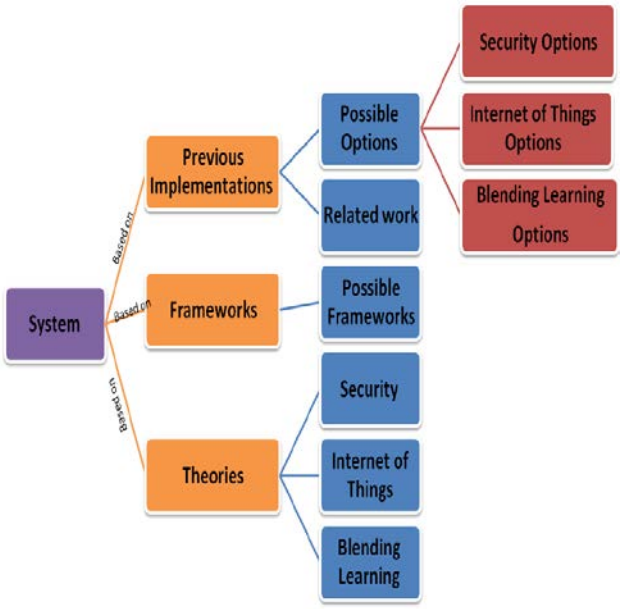

Figure 2: Foundation of the Proposed System

It can be seen that the previous implementations, frameworks and theories of the research domain have been studied under the classification of Internet of Things, blended learning, and security and identity.

Unified Modelling Language (UML) has been used to propose the new system. UML helps the software engineers to visualise the concept and main purpose of the system in terms of graphical representations. UML possesses the following three basic types of modelling technique: architectural modelling, behavioural modelling and structural modelling. Among these three types, different UML modelling techniques have been chosen to achieve an innovative design of the system. Figure 3 highlights the models that have been developed:

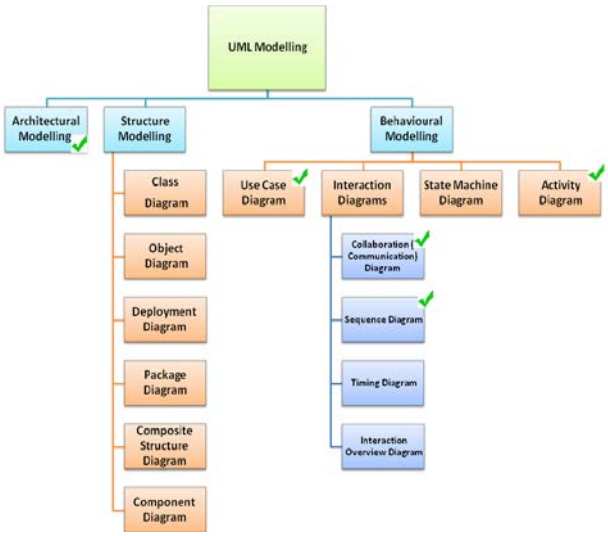

Figure 3: Types of UML Modelling Techniques

Among these types of UML modelling techniques, the following have been chosen to devise an effective system for the research topic under discussion:

- Architectural modelling
- Use case diagram
- Activity diagram
- Collaboration and communication diagram
- Sequence diagram

4.1. Architectural Modelling

Garlan & Schmerl explain architectural modelling as various components of the system, along with the connections existing between them [6]. The architectural model for the attendance system based on Internet of Things for supporting blended learning is shown in Figure 4.

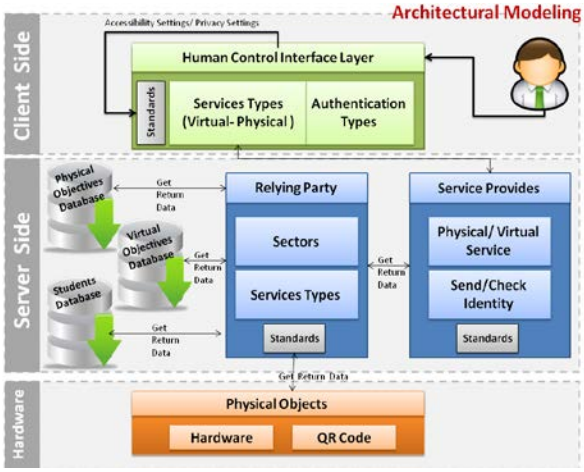

Figure 4: Architectural Model of the Proposed System

It can be seen from Figure 4 that there exist three layers in the proposed system:

