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Feasibility of RFID technology application in intelligent highways in Iran

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Abstract

Rapid changes in technology and communication have considerable effect on communities. With a simple review of urban transportation in recent years, it is found that despite great investment and construction of new roads, there are some problems including congestion, accidents, environmental pollution, etc. The realities in the analysis of transportation of Iran show that the problems in transportation system are extensive and having access to safe and rapid transportation requires extensive studies. It seems that control of effective factors is not possible via traditional methods. The idea of using intelligent transportation systems presents a new horizon to achieve continuous progress in information and communication community. Vehicles tracking and positioning in urban environments are the urban planning and management principles. This study aims to evaluate feasibility and presentation of RFID strategies as an exact and cheap technology compared to other technologies including GPS in smartization of highways and land transportation system. RFID is a cheap technology in advanced countries, even store systems and is also used in urban and transportation systems. RFID indicates the systems using Radio frequency to transfer identity of an object. This technology has proved its efficiency as an economical tool in improvement of performance and reduction of time and man power costs. This study indicates that more than 76% of prioritization in RFID application is dedicated to public transportation, intercity system and personal cars. One of the challenges of RFID application in Iran is the lack of planning and required infrastructures in this technology.

Keywords: Intelligent highways, RFID technology, Land transportation systems.

1. Introduction

The realities in the analysis of transportation of Iran show that the problems in transportation system are extensive and having access to safe and rapid transportation requires extensive studies. Intelligent transportation system is a set of automatic tools by which control operation (control of traffic flow), statistics, informing, and data collection are performed to solve the traffic problems. In other words, intelligent transportation systems are complex multi-dimensional instruments based on the composition of advanced technologies. These systems are

used to improve transportation condition and present some strategies to promote safety and reduce traffic accidents. An Intelligent transportation system is a new technology (electronics, communication and control systems) to enhance safety, efficiency and low cost in transportation system. Radio Frequency Identification (RFID) indicates the systems using radio frequency to transfer information of the identity of an object. This technology has proved its efficiency as an economical tool in performance improvement and costs reduction of man power and resources. Based on the problems of populated cities and the increase of urban traffic and accidents due to high speed, RFID technology is an effective method to reduce accidents and control urban traffic. RFID tags on car can store color, number, engine serial, name, car owner information and other important information. One of the main purposes of intelligent transportation systems is enhancing safety system. This study aims to have an exact study of optimized performance of intelligent control systems on safety of intercity roads and also intelligent highways can be constructed. Intelligent highways have all intelligent operators of information transfer between the road user, driver and management and control center. Based on the new intelligent road technology and lack of construction of such highways, we need the feasibility and structural recommendations in this field. This is evaluated as improvement and future development of roads in Tehran province to manifest the optimal performance of intelligent highways [1].

With a simple review of urban transportation in recent years, it is found that despite great investment and construction of new roads, there are some problems including congestion, accidents, environmental pollution, etc. On the other hand, the government plans on economic development requires a regular, efficient, safe and rapid transportation system. The realities in the analysis of transportation of Iran show that the problems in transportation system are extensive and having access to safe and rapid transportation requires extensive studies. It seems that control of effective factors is not possible via traditional methods. The structural problems of road network of Iran are not removed only by modification of some special areas. The studies of developed counties show that new technologies are effective on organizing traffic system, increasing safety level, controlling traffic offences, etc.

2. Review of literature

RFID technology was established in 70s. With the progress of technology in information systems, emergence of strong and cheap microprocessors, RFID is implemented with lost cost. The current commercial world needs these systems and it is developed easily in trading field. RFID technology is identification of a person or an object with tag using radio frequency in various frequencies since 1970. The most important feature of RFID is that it is used in identification of moving, fixed objects in dusty, rainy or sunny situations. It means that situation has no effect on the performance of a system and despite the bar code in which objects are read one by one, the data of many objects are read once. Briefly, RFID development to RFID progress is shown as followings:

- 1846: Electromagnetic energy was developed by Faraday
- 1935: Radar
- 1973: RFID system implementation for tags
- 1979: RFID application for animals
- 1987: RFID application for toll collection
- 1994: RFID application for cars in US
- 2003: RFID application to identify containers in Iraq war and supply chain system of commercial products before production to the delivery to customers.

