*International Journal of Engineering Applied Sciences and Technology, 2017*
**Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 1-7**
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

# AUTOMATED MANAGEMENT SYSTEM FOR LARGE VEHICLE JUNCTIONS

M. Papoutsidakis
Dept. of Automation Engineering, Piraeus University A.S., Athens, Greece

G.P. Smyrnaiou
Dept. of Automation Engineering, Piraeus University A.S., Athens, Greece

E. Symeonaki
Dept. of Automation Engineering, Piraeus University A.S., Athens, Greece

D. Tseles
Dept. of Automation Engineering, Piraeus University A.S., Athens, Greece

*Abstract*— **The increasing population leads to a growth of the number of cars and commuters using the local, regional and national road network and therefore increased traffic congestion and decreased safety margins, especially in metropolitan areas. Road networks are an integral part of transportation systems that service the demands and needs of passenger and cargo transport. The undoubtedly critical points of these road networks are junctions and interchanges. The primary design criterion of these traffic nodes is the safe, rapid and even throughput of the various traffic flows that pretend priority. Furthermore, it is not desirable to limit transportation and cargo flows by redirecting vehicles in one single path or by limiting access of specific vehicle types in discrete roads or lanes. In industrial facilities and construction site the use of traffic signs, traffic lights, junctions and interchanges in intersections and rail crossings, is very common and portrays an important role in the safety of road transportation, particularly in accident prevention, as well as providing accurate information to the vehicle drivers, concerning their route and destination. In this dissertation we will analyze and present an automated process in road intersections of industrial zones, with traffic interruptions of the main road with the purpose of the safe passage of heavy vehicles and personnel, in order to improve working conditions. The purpose of this dissertation is to signify the importance of automated signaling, as well as make it comprehensible and accessible to the public. Additionally, there are suggestions for improvements to further scale the benefits from the operation of this system.**

*Keywords*— **Traffic Management, Traffic Lights, Intelligent Traffic System, Radio Frequency Identification**

## I. INTRODUCTION

The history of traffic lights begins before the creation of the first automobile, when the only users of roads were horse-powered carts and carriages, pedestrians and bicycles. From the first traffic light, created by J.P. Knight in 1868 – a reconstruction of a railroad crossing light using semaphore arms and lamps, to the present automated traffic management systems, traffic lights are an indispensable part of traffic flow control in road and railroad networks.

A traffic light is the traffic flow control system which is responsible for the even flow of vehicles and pedestrians, with the purpose to secure the balanced service of all directions, the increase of traffic flow, as well as the marking of various points in public or private areas, that require attention from the driver's part. The achievement of these objectives comes with the aid of special apparatuses that commonly operate with electrical power. The fundamental characteristic of traffic lights is the use of simple color indicators or simple codified symbols, with the purpose of controlling traffic by either halting or allowing the passage of vehicles or pedestrians.

Traffic light's applications are in:

- Road junctions where there is increased traffic load or the landscape formation is not deemed safe or in junctions where actuated signaling is needed to accommodate increased traffic flow in one direction and decreased in the other.
- Railroad crossings.
- Toll posts.
- Motorway entrances.
- Narrow accesses where a single lane is used, such as in narrow bridges, tunnels or construction areas, with the interchange of flow between the two directions.
- Movable bridges.
- Display the allowed lanes, in cases where lane direction is reversed.
- Automated boom barriers and gates.
- Cargo loading and unloading areas.
- Emergency service vehicle stations (e.g. fire service), to provide priority to those vehicles.
- In junctions with increased pedestrian traffic load.

The most common application of traffic lights is in urban areas' junctions. In those cases, special transport studies are needed, which include vehicle and pedestrian flow

*International Journal of Engineering Applied Sciences and Technology, 2017*
**Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 1-7**
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

measurements, previous accident analysis, landscape analysis and analysis of the wider transport network.
Traffic lights systems can be separated per actuation type and synchronization between multiple junctions:

- Fixed time or pre-timed signaling.
- Semi-actuated signaling depending on traffic flow.
- Fully actuated signaling.

In respect to synchronization the following types can be discerned:

- Non-synchronized signaling.
- Synchronized signaling along a route.
- Fully synchronized traffic control systems.

