ISSN No:-2456-2165

IoT and web-oriented Secured Parking Guidance and Information System

Abel M. KONNON, Ouadoud BOURAIMA,
Jonhn-Sun LALY NOUKPE
Department of Electrical Engineering and informatics, INSTI of Lokossa, UNSTIM University, Republic of Benin

Abstract:- **A secured parking guidance and information system (PGIS) is essential, from the management point of view to improve the efficiency of parking guidance process, and from the security point of view to guarantee the safety of vehicles in garages and parking spaces. This paper presents the design concept of a security-oriented PGIS as an application of IoT (Internet of Things) in smart city. The system architecture includes a sensor layer, communication layer, and application layer. In addition to parking slots supervision and information services, the application layer provides two import services to guarantee a high level of security: web-based user enrollment in a database and user authentication at the entrance/exit gates. The control access policy is based on biometrics (fingerprints) and deployed in a password protected wi-fi network with the use of a router's MAC addresses whitelist. The place availability information is accessible online through a web portal for non-registered users. A scale model for tests is created to validate the smart parking guidance and information system with security concept.**

Keywords:- *Parking Guidance And Information System (PGIS); Iot; Smart City; Information System Security.*

I. INTRODUCTION

While in developed countries the parking industry is growing, in developing world much remains to be done. Many reasons justify the need for having a parking management system in developing countries specially in urban areas. The document [1] had listed out some influential and informative resources that highlight the importance of parking management in cities and had shown opportunities.

The innovative solutions of IoT (Internet of Things) enabled the creation of Smart City using intelligent and connected devices to provide even-driven services and to ensure sustainability and efficiency [2, 3, 4]. One of the key issues that smart cities relate to are car parking guidance and street traffic management systems [5, 6]. Many research works are focused on various parking problems like design, planning, geolocations and pricing [1], but the security issue is not really addressed. Opting for a secured parking guidance and information system (PGIS) offers various guarantees to cars owners and garages or parking spaces managers. Security in parking lots begins with the access control management. The Internet of Things gives the opportunity to use intelligent devices and to interconnect them with Internet for remote control and security concerns.

The access control quality, as a security criterion of a system, depends on the level of guarantee provided by the authentication method that is deployed. In [7] authors present an overview of some of the available authentication methods namely biometrics, which make a personal authentication by determining the authenticity of a specific morphological or characteristic possessed by the user. Within biometric methods, fingerprint technology is recommended to provide a good general security level.

An IoT-based PGIS with an access control principle can offer different advantages in parking management and help to enhance the security level of parking lots, preventing abusive use of cars in a parking spaces or garages.

II. SECURED PARKING PROBLEM ANALYSIS IN LOW-INCOME COUNTRIES

In low-income countries, particularly in the West African region, the secured parking problem exists from two different points of view.

Firstly, urbanized areas of low-income countries are characterized by a growing parking demand. Thus, there's a real lack of parking spaces in highly commercialized zones and residences. This situation, most of time, drives users to park their cars on the streets. The practice of car parking on streets is the cause of:
- insecurity of parked cars, which are sometimes damaged in accidents or by ill-intentioned people;
- traffic congestion, because the streets are often narrow and not dimensioned for parking lots;
- street accidents, especially with pedestrians, who are forced to walk in the middle of street traffic.

Secondly, there is an abusive use of administrative vehicles in garages, even in certain cases by simple driving agents. Users take advantage of the lack of an access control policy to drive out administrative vehicles without authorization or for personal needs outside of service hours.

To solve the problem of parking security, some solutions like security barrier or anti-intrusion alarms are still deployed to filter the entrances and exits gates of car parking spaces in resource poor systems. Advances in IoT technologies and the implementation of smart city infrastructure have made it possible for modern car parking information center to be connected to a sensor subsystem for real time secured monitoring. In these conditions, a secure PGIS will be beneficial to all users and may not only limit the problem of on-street parking, but also guarantee a high level of security in administrative car parks.

established for the members of the car parking space management staff.

Use of a secured wireless network. All collected data from proximity sensors and fingerprint readers are sent to the information center through a wi-fi module, that may be connected to the secured wireless network in password protected mode [8].