Today, RFID technology is an effective step in traffic and transportation control systems.

RFID is a set of technologies in which Radio frequencies are used to identify people and objects and this is performed via storing the serial number of a person or an object in a microchip connected to an antenna. RFID is one of the most common automatic identification methods using Radio frequency and can exchange data between the tag and reader. Normally, RFID systems use electronic and electromagnetic signals for contactless data reading and writing. A set of technologies being used for identification of objects, human and animals is called automatic identification AI[3. 1]The goal of most of automatic identification systems is increase of efficiency, reduction of error, enter data for performing important works as better service providing to customers. Various technologies have been designed and implemented for automatic identification. Bar codes, smart cards, voice identification and some biometric technologies are some examples of these technologies [3].

There are many challenges in RFID application. A survey of more than 350
IT executives in April, 2004 showed that the top three business risks of using RFID are that:

1- Technical standards are not final
2- Business benefits or return on investment are unclear
3- There is a lack of industry-wide adoption

The major RFID implementation challenges and the corresponding strategies are presented in Table 1.

[1] Auto ID

Table 1 : The challenges and strategies [7]

Relevant strategy	Technical challenges	
The price of the tag and reader will continue dropping. Profit/cost and rate Return of investment in implementation	Passive tag price ranges from 20 cents to 1 dollar. Major retailers will have to invest $400,000 at each distribution center, $100,000 at each store to read and manage the data, and $35 to $40 million to integrate the RFID system into existing information systems.	**Cost**
UHF is considered the standard frequency for the retail industry supply chain.	No general accepted standard. ISO 11785 for 125 KHz, ISO 15693 for 13.56MHz, and ISO 18000-6 for 860-930MHz. ISO 15693 for passive, read-write tags which operate at 13.56 MHz. 915 MHz UHF frequency by The American National Standards Institute.	**Standard**
Use a circular polarized reader antenna if the tag orientation within the radio frequency field is unknown; use a linear polarized reader antenna for greater frequency penetration and longer read ranges. A multi-directional tag antenna performs better than a single-directional antenna. Tags should be slightly away from metal containers and from Items containing liquid or attached to a teflon bracket. A signal light system (poka-yoke).	Tag frequency. Reader antenna shape. Tag antenna design. Read rate. Read reliability.	**Tag and reader selection**
Application of a RFID middleware to process the data and to filter Out redundant and unneeded information.	The quality and synchronization of the data generated by RFID devices. False read and multiple reads of tags. Noise and dirty data. The effective use of the massive amount of data generated.	**Data management**
Data synchronization. Many software developers have focused on the integration issue of RFID technology in ERP systems such as SAP, Oracle, and Microsoft.	Integration of RFID systems and the data they generate with other functional databases and applications.	**System integration**
Using special methods and algorithms Using Blocking tag Using special readers	Eavesdropping. Tracking attacks.	**Security**

3. Study purpose

This study refers to the importance of study on new and intelligent systems in land transportation and their application. This study analyzes the application and development of

RFID radar technologies in roads and transportation systems, RFID application method, comparison with *Global Positioning System (GPS)* in terms of accuracy and its cost, application of RFID system, explanation of the main components of system and finally presentation of a basic solution for actualization of RFID system with the priority of implementation in transportation systems for intelligentization and safety of transportation system.

4. The introduction of RFID technology and its comparison with other technologies

RFID is a set of technologies in which Radio frequencies are used to identify people and objects and this is performed via storing the serial number of a person or an object in a microchip connected to an antenna. RFID is one of the most common automatic identification methods using Radio frequency and can exchange data between the tag and reader. Normally, RFID systems use electronic and electromagnetic signals for contactless data reading and writing. By Radio frequency, RFID is used for identification, tracking and management of objects, human and animals. RFID performance depends upon tag and readers using Radio frequency. RFID is a set of technologies for automatic identification of people and objects using Radio frequency [5].

