Smart Airport Architecture Using Internet of Things

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Abstract— **The future vision of internet is to connect everything, such as connecting things like transportation networks, communication networks, etc. Each of the entities will be connected through a network framework that will let all channels interconnect and communicate with each other in an easy mode. This will further turn into a good source of motivation for integrating a more efficient transport system. By employing the proposed architecture in this research paper, the airports can be transformed into smart airports with the integration of Radio Frequency Identification(RFID) technology and Internet of Things (IoT) which will allow all concerned an immediate access to relevant information about various operations required by the travelers and employees and make use of the smart airport facilities. It will ensure better efficiency and effectiveness of all the operations of smart Airport services. As a result, departures, arrivals, luggage delivery and welcoming visitors - everything will be handled in a smart way with the help of proposed architecture. Smart airport technology will lead to many innovations in the aviation sector, which in turn will increase the efficiency and productivity of the entire airport management system. This architecture will provide personalized services and content to different travelers at the airport and makes sure that each and every traveler who enters the airport will get the ultimate customer experience and satisfaction.**

Index Terms— **Internet of Things, Smart airport, RFID, architecture.**

I. INTRODUCTION

Presently travelers are connected to internet most of the time by default, and they also fully expect that the available interactions related to them to work seamlessly at their fingertips. This research paper is intended to propose architecture in resource management system for the utilization of airport services offered to the travelers. Smart Airport will provide an intelligent system with the integration of RFID technology, IoT and 'Google Indoor' maps onto the existing infrastructure of the airports in order to determine more precisely the use of airport services by the travelers. This architecture will provide personalized services and content to different travelers at the airport and makes sure that each and every traveler who enters the airport will get the ultimate customer experience and satisfaction. RFID technology with use of IoT has the potential to completely restructure the airport business model. Some of the airports around the globe have started to use of IoT for improve customer experience, handling of luggage, tracking of goods on transit, monitoring of equipment and etc. The top three investment priorities in 2015 are passenger, operations and baggage [1].

The Internet of things (IoT) promises wide ramifications, especially in the aviation sector. In this sector, technology could mean reduction of travel period, buffering security and safety of the passengers. However, these achievements will only be realized if there is international integration with government agencies and business organizations in order to respond to each of these technological needs appropriately.

Internet has already played a big role that has dramatically changed the operations at the airports. This research paper entails a current literature review of the basic concepts of the incorporation of IoT concept in the aviation industry. This trend has been recognized by most of the airports in UK and United States and other developed countries.

A number of research institutions are currently carrying out comprehensive research on the innovative solutions that will fulfill these technology needs. The main motive of this paper is to provide a comprehensive discussion on the present state of RFID technology and use of IoT with particular focus on the aviation sector.

The RFID technology in information technology systems is used to transmit the signals wirelessly without the presence of the physical gadgets to identify and track the objects automation by using the information from the centralized database in a very simple and easier way. The RFID tags will be attached to the various objects that need to be tracked or identified from the data and the information stored in it. These objects are sensed by the RFID readers by emitting the electromagnetic waves which will be present around the object movement [2].

When the RFID tag enters the zone of RFID reader the electromagnetic waves from the reader powers the tag, the tag transmits the data and the information stored in it to the RFID reader. The RFID reader sends the captured data to the centralized database for validation. RFID can be utilized to track and screen the physical world naturally and with exactness. RFID is fundamental to the advancement of the

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Internet of Things—an all-around interconnected web of items permitting the physical world itself to wind up a data framework, consequently detecting what is going on, sharing related information, and reacting.

Internet of things (IoT) is interconnecting all the unique identifiable objects around us which we come across on daily basis within the existing internet infrastructure. IoT enables to quickly access the information on all the "things" under IoT by enriching the awareness, communication and interaction of the individual entity both physically and virtually. The expectation of IoT are more advanced in terms of connecting devices and services that goes beyond Machine-To-Machine communications to completely automated [3]. The internet of things is used worldwide. IoT can be used in most of the applications and most the aspects of human life and production such as environmental protection, personal health, public safety, intelligent transportation, intelligence testing, and many other fields. The impact of IoT is clearly visible in as there some preliminary applications utilized in smart home, intelligent greenhouse monitoring, logistics management, public safety monitoring, safety traceability of food, distribution, digital oil field, digital substation, intelligent transportation and etc. The applications of IoT are being developed rapidly. There are several new technologies which are not able to meet the IoT's requirements; therefore research on the new technologies has been conducted as to meet the requirements of IoT [4].