Colored indicators in traffic lights are globally designated using three distinct colors (green, yellow and red), with either constant or flashing light.
Traffic signs perform an important role in terms of safety in road networks, particularly in accident prevention, as well as providing key information to the driver regarding his destination. Traffic signs also perform a role in traffic management, as well as assisting drivers in adhering to the Highway Code.
Traffic signs consist of symbols, drawings and text and are also standardized, simple and recognizable. Traffic signs are placed according to their size and function, in specific positions along roads.
One of the most important issues concerning traffic signs is their nighttime visibility. As a rule, traffic signs are within the headlight's beam range, however their visibility may be limited. In order to address this issue the following types of traffic signs are used:

- Light emitting signs
- Externally lighted signs
- Signs with reflective material

Depending on the materials used to manufacture them (reflective or not membrane), traffic signs can be categorized to:

- Non-reflective signs
- Semi-reflective signs
- Reflective signs

## II. SYSTEM DESCRIPTION

In terms of Railroad traffic management all specific signs provide the main source of information for train drivers and are designed to notify for the approaching rail track conditions, giving appropriate instructions for safe and proper passage. Railroad traffic management is the result of a lengthy trial-and-error process.

In the early years of railroad transportation, the most common method of traffic management were constant time intervals. This method required trains to depart from a station at a pre-specified time interval from the previous train traversing in the same direction.

One important safety improvement in railroad traffic management, was the application of the block system. Block systems consist of sections of tracks (blocks) that trains were forbidden to pass through until the previous train that traverses them, exits.

This system was further evolved in modern railroad traffic management with the application of the automated block signals. This system uses electrical track circuits, were a locomotive's wheels and axes short circuit the system and activate the red beacon, indicating danger, afore of the train or, in the case of a single-track railroad, the beacon ahead of the train.

In the event of a failure of acknowledging a warning signal, several fail-safe systems have been implemented, either warning a train driver of an imminent immobilization or by enforcing the train to immobilize.

In modern warning systems used in locomotives, a green light signal activates a bell chime in the control stand. Any other indication in a signal, activates an alarm. In this event, the train driver must acknowledge the alarm, within a time frame of seconds, otherwise the emergency brake system of the train is applied automatically. After the train driver has disengaged the alarm, a visual indicator, known as Automated Warning System (AWS), remains in operation as a reminder.

The evolution of this system is known as Automatic Train Protection (ATP). A typical version of it can be founf in Figure 1. With this system, visual indicators on the control stand duplicate the indications of the railroad traffic lights along the course of the train, as well as displaying other information regarding the train's velocity and the need to accelerate or decelerate, depending on the traffic flow ahead of it, like [1].

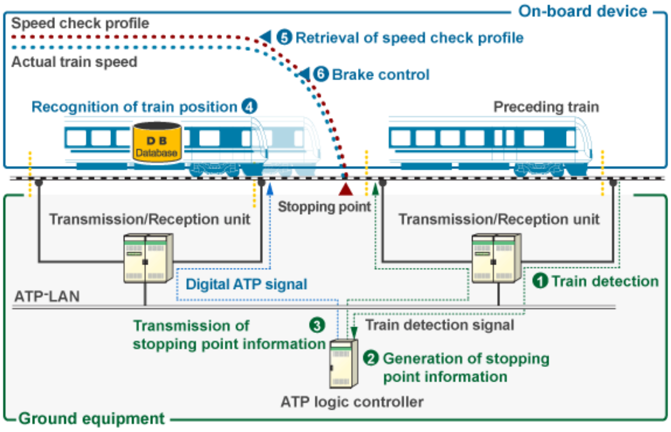


Figure 1. Configuration of digital ATP

The terms and definitions of Automation Control Systems vary depending on literature and industry:

- Automatic Train Protection (ATP) is a system where the train is operated manually by the driver but the system intervenes in the breaking. Although the control of the train is mostly performed locally by the driver, there is the ability of remote control.
- Automatic Train Operation (ATO), in contrast with ATP, the system has the ability to intervene in all the aspects of the train's operation, from acceleration to complete immobilization. Presently, ATO's are only installed in monorails and subways.
- The Automatic Train Control (ATC) system, is a combination of ATP and ATO systems.
- The Automatic Train Supervision (ATS) system, is a centralized control system, that oversees and manages a train, based on ATP and ATO subsystems. At the present time, control is performed automatically by computer systems, but with a manually override ability by the control center operator, in order to modify the itinerary matrix.

