Applications and Opportunities for Radio Frequency Identification (RFID) Technology in Intelligent Transportation Systems: A Case Study

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***Abstract*—RFID technology has been known to be one of the noteworthy converging technologies of the 20th century. The technology can be applied in many fields. However, this paper focuses on the application of the technology in the transportation industry. The application of RFID in Intelligent Transport Systems (ITS) is gaining popularity with its widespread use in the field of toll management and the management of the overall transport sector. There are many RFID applications available in the market such as RFID contactless smart card commonly used in buses and LRTs, Automatic Vehicle Identification (AVI), Electronic Toll Collection (ETC), Smart Parking, and congestion zone pricing.**

In Mashhad, the second largest city of Iran, the "My Card" is used not only in Public transit but also in car parking, and soon in taxis and also other public municipality Services. Driven by such success stories, deployment of RFID technology in Mashhad is thus encouraged. This work has been carried out with a purpose to demonstrate benefits of the RFID technology in developing countries and its application in transport sector. This paper explores existing technology and surveys a set of successful implementations in Mashhad for Intelligent transportation applications .The integration considerations and challenges facing RFID deployment are also discussed.

***Index Terms*—Radio Frequency Identification, Intelligent Transportation Systems, Public transport, Tag, Reader, My card.**

I. Introduction

RFID technology is an important technology that has found its application in many places [1]. However, its application in the transportation is one of the best system applications. The technology is applied in the transport sector to perform various tasks such as vehicle or product identification during transportation, security, safety and operations. The system works using a tag that is placed on the vehicle or product to be tracked. The tag carries vital information concerning the vehicle or product identity and location that is transferred to the wireless reader (Fig. 1). In spite of their wide potential applications in the sector, the applications of the system are still limited. This paper conducts an extensive survey in the application of RFID technology in the transport sector with the major areas of application being intelligent transportation systems (ITS) and vehicle infrastructure integration. Further, this paper surveys a set of successful implementations in Mashhad for Intelligent transportation applications. The integration considerations and challenges facing RFID deployment are also highlighted.

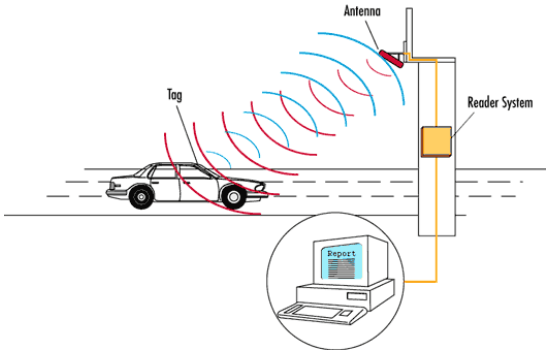

Fig. 1. Long-range RFID vehicle identification system (Source: http://www.witark.com)

II. RFID Anatomy

Short for radio frequency identification, RFID technology is an IT system that transmits signals without the presence of physical gadgets, but wirelessly. It is categorized under automatic identification technologies that have well established protocols [2]. The working of an RFID system is very simple (Fig.2). The system utilizes tags that are attached to various components to be tracked. The tags store data and information concerning the details of the product of things to be traced. The reader read the radio frequency and identifies tags .The antenna provides the means for the integrated circuit to transmit its information to the reader.

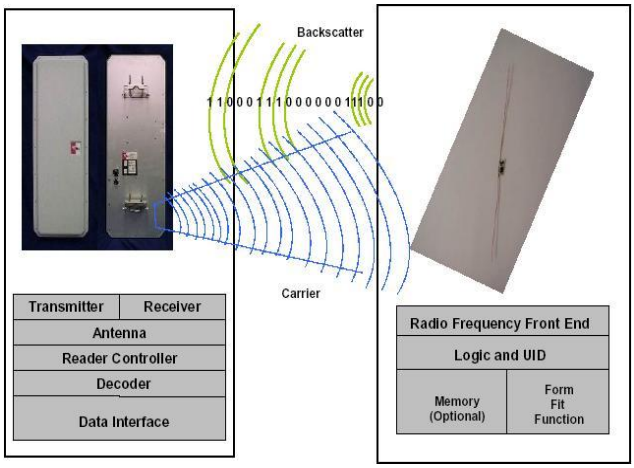

Fig. 2. RFID system components

Two categories, active and passive tags exist. The tags that do not utilize power are referred to as passive and they are driven by an antennae that enables the tag receive

Manuscript received November 10, 2012; revised December 6, 2012.

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electromagnetic waves from a reader. On the contrary, active tags rely on power and they have inbuilt power sources that enable it to send and receive signals from an RFID reader. This is the distinction between these two types of RFID tags .There are also semi-active or battery-assisted passive tags which use thin batteries and provide greater range (less than active) and require less power from reader. Memory rewritable tags formed the first patent of RFID technology in the U.S that was used for active and intelligent door system with passive tags.