- The top layer communicates directly with the user and provides an accessible and user-friendly interface offering the choice of different authentication types (identity tools) and different blended learning services that are provided by Taif University in physical places (university campus) or virtual places (university website). All the functions and operations are in accordance with the standards chosen as a result of research activities in the respective domain of the study. This layer is responsible for the acquisition of the identity of the user and also for transferring the acquired information to the second layer for verification purposes.
- The second layer of the proposed system provides interoperability between the physical and virtual spaces, and thereby verifies the identity of the student with the concerned authorities. The second layer accesses the database, including information concerning the authentication types (identity tools) and the different standards maintained as guiding principles for the model. Importantly, the second layer corresponds with the relying parties (different departments and centres at Taif University) to verify the identity of the user with the aid of the presented authentication type: for example, a user might present a student ID card, which will be used to verify the identity of the user with the university campus. The details of the student on his/her ID card are communicated to the relying party over a secure session. Upon the successful verification of the identity of the student, the student has the benefit of availing him- or herself of any element of the University's blended learning services for physical and virtual places. In the case that the student is not able to provide the correct identification attributes, the student will be denied access to the services and returned back to the front layer for entry of another authentication type.
- The third layer of the proposed system contains the physical objects that include hardware to read the quick response code(QR code) for connecting the physical objects with the virtual places. For example, all the classes at the university have QR codes, and the students can scan the QR code at the traditional lecture, so the blended learning systems at Taif University will have all the attendance information about the students if they are online or at the university campus.

Different types of authentication types have been shown in Figure 5:

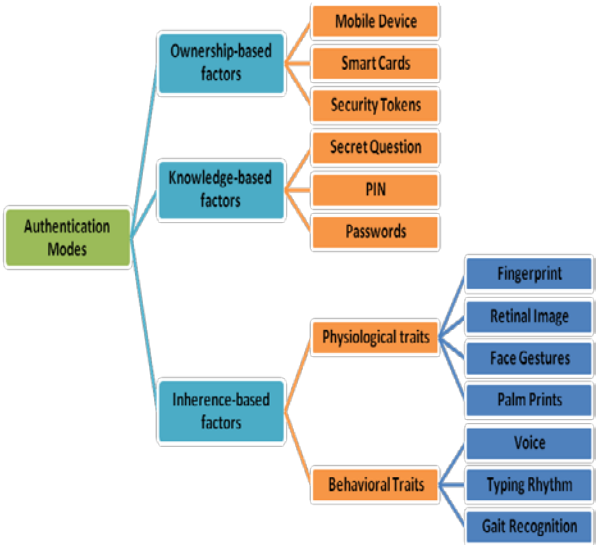

Figure 5: Architectural Model of Authentication Modes of the Proposed System

The different types of authentication mode have been classified into three categories: ownership-based factors, knowledge-based factors and inherence-based factors [2]. Ownership-based factors include the activation of the authentication on mobile devices, smart cards and security tokens; knowledge-based factors include a secret question, PIN and passwords; inherence-based factors are further classified into physiological traits, such as fingerprints, retinal images and palm prints, and behavioural traits, such as voice, typing rhythm, and gait recognition. Among these types of authentication tools, Taif University currently uses smart cards (student ID cards), security questions, passwords, PIN (university ID), and fingerprints (for entering the university gateway).

It can be seen from Figure 4 that standards are important aspects of the different layers within the proposed system. The standards that have been chosen for the proposed system are shown in Figure 6.