### *A.* Interlocking and Solid State Interlocking

Interlocking is the prevalent traffic management and facility control system with the use of telecommunications [3]. In railroad networks, interlocking is the aggregate of signalling devices that avert conflicting and competitive passages within the rail network's layouts, such as intersections, crossings and junctions. An interlocking system is design to prevent a free passage signal if the route to be used is occupied by another train and therefore is not deemed safe. A typical interlocking system consists of signals, as well as other devices such as railroad turnouts, crossings, junctions and even movable bridges.

Solid State Interlocking (SSI) is a contemporary version of interlocking and is considered to be the most advanced system of railroad traffic management [4], consisting of electronic circuits in lieu of relays. This system has been successfully implemented in a significant number of railroad networks globally, with a very high reliability and safety record [5].

Technology has augmented the railroad network control capabilities, by overseeing and adjusting signals. This implementation is termed Centralized Traffic Control (CTC).

The personnel has at its disposal:

- Display monitors comparing the theoretical with the actual itinerary of the train.
- Projections on possible delays, to avoid problems in the various nodes of the network and to continuously reassess priorities in order to maintain the itinerary matrix.

In a CTC the discrete number of the itinerary or the alphanumeric code of a train is imported in the signaling system, in the specific block, controlled by a track circuit, the train commences its itinerary. When the train is moving to the subsequent block, it utilizes successive track circuits, altering the position of the number/code on the display monitor at the control center. When a train passes from the oversight of one control center to the other, its code/number is transferred automatically to the display of the new control center. The LANs (Local area Networks-LAN) are private networks used in homes or offices and generally on land of a few kilometers to link computers or workstations to factories and offices so to be able to share common resources, such as an Internet connection, the hard drive, the files, the folder of access and exchange information. [10]

In instances where control of the smart home relies on a network of computers, a wireless modem and an antenna are available so that the computer can communicate with other systems within walking distance.

### *B.* Intelligent Traffic Control

The continuous increase of passenger and cargo transportation, and as a consequence the increase in vehicle movements, as well as the inability to meet this increase in demand by increasing supply, lead to traffic congestions, especially in urban areas. Delays, increase of fuel consumption and pollution make traffic congestions one of the most severe problems of modern cities. Their main function is to monitor traffic on highways and their entry ramps, lane control either in normal traffic conditions or during emergencies, to inform commuters and policing. The road networks that followed the automobile boom have begun to adversely affect and in an intensive way, the character of urban areas in the following three ways. Traffic congestions, especially in the main routes, accident risks and air and noise pollution.

In order to tackle this problem of traffic congestion by further expanding road infrastructure, extensive funding, that is seldom available, is required. Furthermore, there are other limitations that hinder the implementation of expansion plans, such as limited availability of free space, environmental concerns and objections by residents. Also, the increase in the supply of road networks contributes to traffic increase and averse environmental effects, so in turn new infrastructure is needed, leading to a vicious cycle.

Traffic Control is a method to reduce the need for further infrastructure development, by:

- the efficient use of existing infrastructure in the short-term, as well as limited investment in new ones (Transportation System Management – TSM).
- limiting demand for transportation and preventing the use of automobiles in congested areas, especially during peak periods (Transportation Demand Management – TDM).

Traffic Control is currently a topic of increased importance both internationally and in Greece. Especially in Athens, where traffic congestion is the main source of atmospheric

**_International Journal of Engineering Applied Sciences and Technology, 2017_**
**Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 1-7**
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

pollution, several initiatives, that mainly consist of Traffic Control measures (TSM and TDM) have been announced to combat smog, as in [6] [7] [8].

A typical Traffic Control system consists of the following subsystems:

- Traffic Control center.
- Central computer system.
- CCTV.
- Vehicle detection stations.
- Variable message signs.
- Vehicle counting sensors.
- Service stations.
- Duct telecommunications subsystems (optical fiber cables, coaxial cables).