To enhanced the security level, we propose the use of a router's MAC addresses whitelist.

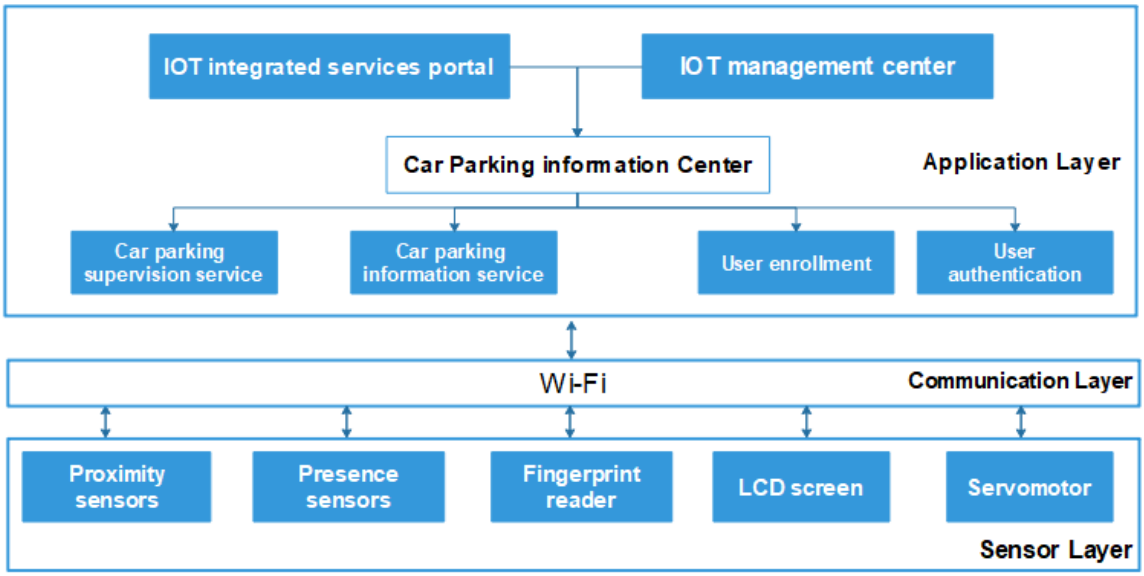

Fig. 1. Architecture of the proposed secured IoT-based parking guidance and information system.

III. PROPOSED SECURED PARKING GUIDANCE AND INFORMATION SYSTEM

In this work, we propose a secured parking guidance and information system (SPGIS), that deals with space and security constraints handling and is optimized to meet the expectations of cars owners and parking managers. Our SPGIS is a layered parking management system, that follows the topdown design pattern (figure 1).

A. The security concept of the SPGIS

User authentication. In this SPGIS, we organized a parking lots access control policy based on fingerprint recognition for efficient parking management. Proximity sensors placed at the parking space entrance and exit gates trigger the access control process whenever a vehicle is detected. At the entrance/exit, the control process is based on the fingerprint verification in the database of previously registered users. A web application is used as a control center for the system and user management. The authentication systems based on fingerprint recognition provides the answers to both questions: (i) who is the user at the entrance/exit? and (ii) is the user really who he/she represents himself/herself to be? [7].

An access control, based on login and password checking, to the web application's back-end is also

Therefore, when a device sends a connection request to the local wi-fi network, the router tries to detect the incoming MAC address in the whitelist. If there is no matching entry, the incoming packets, from the unknown device, are rejected (the access to the network is denied).

Guaranty of non-repudiation. The data base of the web application is used to store all in/out movements of the parking space with details about the vehicles and their drivers to guarantee non-repudiation criteria.

B. Description of the architecture layers

Sensor layer. The electronic part of the system is made up of proximity and obstacles sensors, Arduino boards, a wi-fi module, two servo motors, LCD screen and two fingerprint readers. The management center (web application) retrieves the information sent from the sensors layer about the identity of the user at the entrance/exit gates, the date and time of parking entrance/exit Collected information is then stored in a MySql database.