This paper is organized as follows. In section 2 the related research work is represented. The proposed smart airport architecture and discussion of the proposed system are given in section 4 and 5 respectively. Section 6 concludes this paper and gives general direction of future research.

II. Literature Review

The potential of IoT for improvement of travelers experience during the trip, as well as all involved parties, which include handling of luggage and connection of flights, is significant Dave Bartlett [5] described how RFID technology and IoT can be effectively used for tracking of luggage by travelers using their smart phones, or the bags' ability to 'sense' the owner from the carousel area and effectively exiting the carousel at the point where the travelers will be standing.

The sensor technology is to play a significant role in the concept of smart airport. It is not a surprising thing to see that not only the aviation sector but also other industrial sectors are strategizing on investing huge resources on the smart sensors technology development [4]. According to statistics by Carrington [6], use of the smart sensor technology has grown in different areas, for example, in energy sectors (33%), power industry (31%). and aviation sector (32%). These are the sectors wherein most of the sensors are embedded on runways and in automated teller machines, used for security checks. It's predicted that the production of smart sensors will grow 25% in all industries in the near future. Potential areas that can benefit from implementation of such sensors are the management, arrival, luggage and cargo and, finally, the booking sections.

A Survey produced by SITA [1] and the Airline businesses suggests that the aviation industry is aware of the benefits presented by the IoT. Two out of three airlines feel that the application of IoT presents an instant benefit for the airlines while 86% believe that the airline will benefit within 3 years. 37% of the existing airlines have already invested in budgeting for the purposes of implementing IoT concepts. The study however suggests that only 58% of airlines are planning to investment in IoT over the next 3 years. Emphasis is placed more on experimental projects; however 16% are willing to invest fully into the IoT concepts.

IoT and embedded technology based airport parking system application was proposed by Suresh [3]. This system uses Arduino as an embedded controller to the interface Ethernet shield with a computer to enable IoT over Ethernet. Using their credentials (user ID and password), users and airport authorities can view the status of the vehicle in the parking lot by means of IoT applications on their smartphones via cloud server of the airport. This proposed IoT based airport parking system can ensure the safety and security of the vehicles in airport parking lot. It must provide cyber security to the parking cloud service because of security risks involved in the real time implementation of cloud computing and IoT. Zhou [7] presents an agent based intelligent cargo tracking system, which includes an agent structure and system architecture based on the Internet of Things. Cao at el. [8] proposed and designed airport perimeter security system based on Internet of Things. Moller at el. [9] describes the essential work required to address the barcode system currently used for luggage identification and how to address this problem by using IOT and RFID technology.

Increased mobility of customers, workforce and demand for services necessitates the utilization of business tools. RFID Technology with IoT is a platform that has led to increase in the level of connecting things and people on such a scale that was not possible before.

The big question is how the interconnected aviation world will look like. Tim Graham, a technological development and innovation manager at virgin Atlantic, proposes a number of eventualities [10]. He suggests that the application could include fitted displays, wearable equipment with sensors etc. for the purpose of helping passengers navigate their way around, user identity during airport check in, boarding and/or lounge areas and tracking of luggage, cargo, etc.

III. Proposed Smart Airport Architecture

Presently travelers are connected to internet most of the time by default, and they fully expect the availability of interactions related to them to work seamlessly at their fingertips. The intent of this research paper is to propose architecture in resource management application for the utilization of airport services offered to the travelers. Smart Airports will provide an intelligent application with the integration of RFID technology, IoT and Google indoor maps onto the existing infrastructure of the airports in order to determine more precisely the use of airport services available to travelers. This application will provide

personalized services and content and makes sure that each traveler who enters the airport will get the ultimate customer experience and satisfaction.