Intelligent transportation systems are the combination of information technology systems and telecommunications, applied in the transportation sector to achieve efficient, safer and cost-effective transportation of passengers or cargo. They are applied and used in vehicles, infrastructure or joint systems on road networks, railroads, air transport and sea transport or in combined transport means.

ITS applications are divided in six technological categories, as found in [9] [10]:

- Advanced Traveler Management Systems (ATMS).
- Advanced Traveler Information Systems (ATIS).
- Advanced Vehicle Control Systems (AVCS).
- Commercial Vehicle Operations (CVO).
- Advanced Rural Transportation Systems (ARTS).
- Advanced Public Transport Systems (APTS).

Figure 2. The Intelligent Transportation System

The foundation of an ITS system is its input data, that is the data from the sensors. Generally sensors are discerned in mobile and static ones. For example:

- Inductive loops.
- Cameras.
- Infrared detectors.
- Floating Car Data/Floating Cellular Data (FCD).

A Programmable Logic Controller (PLC), which was used for this project, is an automation system that is capable of:

- Receive electrical signals in the form of current or voltage (input)
- Process them
- Produce appropriate signals (output) that will activate the controlled arrays.

PLC's use a programmable memory to store specific functions such as logic, sequence, enumeration, time, mainly to control machines and the operating procedure. They were built with the purpose to replace classic automation. To program a PLC, a series of instructions is created through specialized software and programming language, so as to solve an algorithm that corresponds to the operation of an automation system. PLC's are versatile devices utilized in numerous and diverse applications, like [11] [12].

### *C.* Implementation of Automation Management System

The automation of this research concerns a junction in an industrial area, where the main road has a North-to-South orientation and the road the heavy vehicle traverses has an East-to-West orientation. On the main road are installed boom barriers and three-color traffic lights in each direction, so as to interrupt traffic when a heavy vehicle approaches loops No. 1 and No. 3. On the heavy vehicle road are installed boom barriers and two-color traffic lights in each direction, so as to interrupt traffic when a heavy vehicle departs from loops No. 2 and No. 4. The distance between the inductive loops No. 1 and No. 2, as well as No. 2 and No. 3, is greater than the total length of the heavy vehicle, in order to avoid simultaneous activation of the first and second stage.

The heavy vehicle has exclusive right of passage on the East-to-West road, while all the other vehicles has exclusive right of passage on the main road and only on that. The purpose of this automation is the safe interruption of traffic on the main road while a heavy vehicle approaches the corresponding loops, as well as to timely warn drivers and personnel in the case of malfunction.

*International Journal of Engineering Applied Sciences and Technology, 2017*
**Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 1-7**
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

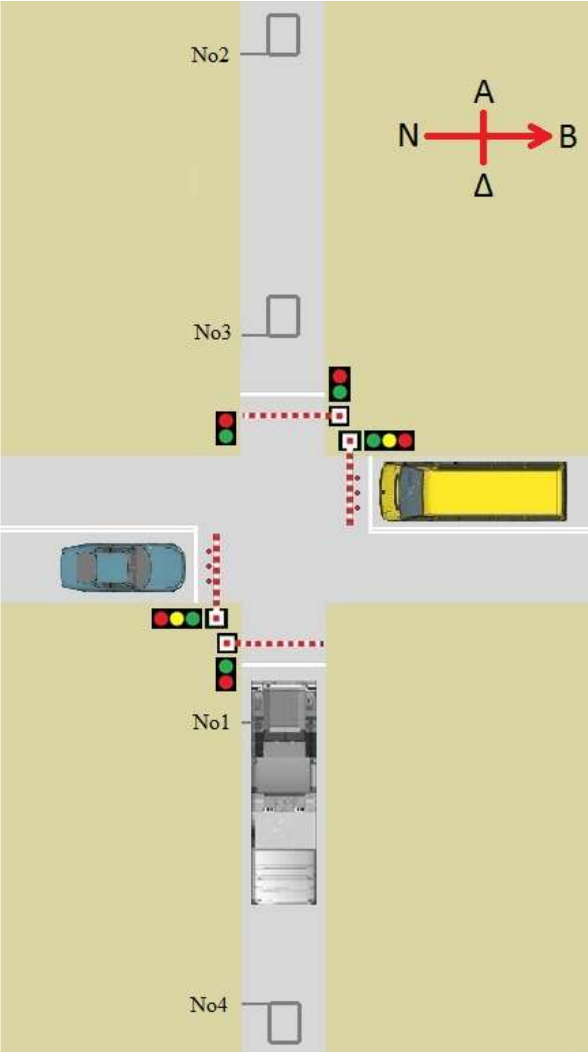


Figure 3. Design of the crossing roads

There are two different modes of operation the manual and the automated one. In the manual operation mode, the operation is performed by specialized technical personnel or by authorized personnel.