RFID system is used in roads to support the vehicle-based intelligent plans. This system is composed of RFID tags, RFID readers, Image Processing Unit (IPU) and Image Sharing Unit (ISU). RFID tags are implemented in roads and registration devices are installed in vehicles. Vehicles transfer data from sensors and RFID tags processed using IPU and with short range from a car to car and from a car to other vehicles. Figure 1 shows RFID System on Road (RSR) in which RFID tags are considered with triangular areas with center position of each narrow path and RFID readers are placed in front or back of vehicles and are used to establish vehicles with each other and central stations beside road. Figure 1 presents green starts indicating RFID tags with regular road data including position but red stars show RFID tags including exceptional data as the distance to the hole being shared with the other vehicle. For example, vehicle a receives red tag and sends the data received to vehicle b. Vehicle b shares the data with vehicle d and reports to the central station. Then, central station informs the data to two vehicles (vehicle c) approaching this region [1].

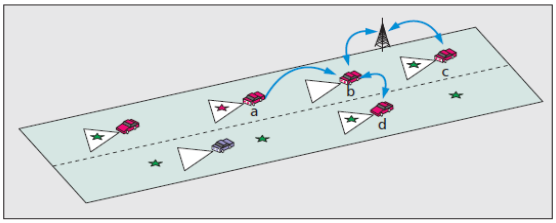

Figure 1 : Schematic view of RSR [1]

GPS systems don’t act well in cities with tall buildings including Chicago and they show false directions as when signals are disconnected. As RSR performance is not affected by surrounding environment, RSR is a good choice for urban system. In addition, this system is good in tunnels

or intersections in which GPS is not working well. By getting information of path, the drivers can perform preventive measurements and increase safety [2].

4.1. Tag

RFID Tag or transponder is the combination of chip and antenna. By an antenna, chip sends required data to identify the items for a reader. The reader converts Radio frequency from RFID tag to digital data to send data to computer and process it. RFID tags are implemented based on a frequency and the requirements of system. The tags are implemented as active (with a battery) or passive (without battery). Passive tags receive the capability to perform operation from the field produced by the reader [4].

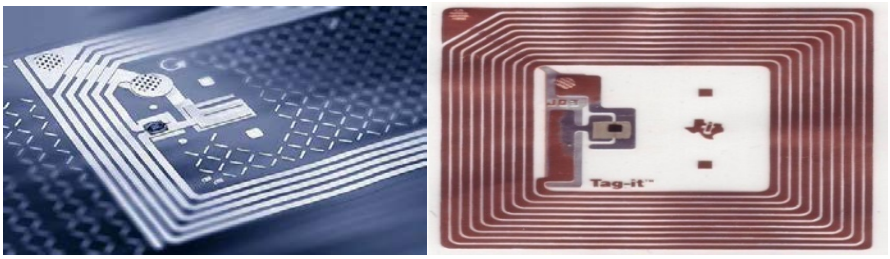

Figure 2 : Tag [4]

4.2. Reader

They are the devices in which Radio frequencies convert RFID tags to digital data to send data to computer and process it [4].

Figure 3 : Reader [4]

4.3. Antenna

Antenna is attached to reader and is designed in different sizes and structures based on the distance between communication and use. The antenna makes tag active and transfers its data by radio pulses [4].

Figure 4 : Antenna [4]

5. Development of RFID radar systems in transportation infrastructures

This section deals with some special efficiencies of RSR transportation systems. These systems are used in road transportation system all around the world and cover the relevant problems.

5.1. RSR intelligent systems

In RSR systems, RFID tags are informed of their position and the vehicle estimates its situation by achieving the situation of approaching vehicle. RSR system is a land system and signals should prepare much information. Normally, the information important for drivers is traffic direction, speed, path regulations, path condition, path statistics and accidents information.

By this information, RSR users can enjoy real time and services of path system while by GPS system with low positioning accuracy; this is not possible [1].