The Proposed Smart airport architecture is shown in Fig.1, which consists of: Mobile Application, Kiosks and Traveler; the RFID reader reading the luggage tag to distribute the luggage to specific conveyor belt; the credit card and Google maps connected to the mobile application to help the application to verify the payment details and to show the current traveler location. Kiosks help the traveler to change their preferences and to print the boarding pass or luggage tag; all these features data are connected in one database to provide all airport services.

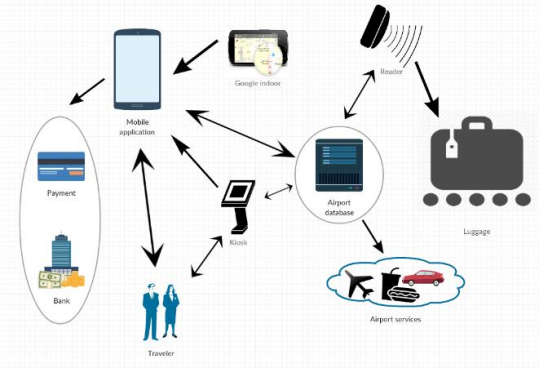

Fig.1: The architecture of Smart Airport

A. IOT Architecture Layers

A typical IoT architecture is divided into three layers: physical layer, application layer and network layer. The physical layer will capture sensed raw data from IoT objects with specific sensing abilities. Information gathered by sensors on the physical layer will be delivered to the application layer, where it will be accessed / used, via the network layer. The network layer may integrate various types of wired, wireless, and mobile networks. In order to integrate the heterogeneous networks to provide a unified application service to access information from the physical layer, the IoT-IMS communication platform can conduct bridging between physical layer and application layer in network layer [11].

B. Physical Layer of IoT

The physical layer comprises of the fundamental systems administration equipment transmission advances of a system [12]. The most well-known physical layer conventions utilized by installed frameworks are:

- Ethernet (10, 100, 1G)
- WiFi (802.11b, g, n)
- Serial with PPP (point-to-point convention)
- GSM, 3G, LTE, 4G
- Cat 5/RJ-45

Internet plays fundamental role in accessing the application; and the physical layer assures connectivity of Internet with a server and provides access to different routers.

The physical layer is a crucial layer fundamental the sensible information structures of the more elevated amount capacities in a system. Because of the plenty of accessible equipment advances with generally changing attributes, this is maybe the most complex layer in the OSI construction modeling.

The physical layer describes the method for transmitting crude bits instead of coherent information parcels over a physical connection associating system hubs. The bit stream may be assembled into code words or images and changed over to a physical sign that is transmitted over an equipment transmission medium. The physical layer gives an electrical, mechanical, and procedural interface to the transmission medium [13].

The mobile application works on the smartphones as they are the information gadgets and the UI of the mobile application if from the application layer. The information from the application should be transmitted to mobile application for the travels and this could be possible only through some communication medium where the physical layer works as back bone to provide the communication medium in many forms as stated above.

In the proposed architecture in this project for transforming the airports to smart airports by utilizing the RFID technology physical layer is like a backbone where it plays a major role in interconnecting the network layer and the application layer used in this model.

C. Network Layer

The Network layer knows the location of the neighboring hubs in the system, bundles collected information with the correct system address data, chooses courses and nature of administration, and perceives and advances to the Transport layer approaching messages for nearby host areas. Establish a link for transmission of information and builds up and keeps up the association between server and client.

The data link layer is the one that fundamentally characterizes the limits of what is viewed as a system; the network layer is the one that characterizes how internetworks (interconnected systems) capacity. The network layer is the most reduced one in the OSI model that is concerned about really getting information starting with one PC then onto the next regardless of the fact that it is on a remote system; interestingly, the information connection layer just manages gadgets that are neighborhood to one another [13].

The network layer gives the utilitarian and procedural method for exchanging variable-length information successions from a source to a destination host using one or more systems while keeping up the nature of administration capacities.

Since numerous systems are apportioned into sub networks and interface with different systems for wide-zone interchanges, systems use specific hosts, called entryways or switches, to forward bundles between systems. This is additionally of enthusiasm to portable applications, where a client may move starting with one area then onto the next, and it must be orchestrated that his messages tail him [14].

This layer is responsible for the integrity of data to be sent through the passenger to the server for the scheduling of their trip and to acquire ultimate experience and satisfaction

level.