A. RFID Standards

Standardization is an important factor that cannot be ignored in RFID technology [3]. The standards are focused on air interface protocols, the content of data and the application of the technology. International organization of standards created the required standards for RFID technology before 1999. Some of the basic standards created by the organization are the ISO 11784 that is utilized in the tracking of RFID cattle, the ISO 11785 for interface protocol, ISO 14443 for application of smart cards in payments and ISO 15693 that is applied to vicinity cards. The development of the electronic product codes (EPC) was initiated by the auto ID center in 1999. The center was also responsible for the development of a low cost RFID used for tracking goods in transit. The effectiveness of application of RFID technology involves the utilization of six tags that have different capabilities. The first generation protocol tags specifies only the first two generation of tags while users are required to purchase multiprotocol readers in order to read other classes of tags such as class 0 and class1 tags that leads to an increase in the initial cost of setting up an RFID system. EPC global solved the cost issue of using RFID by developing Gen 2 RFID technology that was compatible with other classes of UHF band.

Table I indicates the features of the various tags for the RFID technology .The classification of the features is based on their generation. The second generation is faster, flexible and reliable in counting and enhanced security. The tag is easily upgraded especially when the users have the RFID technology that is based on EPC class 0 and class 1.

TABLE I: RFID TAG CLASSIFICATION

Class	Tags
Class 0	Is a factory programmed read only tag
Class 1	It is passive, read-only, backscatter, write-once-read-many (WARM) tag
Class 2	Has a user memory and encryption. Is a passive field programmable tag.
Class 3	It is semi-passive backscatter tag that has a user memory and encryption
Class 4	It is an active tag that utilizes built in battery as source of power to run the microchip circuit
Class 5	Is a very active tag that is able to communicate with the above five tags or any other device.

B. RFID Applications in Intelligent Transportation Systems (ITS)

Transportation is a crucial industry that affects the national economy and livelihood of the people [4]. Intelligent Transportation Systems, or ITS, can be defined as the application of computing, information, and communications technologies to the real-time management of vehicles and networks involving the movement of people, goods, and services. When integrated into the transportation system's infrastructure, and into vehicles themselves, these technologies relieve congestion, improve safety, and enhance productivity. Intelligent transportation systems (ITS) encompasses a broad range of wireless and wire line communications-based information and electronics technologies (Fig. 3). The versatile features and benefits of RFID technology have proven that RFID can be widely applied in the field of intelligent transportation to improve driving safety, reduce vehicle collisions, and even help reduce vehicle emissions [5].The RFID technology has over 16 subcategories in the ITS used in the electronic payment and pricing subcategories among others .

The Moscow metro, was the first system in Europe to introduce RFID smartcards in 1998.In Taiwan the transportation system uses RFID operated cards The Easy Card is charged at local convenience stores and metro stations, and can be used in Metro, buses ,parking lots and taxis.In Singapore, the public transport network of buses and trains employs passive RFID cards [6]. Traffic into the crowded downtown areas of the country is regulated by variable tolls imposed using an active tagging system combined with the use of stored-value cards .Microwave RFID tags are used in long range access control for vehicles. Since the 1990's RFID tags have been used in car keys to prevent theft. Without the correct RFID, the car will not start [7].

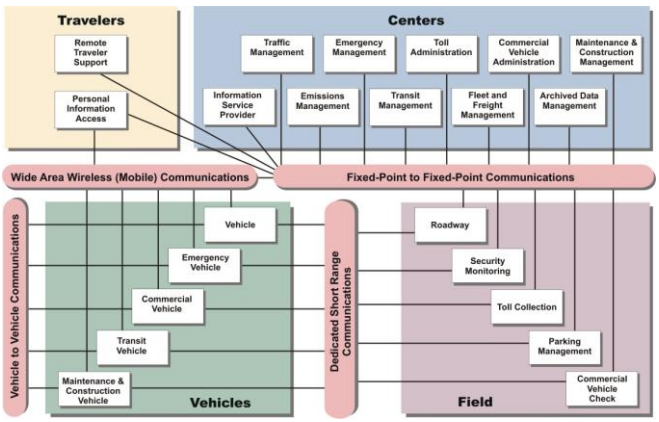

Fig. 3. Basic ITS architecture

III. CASE STUDY: MASHHAD EXPERIMENTS ON RFID AND ITS

Mashhad is the second largest city in Iran and a holy city in the world with a population of almost 3 million people. It is located 850 kilometers east of Tehran, at the center of the Khorasan Razavi province near to the borders of Afghanistan and Turkmenistan. One of the largest cities in Iran, Mashhad is an important transportation, commercial, manufacturing, and religious center situated in a productive region. The shrine of Imam Reza attracts more than 20 million pilgrims and tourists every year. Transport statistics shows that Mashhad basically covers 141 internal traffic zones, 16

sub-urban areas and 6 interstate routes. Interest in deploying ITS technologies in Mashhad come from the problems such as more traffic, more vehicles and more pedestrians that could not be handled by current transportation system and causes significant reduction in efficiency of transportation infrastructure and increases travel time, air pollution, and fuel consumption.