The automatic operation is performed in two stages:

- 1st Stage: Boom barriers on the main road are on the upper position and traffic lights have a green indication to allow free passage of vehicles. At the same time on the heavy vehicle road, boom barriers are on the lower position and traffic lights have a red indication. When the heavy vehicle approaches inductive loops No. 1 or No. 3, the traffic lights at the main road display a yellow indication for five seconds and an alarm sounds. After this time passes, on the main road the traffic lights will display a red indication and the boom barriers will start to descend and simultaneously the boom barriers on the heavy vehicle road will start to ascend. When this sequence is completed, the traffic lights at the heavy vehicle road will display a green indication and the sound alarm will stop.
- 2nd Stage: When the heavy vehicle crosses inductive loops No. 2 or No. 4 and departs, the boom barriers of the heavy vehicle road will start to descend and respectively the boom barriers of the main road will ascend. At the same time the traffic lights of the heavy vehicle road will display a red indication. When this sequence is completed, the traffic lights at the main road will display a green indication and normal traffic will resume.

## III. FURTHER RESEARCH

Traffic control and information systems must rely on a system of sensors in order to evaluate traffic parameters in real-time. Camera-based systems ensure several advantages, such as an extra set of traffic parameters beyond vehicle count and speed. These include vehicle categorization, commute times, lane changes, rapid accelerations or decelerations, traffic congestion lengths in urban junctions etc. Machine vision systems have the ability to recognize and record vehicles in real-time from video sequences captured from motorways and rural roads. Object identification and monitoring in images that are captured in real time from an array of static cameras. The method used is to identify specific characteristics typical for all vehicles. A vehicle identification is confirmed when an objective function outputs an increased value. This objective function determines, using a set of parameters, the likelihood of an object being a vehicle [13].

Machine vision systems are also capable of monitoring more than one vehicles simultaneously, without the intervention of an operator, by real-time video analysis and without the need of specialized hardware – an ordinary camera and a low-cost computer are sufficient.

Figure 5. Video cameras at signalized intersections

In order to further improve the effectiveness of traffic control and to assure vehicle and passenger safety, adopting an RFID system allows faster identification and ease of use. In recent years RFID technology is frequently applied in industrial automation, in vehicle monitoring systems, supply chains etc. [14]. Intelligent vehicle monitoring and controlling systems, that combine information technology with RFID systems is one of most cost-effective, reliable and straight forward technologies. Their ability to minimize interference, fast identification, minimum human interaction and overall supervision, improve efficiency of labor and safety management [15].

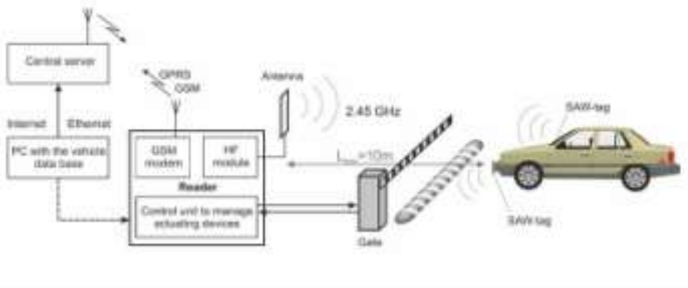


Figure 5. RFID system with passive tags

The main advantages of RFID systems are:

- Identification is performed remotely, due to the existence of RFID labels using a power source, usually from a battery, having the ability to transmit information to the receiver.
- Their ability to store more data, as opposed to Bar Codes.
- Identification does not require an optical means, so they can be concealed.
- Remote programming.
- Extra functions, such as temperature monitoring and logging.
- Durability, reusability, and reprogramming ability.
- Ability to identify objects while in motion. Passive labels do not require maintenance and power source.