The Network Layer is responsible for the source-to-destination delivery of packet, in this proposed architecture the role of network layer to communication between the database server, sensors, RFID Reader, RFID Tags and the traveler through their mobile application installed on their smartphones from time the traveler books his/her itinerary and until the completion of journey and reaching the destination.

D. Application Layer of IoT

The application layer is the one that is utilized by system applications and the mobile application. The application layer via the physical layer and the network layer transmits the information which then will be viewed on the mobile application UI of the travelers in order facilitate the smart airport services.

The purpose behind guiding this out is because not all client applications utilize the application layer of the system in the same way. If you utilize a content tool to open a record on another machine on your system, that supervisor is not utilizing the application layer. Thus, it has no idea that the record you are utilizing is on the system: it just sees a document tended to with a name that has been mapped to a system elsewhere. The working framework deals with diverting what the editorial manager does, over the system.

Likewise, not all employments of the application layer are by applications. The working framework itself can (and uses) benefits specifically at the application layer. It's vital to comprehend that what the OSI model calls an "application" is not precisely the same as what we ordinarily consider as an "application." In the OSI model, the application layer gives administrations to client applications to utilize. For instance, when you utilize your Web program, that genuine programming is an application running on your PC. It doesn't generally "live" at the application layer. Maybe, it makes utilization of the administrations offered by a convention that works at the application layer, which is known as the Hypertext Transfer Protocol (HTTP).

This layer is housing application and end-client forms. Correspondence accomplices are distinguished, nature of administration is recognized, client verification and protection are considered, and any limitations on an information language structure are recognized. Everything at this layer is application-particular. This layer gives application administrations to document exchanges, email, and other system programming administrations and software / applications that work on the internet on networks.

Application Layer of TCP/IP convention suit is concerned fundamentally with human communication and the execution of programming applications and related conventions. It is close to the client end, client collaborates to the system through Application Layer [12].

The proposed application works on top of TCP/IP protocol including human interaction and communication with server soothe communication will be frequency based using any data services provider.

The scope of application layer in the proposed architecture is to provide access to travelers, so they can access through the mobile application installed on their smartphones, which will be developed to access the smart airport facilities explained in detail in the proposed architecture. The mobile application guides the travelers based on the information provided by the application layer from the data available in the database server which is captured by the sensors, RFID readers, RFID tags and GPS utilizing the physical layer and network layer.

The smart airports application with the use of RFID technologies and IoT will improve operations efficiency and provisioning the needs of the passengers in more convenient and customized way. The major requirements, Product Function (PF), of the proposed airports application are:

1) PF #1

The Airport Services can be provided to the travelers through the Mobile Application and the Ticket Kiosks after booking the itinerary.

2) PF #2

- The traveler will book the air ticket either through travel agent or through the airlines online portal.
- The traveler's smart airport experience starts 48 hours prior to his/her departure with the mobile application especially developed and designed to use the smart airport services.
- Upon accessing the smart airport mobile application, the traveler has to provide the itinerary details then the application gets activated and guides the traveler to use the smart airport service.

3) PF #3

The primary options of the smart airport mobile application after providing the itinerary details is as follows in the form of checklist:

- Pickup My Luggage: (Luggage will picked from the specified location so that the traveler don't have worry about carrying the luggage to the airport along with him/her).
- Pick Me Up To Airport: (Airport will provide the cab services to the travelers to pick them up from the specified location and drop them to airport).
- After clicking on "Submit" the smart airport mobile application will start functioning by providing the flight schedule details alerts and status of the selected services and reminders to go to the airport.
- By using the Google map, the mobile application will show correct terminal directions.

4) PF #4

- After getting inside the airport the application guides the traveler to walk down towards automated boarding kiosks along with "Google Indoor" by showing the directions and distance remaining so that the traveler can speedup accordingly.
- Upon reaching the kiosk the traveler has to validate the itinerary at automated boarding kiosk and select the preferences like seat selection.
- After validating the credentials of the traveler, the kiosk prints the boarding pass and the luggage identification tags. Both the boarding pass and luggage identification tags will be embedded with an RDIF chip which will

contain the traveler's information, the luggage identification tags should be tagged to the luggage of the travelers by themselves.