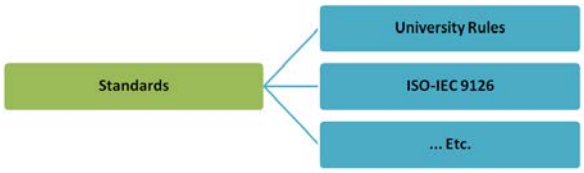

Figure 6: Standards Chosen for the Proposed System

ISO IEC 9126 standard provides guidelines for introducing usability and accessibility in the system [1-13], while university rules are included to ensure privacy and security for the information of the students.

Figure 7 shows some of virtual and physical learning services that are provided at Taif University. Each of these services asks the student to provide a specific identity tool. For example, the Blackboard system asks the student to provide a username and password to allow him/her to register and attend online classes using virtual classes rooms in the Blackboard system. On the other hand, in the physical places on the university campus, the student needs to scan his/her fingerprint to enter the campus. Currently on the Taif University campus, the traditional classrooms do not include any attendance system for registering the students digitally.

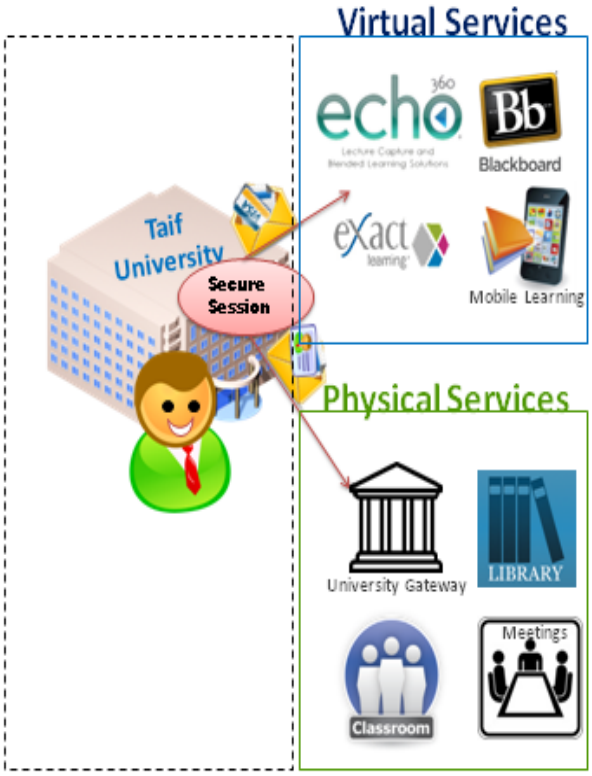

Figure 7: Virtual and Physical Learning Services at Taif University

4.2. Behavioural Modelling

4.2.1. Basic Use Case Diagram. The main actor in the proposed system is the student who wishes to access the physical and virtual blended learning services. The student is given a list of authentication types ("Select Authentication Tool") from which any proof of identity can be presented to the system. Upon the identification of the student, the system will display a list of blended learning services ("Select Service") that can be availed by the user. Upon establishing a successful connection with the chosen service, access is granted to the student and the student will register on the attendance system that is related to all blended learning services at the

university. Figure 8 depicts the graphical representation of the preceding explanation in the form of a use case diagram under the domain of behavioural modelling:

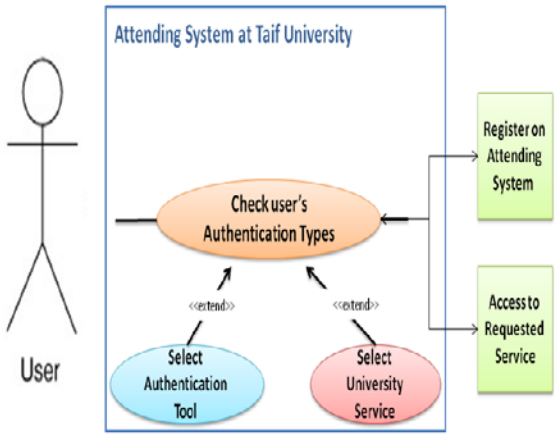

Figure 8: Behavioural Modelling (Use Case Diagram)

4.2.2. Detailed Use Case Diagram. As stated earlier, the student is the main actor in the proposed system; Figure 9 includes detailed operations that can be performed by him or her:

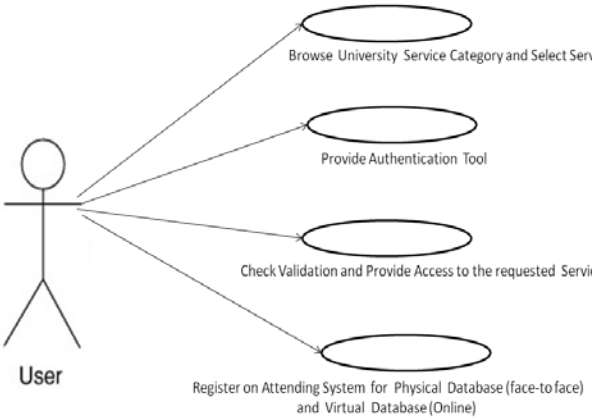

Figure 9: Detailed Use Case Diagram of Proposed System

1- *Browse Services Category and Select Service:* The student can browse through the list of services and select the learning service of his or her choice.
2- *Provide Authentication Tool:* The student presents the chosen authentication type (identity tool) as the input in the system.
3- *Check Validation and Provide Access:* The authentication tool is validated and verified for the student's claimed identity. Upon successful validation, the student is granted access to the requested service.
4- *Register on Attendance System:* The student will automatically register on the attendance system for different learning services at the physical places database (face-to face) and virtual database (Online).

4.2.3. Communication and Collaboration Diagram. Figure 10 shows the steps of collaboration and communication taking place during the operations of the system, which are as follows:

1- The initiation of the communication is done from the student's side when the service request is send. The service request parameters are:
   - Service name
   - Authentication mode
   - QR code
2- The service request is received by the 'Service Provider' layer that sends a request to the index to look up the name of the service, and QR code.
3- The index returns the information to the 'Service Provider' layer.
4- The service name, authentication type, and QR code are sent to the 'Assistant to check' to validate the presented authentication type for the respective service.
5- If the presented authentication mode is enough for granting access then the student will be connected with the service.
6- If the authentication type is wrong for the respective service then another authentication type is requested to be entered by the student.
7- Another authentication type is sent to 'Assistant to check' to be validated for successful access.
8- Upon successful presentation of the authentication type, the student is granted access to the desired service.

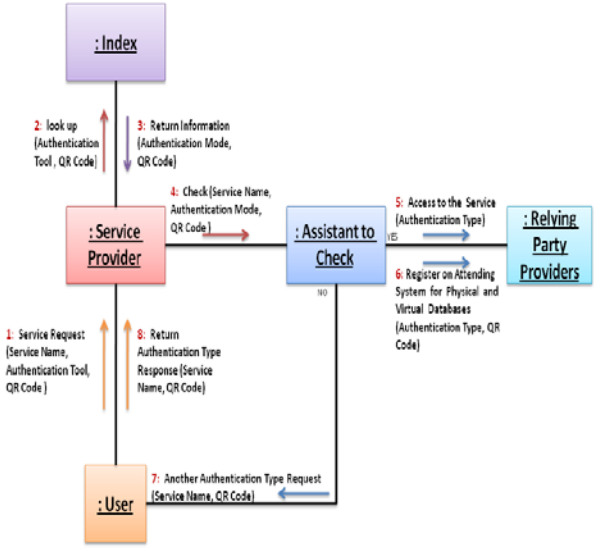

Figure 10: Communication and Collaboration Diagram of the Proposed Model

4.2.4. Interaction Sequence Diagram. The same functions that were explained in the preceding section can be seen in a sequence in the following interaction sequence diagram:

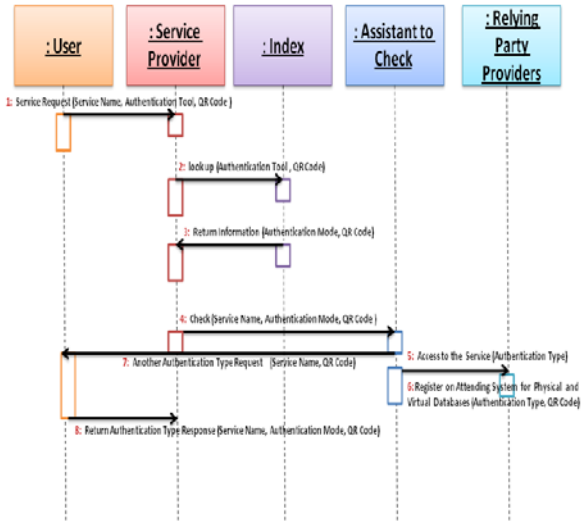

Figure 11: Interaction Sequence Diagram of the Proposed System

The service request is initiated by the student. The service provider looks up the service name by means of the Index. This information, alongside authentication type, is sent to 'Assistant to check' to evaluate the sufficiency of the authentication mode for the respective service. Upon sufficiency, the student is granted the required access to the respective service. In case the specific authentication mode is wrong, the student is denied access and he is expected to present another authentication type. The student has to scan the QR code for connecting the physical objects with the virtual places. For example, all the classes at the university have QR codes, and the student can scan the QR code at the traditional lecture, so the blended learning systems at Taif University will have all the attendance information about the students if they are online or at the University Campus.

4.2.5. Activity Diagram. Figure 12 shows the activity diagram that depicts the same flow of operations for selection of the service, entry of the required information and requesting the authentication type. However, the flow breaks into different directions on the basis of the authentication type presented to the system. If the authentication type is correct then access is granted for the learning services and the student can register on the attendance system that connects all blended learning services at Taif University; otherwise the system follows the path of re-requesting an authentication type if the authentication type provided by the student is wrong. If the student chooses not to present another authentication type then he/she can choose 'Cancel' to abort the process.

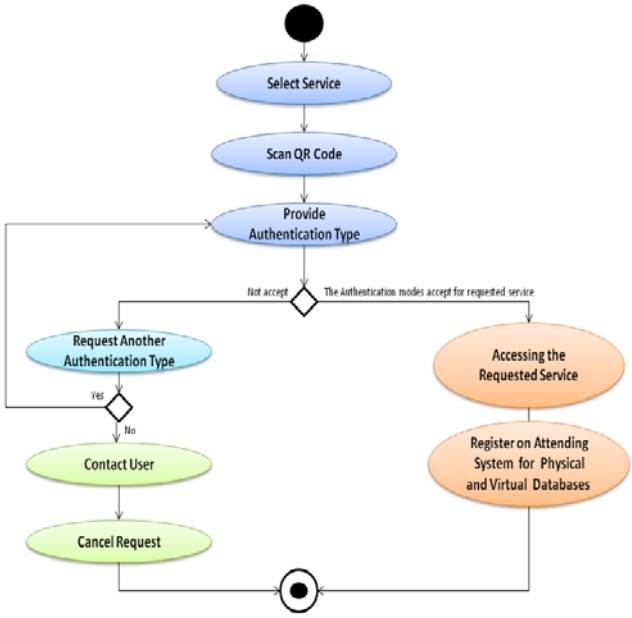

Figure 12: Activity Diagram of the Proposed Model

5. Future Research and Conclusion

The extensive study of the existing frameworks and relevant theories enabled understanding of the requirements of integration of physical and virtual attendance systems from the three perspectives: security, the Internet of Things and blended learning. However, there is no research known that considers the integration of physical and virtual attendance systems based on the Internet of Things for supporting blended learning from the user's viewpoint.

This paper proposed a new attendance system that would conform to the standards of these three perspectives for different users and sectors. It describes UML modelling and graphical representations of the new prototype system, which is identified as an attendance system based on the Internet of Things for supporting blended learning at Taif University. There are different types of UML modelling techniques selected for this research, which are architectural modelling, use case diagram, activity diagram, collaboration and communication diagram and sequence diagram. These modellings help to imagine the concept and main purpose of the system, and simplify the design of the prototype system with regard to testing the list of hypotheses for the research study for future research.

User and expert evaluations are being conducted to validate the components of the proposed system. Such evaluation activities will be discussed in detail in the future papers.

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