5.2. Intelligent traffic control RSR

According to the report of US traffic organization, the main cause of fatal accidents is bad performance of traffic control. There are many negative factors on traffic control including broken traffic light, unsuitable signs and similar traffic signs. To overcome problems of bad performance of traffic control, RSR can be implemented and exact traffic information can be provided for drivers. By reading traffic data from RFID tag, the vehicle can not suffer from unsuitable signs. To present information in RSR, RFID tags need planning as vehicles or people can update the information of markers. Thus, when traffic light problem is detected, RFID markers can inform the approaching drivers as they can drive carefully. If the entire vehicle is managed by the drivers respecting traffic rules, accidents rate is reduced naturally. Even these drivers experience the stopping by road authorities for some offences and this is due to unexpected reasons as driving in an unfamiliar environment or temporary regulations violation. Thus, there are drivers who had offences frequently but they are not reported. For the first case, RSR can increase the drivers information about the road and remind the traffic rules to them. To reduce second type of offences, police should be present in all regions in which offences are registered. Indeed, traffic control devices can not apply the entire supervising regulations. Thus, a RSR system is implemented based on unmanned patrol to improve traffic rules. In unmanned

patrol systems, a RFID reader is installed on vehicle and sends the collected data to a device, this device is controlled only by police officers. This device defines whether the driver has violated based on the received data or not. Some offences as speed, highest offences, lack of stopping, previous offences are found by this system. If inspection station detects these offences, the data should be reported to the police station or upload it to special places as inspection station [1].

5.3. Estimation of vehicle distance in RSR

The distance between two vehicles is one of the important parameters in a safe driving. By being informed of exact distance of the frontal vehicle, the driver can keep the distance. Normally, people estimate the distance by their eyes. Thus, calculation accuracy is affected considerably by vision focus. To measure the distance at an undetermined environment as slopes or under bad weather condition: storm or fog, the radars can use the distance reported in the system. Radars measure linear distance not the road distance as the vehicle doesn't move in a direct line and RSR system is suitable. For example, in Z/U roads or the roads with road distance, the distance in the road of two vehicles is reported. As it was said, RSR system is designed based on estimation of distance of vehicle to improve the data of the distance. In RSR, a vehicle can receive different times passing a marker between the frontal vehicle by reading similar markers. After receiving data from different markers, the vehicle can estimate the distance and speed of frontal vehicle and it is good information for a safe driving [6].

5.4. Intelligent park systems in RSR

Normally, finding parking in big cities is difficult. There is no available open space. To remove this problem, intelligent park system is designed in RSR. In RSI, a vehicle acts based on the rules read by RFID markers in parking. By combing local time, the drivers have information about the duration of parking or the relevant costs. By RFID system, the drivers can pay the parking cost automatically. If parking time is increased, RSR informs the control center [2].

5.5. Tracking path and access control in RSR

Tracking path and access control systems are designed based on RSR to track the path of a vehicle and to help the authorities for car access control in a region. In RSR, the markers store access regulations to road (priority and codes) and the position of vehicles. By such system, the driver can find about his movement by evaluation of requirements of road access. If a vehicle is in a wrong path, RSR should inform the information via network [1].

In RSR, vehicles can achieve hidden codes by reading the markers. A hidden code is a password as it can be changed as periodical. By such control policy, RSR ensures that:

- The vehicle passes all security gates.
- The car passes all gates without any danger (via checking the time of passing from the first gate and timely code change)

- The car has no access to any insecure region (via checking the path)
- The car has access only to allowed regions (via checking the path)

In addition, by path analysis of a vehicle, the security system integration is improved. For example, if two consecutive reading of two markers are available, the broken paths as not available or indefinite can be available [4].

5.6. Welfare applications for pedestrians

It is worth to mention that by developing RSR idea to internal environment and private driving paths, new plans can be considered for emerging needs. For example, public transportation in which RFID tags is established in indoor or outdoor of areas. In these applications, RFIDs are used as a special store in a shopping center for internal transportation system. Another example is administrative access control. By having series codes of a user, security of an office in a big building with some access ways is improved considerably [7].