- The traveler has to dump his/her tagged luggage onto the conveyor belt, the luggage moves on the conveyor belt and reaches to place where there will be RFID readers and intelligent gates which with sub conveyor belts connecting to correct flight.
- After dumping the luggage the application will guide the traveler towards security check/emigration along with "Google Indoor" by showing the directions and distance remaining so that the traveler can speedup accordingly.
- After the security check/emigration the application guides the traveler towards the boarding gates along with "Google Indoor" by showing the directions and distance remaining.
- Upon reaching the boarding gate, the application provides the flight details of the traveler and if any delay in flight or rescheduling any announcement everything will be notified by the application. In addition, the application will provide details around the traveler such as cafeterias, food courts, washrooms, lounges smoking zone etc. along "Google Indoor" by showing the directions and distance remaining from his/her place to reach the place of interest.
- Once the boarding gates are open, the application will guide the traveler to the boarding gate. Before boarding the flight there will automated turnstile stands with RFID readers, the traveler just has to pass his/her boarding pass on gate reader and the turnstile stand allows the traveler to board the flight.

Analysis of smart airport is a process of identifying the conceptual items and properties necessary for a solution to be both correct and proper. Our analysis approach is requirements analysis. During the requirements analysis, an informal set of requirements was formulated and expanded into a more formal description. This transformation is done gradually through use cases. Use cases offer application and intuitive way to capture the functional requirements with particular focus on the value added to each individual traveler or to each external application. Use cases play a key role in driving the rest of the development work and that is the important reason for their acceptance in most approaches to modern software engineering. A use case model describes what the application does for each type of traveler and provides the essential input for analysis, design and testing. It is a top-level view of the application and shows the actors, use cases, and their relationships. The actors are entities that interact with the application. Fig. 2 and Fig.3 show the use cases for Application and Kiosks correspondently.

Sequence diagrams define inputs and outputs and sequence of interactions between user and system for each use case. Fig. 4 and Fig. 5 show the sequence diagrams for Application and Kiosks correspondently. Activity diagrams use to visualize the workflow of a business use case and to document work flow of business process activities for each use case scenario. Figures 6 and 7 show the activity diagrams for Application and Kiosks correspondently.

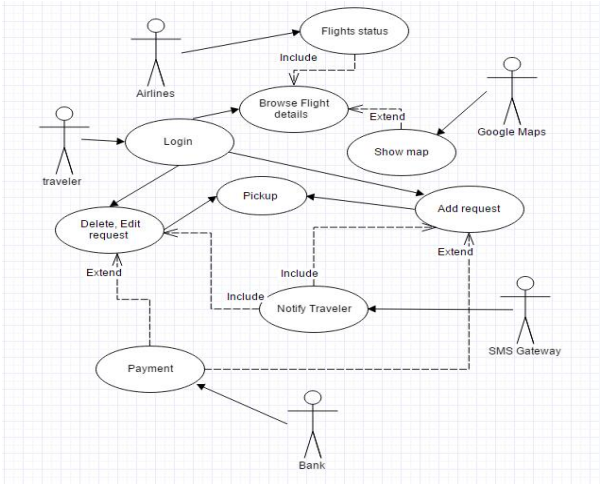

Fig. 2: Application use case

IV. DISCUSSION

Every air traffic passenger waste considerable amount of time due to the different reasons due to the luggage claims, security clearance or just finding the right gateway in airports. This varies from airport to airport. The flow of airport operations includes:

- Check in
- Airport Security Clearance
- Terminal
- On board
- Luggage claim
- Taxi Claim

The major time waste is in airport security clearance, and then difficulties in searching the specific terminal especially on international airports and claiming the luggage once arrived to destination then to find a taxi. The application will do all this for you and helps in saving time and making your trip easier. Worldwide air terminal spending on IT moved to 5.82% of incomes in 2014, a sizeable stride up from the 4.41% of income reported for 2013. In air terminal industry complete IT spending in dollars has risen 37% to achieve a record level of US$7.8 billion in 2014 [1].