A. Mashhad "My Card"

Mashhad municipality launched the "My Card" contactless smartcard system in 2010, and has issued 2.2 million cards since with a further 2 million still being rolled out. Every day approximately 1.1 million transactions are made on the public transport system, primarily for bus and metro fares. It is considered to be a major multi-modal smart card system of its kind in Iran that incorporates all modes of transport systems. This system has the ability to handle up to 5 million transactions per day across all modes of public transport.

Technologically, Mashhad "My Card" is Based on a MIFARE DESFire EV1 card which can hold up to 28 different applications and 32 files per application (Fig. 4). "My Card" holders can experience convenient contactless ticketing while also having the possibility to use the same device for applications such as payment at vending machines, access management, loyalty or social services.

By launching "My Card" system, cash wouldn't be accepted for urban services because now, one of the major problems in using urban services and in some dealings such as paying taxi fare, is the lack of change and usually this is in favor of the driver. Using "My Card" makes people able to pay for taxi, bus, subway, parking and so on. Each person can charge the card dealing with his needs; so, this system won't have any financial benefit in favor of Mashhad Municipality. Pilgrims and tourists can also use these cards too and the system will develop so that Mashhad citizens would be able to use this card in other cities. "My Card" is a unique system in Mashhad and the Iran Ministry of Interior's recommended all major cities including Tehran, to change their existing system based on "My Card" experiment. Fig. 5 shows Mashhad "My Card" concept and the related services and applications architecture.

In Mashhad Bus management system project, more than 2,000 buses on 161 routes are equipped with electronic fare collection system. A wide Sale and charge network, which is distributed all over the city, provides services such as card personalizing and cash-charging using POS and debit cards. Fig. 6 shows the basic architecture of Mashhad bus fleet management and fare collection system.

Fig. 4. Mashhad "My Card"

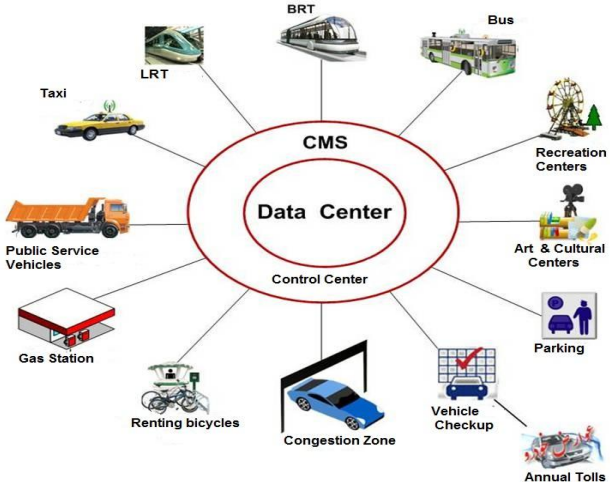

Fig. 5. Application architecture for mashhad "My Card"

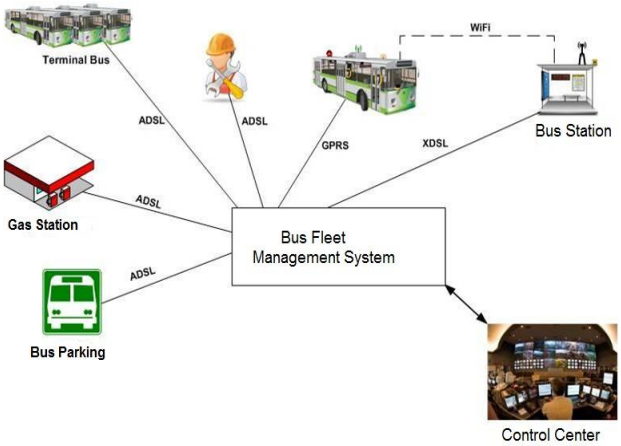

Fig. 6. System architecture of Mashhad BUS management system

B. RFID Application in Mashhad Taxi Fleet Management System

A variety of advanced technologies are in use for managing taxi fleet operations. The most common technology system for taxi fleet management is automatic vehicle identification (AVI) including RFID technology. AVI systems can be employed in a central staging area to automate entry of identifying information to a central dispatching system, to enforce access restrictions, to communicate terminal assignments to drivers, and to monitor vehicle volumes in the holding area.