5.7. RSR system for unmanned vehicles

An unmanned vehicle is a dream for most people in recent decades. The governments, universities and private companies attempt to perform research in this regard. For reliability and costs, unmanned vehicles are no available in roads. Are we comfortable with these types of vehicles? Our answer is mostly conservative. Thus, these vehicles can be used in special paths. The physical structures for unmanned vehicle are not wise. One of the reasons is high cost and another factor is low scale and consistency. Also, by dividing current roads to separate lines, efficiency of roads is reduced. Thus, a flexible system providing exact information (both in time and place) can be of necessary infrastructures for independent vehicle. RSR system is useful in this type of technology [2].

6. Data analysis

There are various applications in private and state sectors (even small economic units) for RFID and it can inspire the researchers. The tags detected from close distance to the reader gate are provided for exact applications. But there are other cards and tags being detected from far distance. Thus, different applications can be defined.

6.1. Feasibility and prioritization of using RFID systems in Iran

One of the remote applications of RFID is road control by which the cars by attaching tags can pass the toll gate of highways without any stopping. There are some challenges of using RFID technology in Iran as: The lack of infrastructures (antennas) in required places, the lack of software system for analysis and control of transportation and the lack of coordination between users of collected data by these technologies. To use RFID technology in future, we should perform the mentioned items. This section weights and prioritizes the implementation of RFID systems in Iran to have a good prioritization in terms of the effect of these systems. AHP analysis method is used for weighting in this study.

AHP is a quantitative method and a value is given to all decision making criteria using pairwise comparison and AHP method is based on three principles of analysis, comparative judgement and c combination of priorities. One of the applications of fuzzy theory is decision making and multi-criteria decision making by hierarchy analytic method is one of the most important issues. In this method, different alternatives should be compared to each other. Thus, we have pairwise comparison matrix. In this process, different alternatives are involved in decision making. To form comparison matrix, expert opinion is used and preference of alternatives is determined based on the experts' opinion and in Table 2, the opinion of experts is replaced with numerical scale. With seven main criteria, a 7*7 matrix is formed (Table 3) and the main diameter is one due to the similar preference of each criterion to itself.

Table 2 : Relative importance scale of criteria

Numerical value	Importance of a criterion to antoher one
9	Strongly important or strongly better
7	Very strong importance
5	Strong importance
3	Slightly important
1	Simial importance
2,4,6,8	Importance beteen the distances

In this process, differnet alternatives are invovled in decsion making. Four axioms as AHP process principles include:

a. Reciprocal axiom: if preference of element A to B is n, preference of element B to A is 1/n.
b. Homogeneity axiom: Element A should be homogenous with element B. In other words, the effect of element A on element B cannot be infinite or zero.
c. Synthesis: Any hierarchy element is dependent upon its top element and this can be linear to the highest level.
d. Expectations: If there is any change in hierarchy, evaluation process is replicated [8].

The stages of structural model of this method are shown in Figure 5:

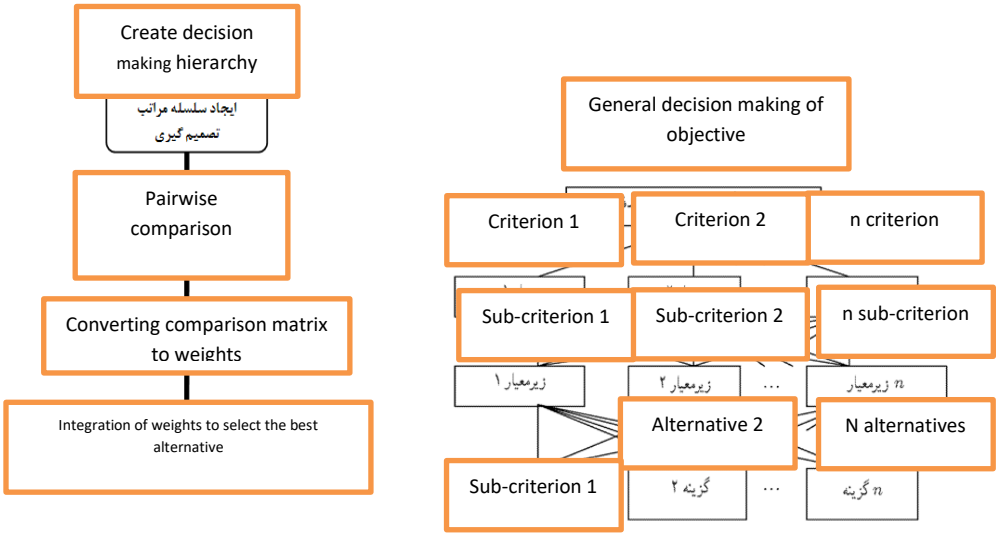

Figure 5 : The stges of structural model of AHP method [8]

The comparison matrix of criteria in AHP method to prioritze RFID tehnology application in common transportation systems in terms of vehicle type is as follows:

Table 3 : The comparison matrix of criteria in AHP method for priotization of RFID systems

Application priority in motorcycles G	Application priority in personal cars F	Application priority in intracity system E	Application priority in intercity system D	Application priority in international passenger system C	Application priority in public local transit system B	Application priority in international load transit system A	
0.25	**0.12**	**0.11**	**0.5**	**0.67**	**0.41**	**1**	**Application priority in international load transit system A**
0.41	**0.14**	**0.16**	**0.24**	**0.29**	**1**	**2.4**	**Application priority in public local transit system B**
0.5	**0.13**	**0.11**	**0.21**	**1**	**3.4**	**1.48**	**Application priority in international passenger system C**
0.6	**0.2**	**0.14**	**1**	**4.6**	**4.05**	**2**	**Application priority in intercity system D**
0.25	**0.27**	**1**	**7**	**9**	**6**	**8.6**	**Application priority in intracity system E**

2.77	**1**	**3.6**	**5**	**7.5**	**7**	**8**	**Application priority in personal cars F**
1	**0.36**	**4**	**1.5**	**2**	**2.4**	**4**	**Application priority in motorcycles G**

After the analysis of data by weighting software, criteria are as follows:

Table 4 : Data analysis results

Application priority in motorcycles G	Application priority in personal cars F	Application priority in intracity system E	Application priority in intercity system D	Application priority in international passenger system C	Application priority in public local transit system B	Application priority in international load transit system A	Criterion
0.04	**0.20**	**0.23**	**0.08**	**0.05**	**0.33**	**0.07**	**Weight**

Figure 6 show a chart of data analyshis by AHp software to have a good understanding of results.