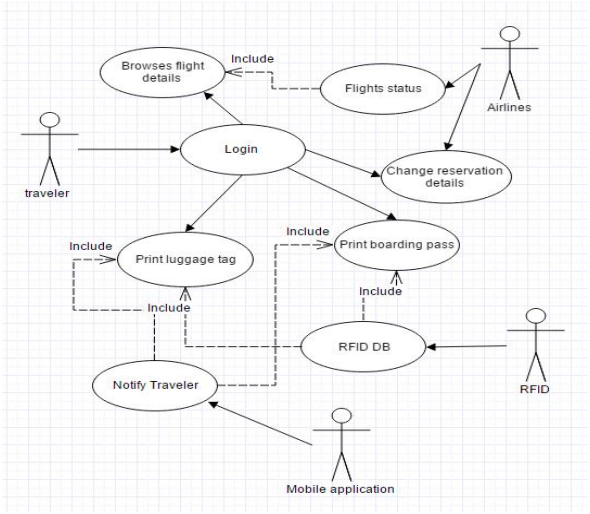

Fig. 3: Kiosks use case

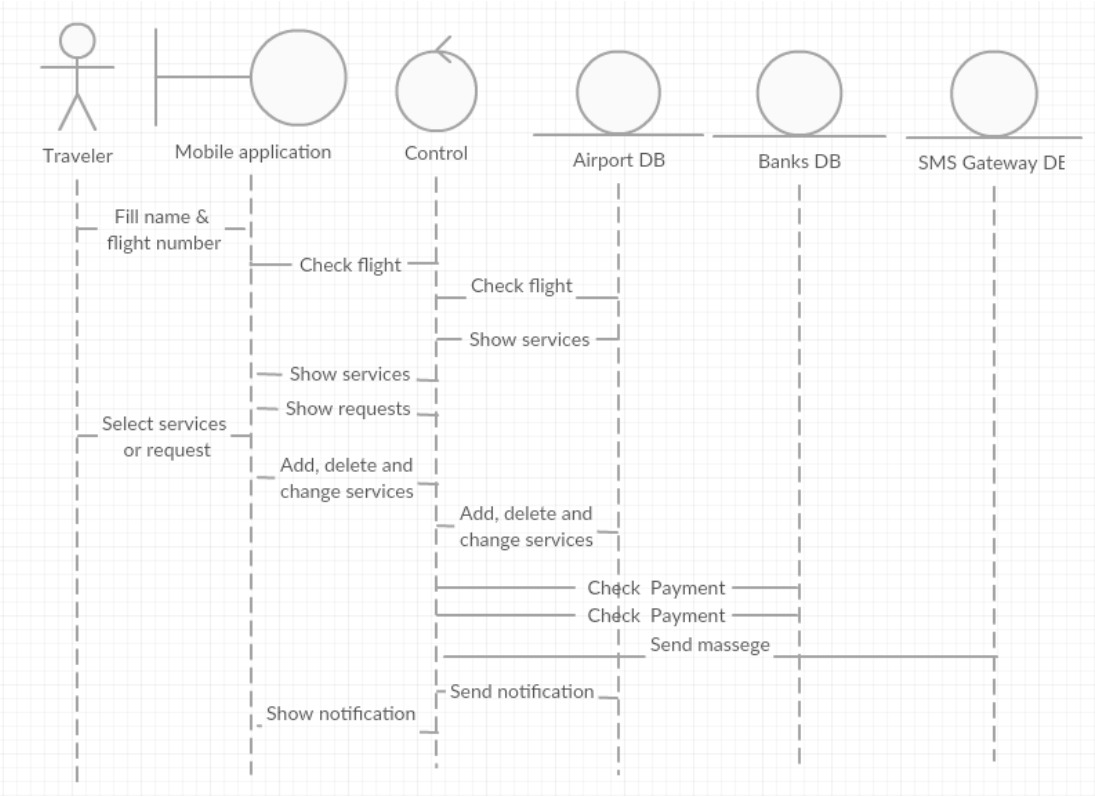

Fig. 4: Application sequence diagram

The deployment of sensors to monitor the arrival processes, in areas such as luggage claims, is almost non-existent today and only just over one-third of airports expect to install them by the end of 2018. The majority of airports are mainly focusing investments on outbound passengers.