## IV. CONCLUSION

This research attempts to highlight the utility and importance of signals, signs and traffic management, not only in urban areas but in industrial areas as well, by analyzing aspects of transportation science and by presenting new methods of transportation simulation. There is high significance in the safe passage of vehicles, due to the immediate adjustment of traffic signals to the traffic conditions.

At the same time, due to the increasing traffic congestions in urban and industrial areas, new approaches to signal management are being developed, beyond standard practice with static traffic lights, leading to the application of integrated “intelligent” management systems. This aim is further augmented by the development of computer systems, telematics, telecommunications and automations. However, some of these elements may have adverse effects to the system (e.g. accidents, junctions, bottlenecks etc.).

This application is an example of traffic management in an intersection and the purpose is to analyze the adjustment of traffic lights to react to the traffic conditions in an industrial junction. Adhering to the Highway Code and internal safety procedures are paramount factors in minimizing the likelihood of an accident.

The research of this system aroused questions concerning hypothetical scenarios of an accident, or critical electrical or mechanical equipment failure, events that could radically alter traffic flow at the junction. Therefore, by implementing appropriate signaling and driver information systems, the original design of the automation was scientifically altered by implementing new parameters and safety measures.

However, the limits of this research can extend even farther. Rapid advances in technology and mechanical research, lead to safer systems, by optimizing the various subsystems that constitute them, as well as through analysis of dynamic simulation models, macroscopic or microscopic, of traffic conditions resulting from network interventions.

## V. ACKNOWLEDGEMENTS

All authors would like to express their gratitude to the Piraeus University of Applied Sciences for providing the required data and funding in order to undertake and complete this research project as part of “Automation of Production and Services” Postgraduate Program of Studies.

## VI. REFERENCE

[1] Dong, H., Ning, B., Cai, B., Hou, Zh., "Automatic Train Control System Development and Simulation For High-Speed Railways", IEEE circuits and systems magazine, second quarter, Vol. 10, No. 2, pp. 6-18, 2010.

[2] Leach M., et.al., "Railway Controls Systems", the Institution of Railway Signal Engineers, A&CBlack, 1991.

[3] Michopoulos Michail, "The French Railway Network and Transport Systems in the EU", University of Piraeus.

[4] Cribbens, A.H., "Solid State Interlocking (SSI): an integrated electronic signaling system for mainline railways", Proc. IEE, Vol. 134, No. 3, pg. 148-158, 1987.

[5] Cydney Minkowitz, James Atkiss, "An object-oriented formal specification of a configuration language for railway interlockings", 3rd Northern Formal Methods Workshop, ALSTOM Signaling Ltd, United Kingdom,1998.

[6] Ilias K. Alikidis, "Control traffic using the reinforcement learning algorithms", National Technical University of Athens, 2015.

[7] Dimitris Pappas, "Emissions from Vehicles and Traffic Management", National Technical University of Athens, 2006.

[8] Frantseskakis I. M., Pitsiava A, Latinopoulou M. H., Tsamboulas D. A., "Traffic Management¨", National Technical University of Athens, Papasotiriou Publications.

[9] H. Dia. Towards, "Sustainable transportation - the intelligent transportation systems approach. In: Proc. Shaping the Sustainable Millenniums", Queensland University of Technology (2000).

[10] T. Mast, "Introduction to ITS. In: Human Factors in Intelligent Transportation Systems", Lawrence Erlbaum Associates Inc., Mahwah, New Jersey (1998).

[11] Pantazis Nicolaos A. "PLC Program Logic Controllers", 3rd Public, Ion Publications, 2001.

[12] Roumbis Stavros, "Automation with Siemens programmable controllers", Simeon Publications, 1989.

[13] S. Sivaraman. and M.M. Trivedi. "Looking at vehicles on the road: A survey of vision-based vehicle detection, tracking, and behavior analysis", IEEE Transactions on Intelligent Transportation Systems, vol. 14. no. 4. pp. 1773-1795,2013.

[14] Xuehua Jiang, "Design And Realization Of Vehicle Intelligent Management System", Electric Vehicle & New Energy Technology Research Institute, Linyi University, 2013.

[15] Avgeris Georgios, "Design and implementation of access control system using RFID¨, University of Western Macedonia, Greece.