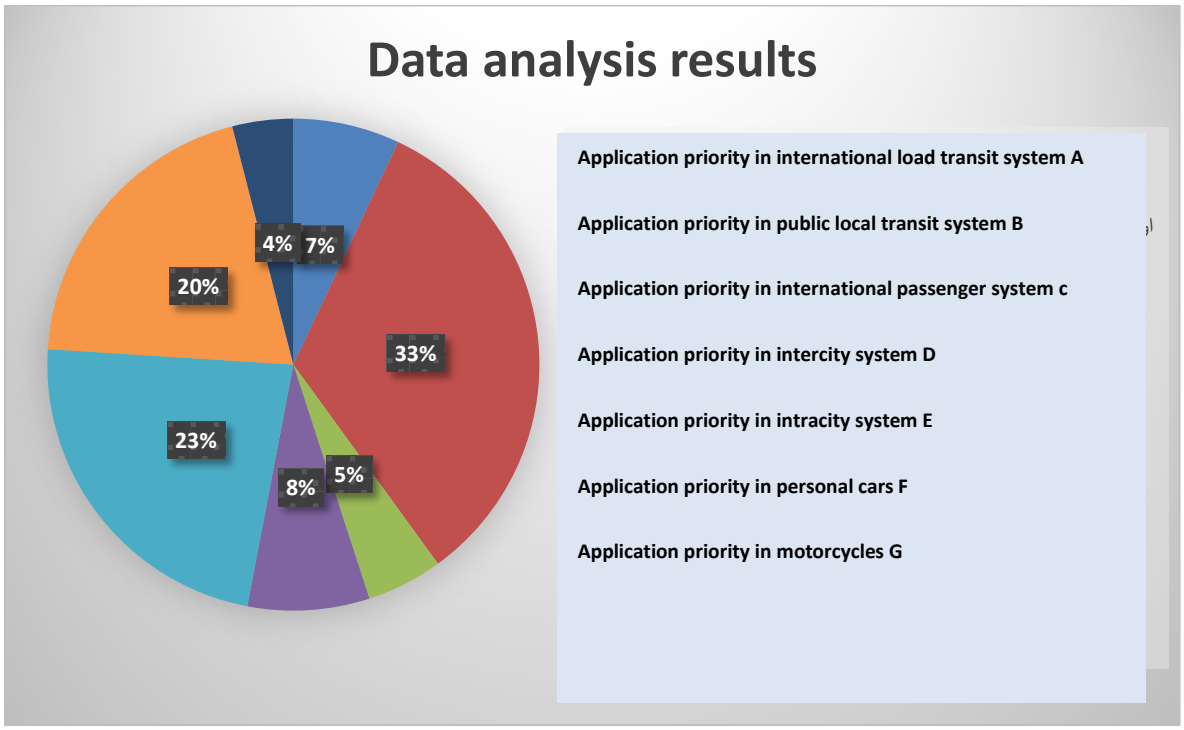

Figure 6 : The chart of data analysis resutls by AHP method

The results of analyses in this paper show that prioritization of using RFID technology in intercity transportation in public transit system with coefficient 0.33 has the highest weight and it is proposed to use the initial investment of development of this technology in this transportation field. This is performed with transportation terms in Iran. Also, it can be used in customs office

and road control centers. The results show that investment in urban transportation can be performed in two priorities of intracity system and personal cars. This is useful based on organizing in intracity bus system network and technical inspection control centers.
Finally, today in all advanced countries around the world, reduction of costs and new technologies are considered. RFID system costs about 5000 Rls for each car and it is the cost of chip and tag and it is low compared to other similar systems costs. By installing the tags on each vehicle, we can monitor their behavior easily. As the tags are inimitable, the have high safety. In case of the approval of organizations, all the components of this system can be produced in Iran to increase various jobs.

7. Conclusion

Based on the studies in this paper, to actualize RFID for an intelligent transportation system and safety of roads, we can use the prioritization of public transportation, intracity and personal cars with the highest coefficients. As the data of path and car are stored in RFID tags, RFID system is a good choice to support the vehicles for the following reasons:

- RFID is cheaper than other systems with similar physical structure.
- RFID is measurable and transportation is very easy in this system.
- RFID is flexible and tags are controlled. Thus, unmanned line information is updated.
- The drivers can use an unmanned line for safety.
- RFID helps a set of manned and unmanned driving systems in including navigation, traffic sign, parking, access control and distance estimation.
- RFID provides information to patrol. For example, tracking of a car with time tag is useful in detection of accidents of unmanned vehicle and other vehicles with driver.
- RFID is a strong system with cheap markers. Thus, the problem in marker has no effect on the system and such problems can be detected easily.
- Although RFID technology is not prepared well, its success trend is clear. Using new technologies in industrial and economic fields increases productivity. Thus, updating new technologies in industry sector and evaluation of new economic strategies require an exact review to achieve sustainable profit with the lowest cost and highest productivity. By using modern science, successful managers recommend using the results of studies. RFID system in transportation leads to better supervision, control and planning. Using such technology based on its simplicity can have progress. Briefly, the benefits of RFID system application in scientific and social community are as follows:

✓ Urban traffic management and collection of exact data regarding transportation behavior.
✓ Tracking public transportation to present transportation services.
✓ Control of vehicles speed
✓ Control of traffic areas
✓ Removal of toll stations

- ✓ Observing justice regarding drivers' offences.
- ✓ Identification of personal vehicles
- ✓ Identification of traffic accidents area
- ✓ Present tax based on the trip
- ✓ Using some strategies regarding the vehicles without identification tag and other vehicles not paying fine or annual tax.

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