The connection of airport operations to the internet will provide a chance for new possibilities; IoT and new air terminal technologies will give rise to new functionalities making the aviation operations easier, efficient and safer. With reference to this context, the major concept of smart airport is linked with RFID technology and IoT which represent the future trends for the aviation sector and mobility application.

IoT is a computing concept that is usually used to describe the future of everyday operations and the way they will be connected to the internet in order to have the ability to identify the users in other devices. The term IoT is usually interrelated with RFID as the mode of communication; the concept also includes other technologies such as "Google Indoor".

In the view of above mentioned the major efforts has been directed towards development of EPC (Electronic product code) in order to support application of RFID in the global modern operations network and to create the airport industry that is driven with respect to the global standards using the EPC global network. These types of standards are usually designed in order to improve the operations of the network based model. It is a significant step to adopt the RFID technology with IoT with focus to transform airports to smart airports.

By connecting real-time data from various transport systems, travelers can easily plan their travel with great certainty. They will have the ability to go through the whole route and easily find connection with other transportation modes upon arriving to their destinations. Better information through the IoT framework will motivate the use of sustainable forms as part of improving the transport sectors of airports.

Air transport is a sector that needs to be more efficient in the coming years, as the number of passengers using air transport is growing due to growth of the global population and also rising of the middle classes in the developing countries. Drones of different sizes will also be developed and these will be a part of our daily life. As the number of air transport mode increases, development of a much more integrated modern traffic management system is essential.

Due to fast increase of the number of people travelling through air, it is important to provide them with the build-in services, deploy technologies that will optimize all the processes, and improve the process flow so as to reduce the overall cycle time of each of the passengers visiting the airport. In a given scenario, it is evidenced that many airports have all engaged the IoT technology to facilitate customer travel arrangements.

However, with the changing times and needs, it is important to address all the issues with the help of new resources and technologies. The new modern-day technology can help the respective authorities in solving all the given operational issues and thereby, streamline the flow of operations for the respective organization.