The Mashhad Taxi Authority has planned to roll out a wireless system based on RFID technology to manage taxi fleets at Mashhad Airport, Train Station, Bus Terminals and all the taxis in the City. Using AVI technology which identifies both a vehicle and its driver, Now Mashhad Taxi authorities are able to manage taxis and drivers. The operators at airport and terminal will also use the system to predict customer demand and dispatch taxis. The solution uses GPRS wireless communication links. Fig. 7 shows the main architecture of the system in which fare payment using "My Card" is also anticipated. The RFID technology will identify each vehicle and driver and facilitate the dispatch of taxis by agents using handheld devices linked to a wireless network. The all new taxi management system, will be completed in 2013 and currently identifies about 2500 tagged

taxis by 300 checkpoints (RSU) which are installed in the whole city (Fig.8). The system also provides important management information for planning and statistics. Some important outcomes of the system are:

- Rapid and accurate tracking of Taxi sign out and activity history
- Effective real-time updates on fleet inventory and activity records
- Rapid check in/check out for reduced turn-around time and client wait
- Accurate information on vehicle use and activity history for maintenance and purchasing decisions
- Current record of vehicle availability for efficient management
- Reduction in labor to manually record data and update system
- Reduced theft and increased safety

An interesting benefit of this project is the ability of checkpoints to gather real-time travel data .Based on this information, traffic management authorities could help predict travel times and optimize their traffic plans. This is an inexpensive way and eliminates the need to probe vehicles for traffic data gathering.

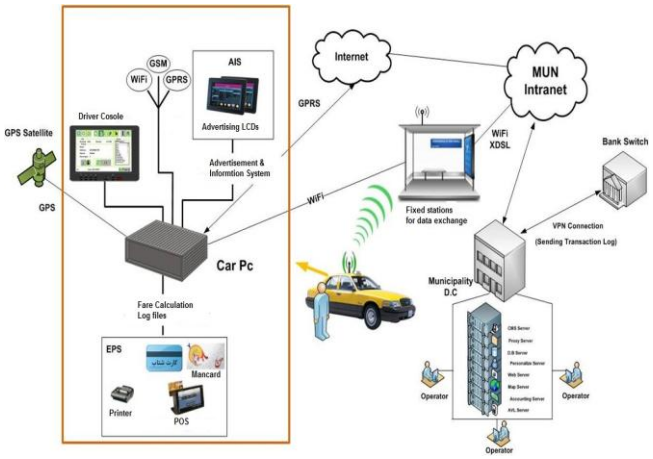

Fig. 7. Architecture of Mashhad taxi fleet management system using " My Card" payment

Fig. 8. Tags, readers and checkpoints used in Mashhad Taxi fleet management system

IV. Barriers for RFID Deployment in Mashhad ITS Projects

In spite of considerable progress in deploying RFID technology for Mashhad intelligent Transportation projects, the effective application of the technology faces various challenges. Due to some reasons like short period, weak technical basis and limitations in development stages, the penetration and development of technology is still at the initial stage. According to the analysis of the development and research condition of Mashhad intelligent transportation system and relevant works [8]-[9], the existing shortages could be mentioned as follow:

- Lack of Integrated and unified deployment: each division or organization establishes its own system without essential connection and coordination.
- ITS & RFID technologies, developed in recent years, is not yet fully accepted by traditional transportation industry Managers. At present, intelligent transportation system is not included when the main industries and metropolitan projects are being planned, or just put it in technical developing plans which are not beneficial to promote the generalization of intelligent transportation system.
- High cost of applying the system to large transport sector.
- Severe shortage of ITS talents: Intelligent transportation technology is the combination of traditional transportation technology and information technology (IT), hence intelligent transportation talents should be compound talents which not only know transportation but also understand IT.
- Technological challenges: Reading distance and rates, physical challenges and the human health challenges the technology poses to drivers and other system users [10].
- Policy and privacy challenges: Policy makers need to support the system for effective application. Standard measures are also vital.

V. Conclusion

The advantages of RFID solutions have been recognized by traffic sector & transportation industry in developing countries. It is believed that RFID-based technologies can be extensively exploited to improve transportation safety and security, increase the efficiency of the transportation system, ultimately save costs, and improve people lives. Also, Smartcard-based fare payment provides convenience for passengers and efficiency gains for transport service providers. International experience suggests that successful implementation may take many years, and difficulties are commonplace.

In Mashhad, which is a leading city in Iran for IT projects, there is a great opportunity to implement RFID technology especially in the growing need-based transportation system such as the RFID contactless smart card. "My Card" system has been implemented in Mashhad city with an acceptable degree of success and its benefits outweigh the costs and challenges. Nevertheless, integration issues, cost, policy, privacy, and talents are still obstacles that have dampened wider applications of RFID technology in Mashhad transportation development plan and these key success factors need to be realized to successfully implement RFID projects in Mashhad.

ACKNOWLEDGMENT

The author thanks ICT organization of Mashhad Municipality for providing helpful information.

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