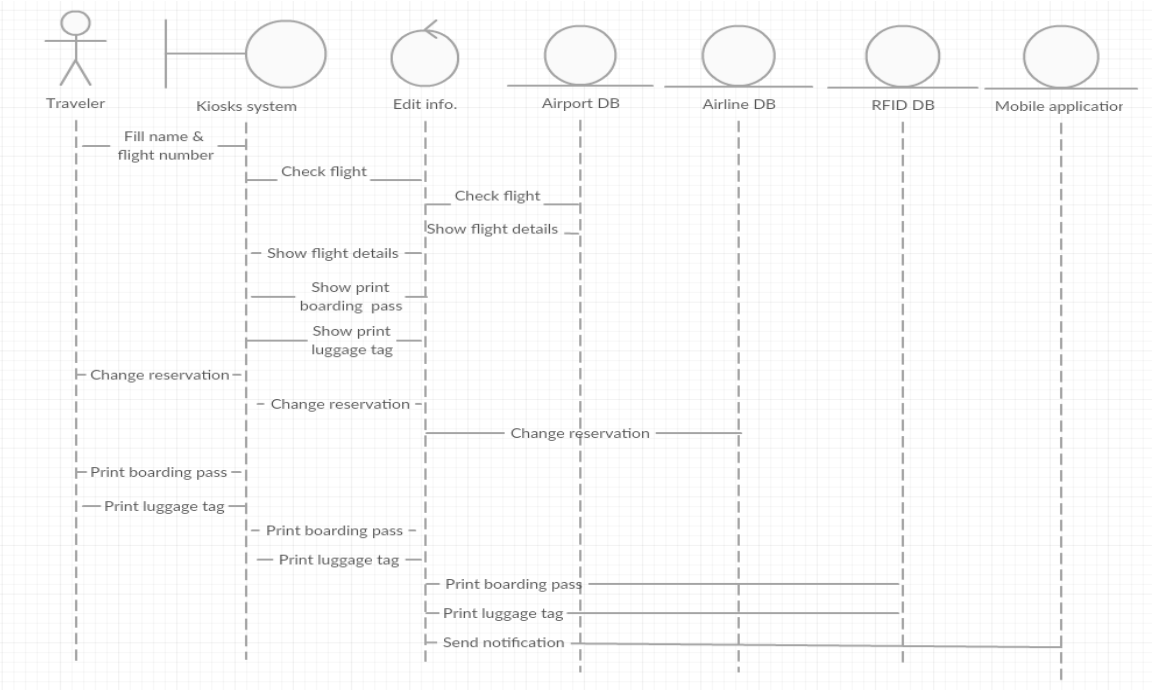

Fig. 5: Kiosk sequence diagram

V. CONCLUSION

The airport management is a very complex task as thousands of travelers must be dealt with appropriately every day in such way as to provide customer satisfaction to each and every individual traveler which in itself is a challenge. The particular project identifies the various aspects of internet, RFID technology and IoT that can play a positive role in improving the airport services and transform the airports to smart airports with proposed architecture.

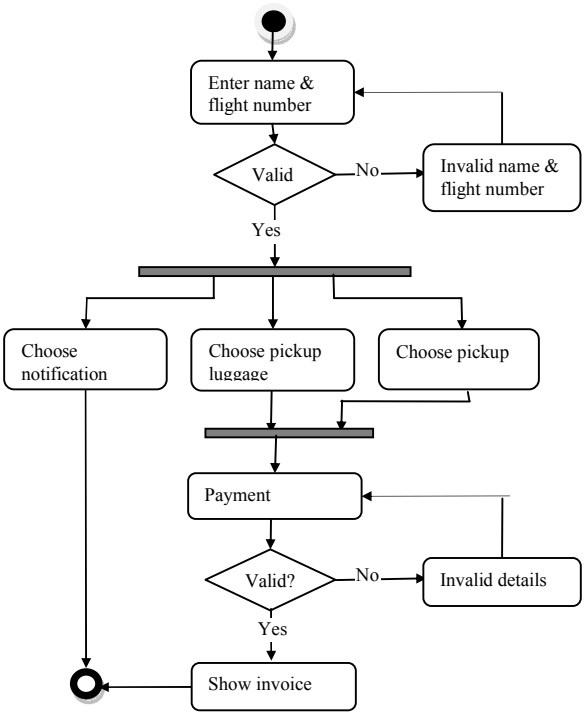

Fig. 6: Application activity diagram

In a view of recent developments, there are various aspects of aviation sectors that need to be considered, such as wireless communication and networking of the airport activities. Through the use RFID technology with IoT and embedding a small mobile application into a wide variety of additional gadgets and equipment that are used in daily operations; this will enable new form of communications and carrying out of various operations with ease of use.

The major strength RFID technology and IoT, especially in the aviation industry, is the high impact that it has on majority of the operations that are carried out in the airports.

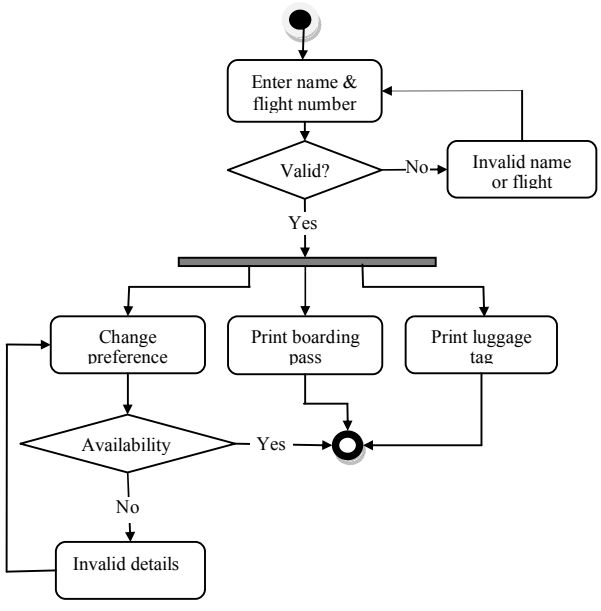

Fig. 7: Application activity diagram

The impact of RFID with IoT will definitely improve the daily operations of this sector. With regards to the development of the smart airports people will find better facilities at the airports. In addition, even the employees working at the airports will have improved productivity at each of their working levels. During the development of application have to concern with different libraries varies to operating system for the successful overcome the internet issues and protocols. The application will run on smart electronic gadgets using operating system provided services and will help the passengers to plan their trips easily and enjoy the journey with application.

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