Communication layer. We used a wi-fi module as a client; this means that our Arduino board needs to be connected to a web server to send collected data. In the case of a car park, all the components can communicate through a local network.

We preferred to configure a network using wi-fi technology to avoid pulling cables. This wireless network is password protected.

Application layer. The application layer of our SPGIS is based on a car parking information center. This center, through the IoT integrated web service portal and the IoT management center, delivers four main services. The IoT management center centralized all collected information from different sensors located in parking slots for supervision and place availability decision. Our web application retrieves and displays the history of entrances and exits movements classified in descending order of time. Some filters are added to allow research by date and period.

b) Connection step: the control device at the entrance/exit gate sends the fingerprint to the web application for the user identification
c) Authentication step: if the identification is successful, then the driver is authorized. In case of failure, after three attempts, the control system triggers an alarm.

3) Car parking supervision service

The space availability checking is ensured by a function using the proximity sensors located in each parking slot.

4) Car parking information service

The car parking information service is responsible for disseminating information about the availability of slots in the parking space, the authorized or denied access to a driver at

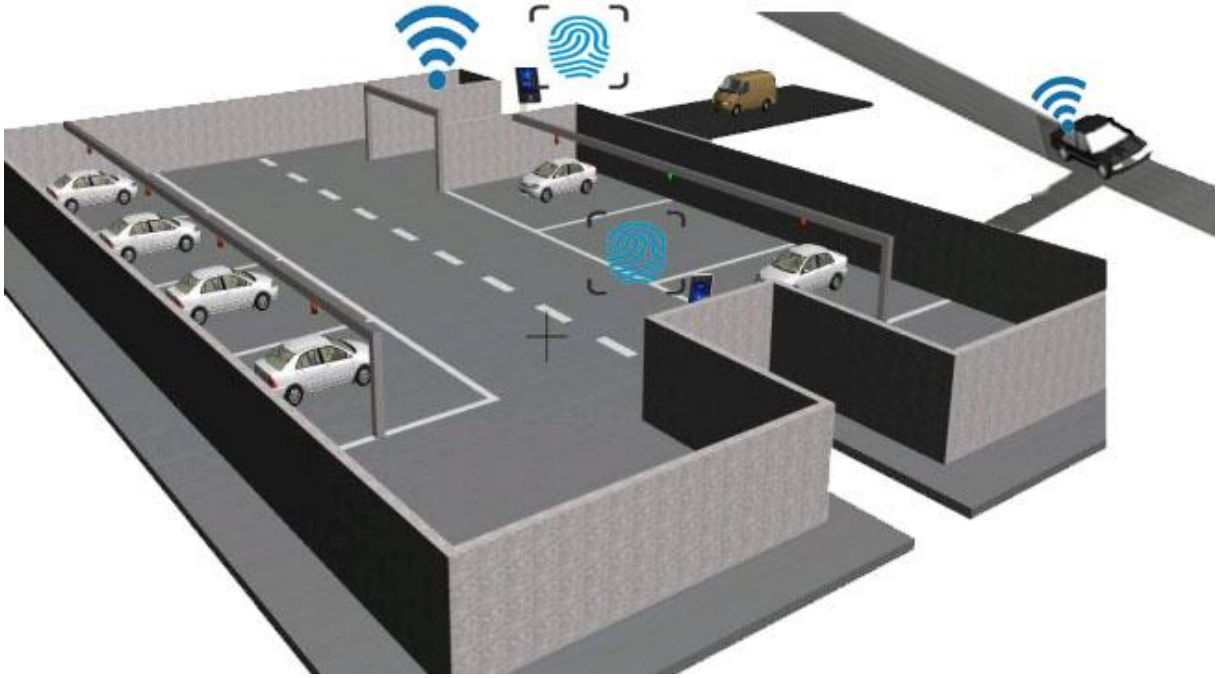

Fig. 2. Demonstration of a parking space

C. Services of the application layer

1) User enrollment service

The enrollment of a user is done by a manager (security agent) in several steps, which are:
- registration of user information on the web portal;
- allocation of a unique user identification number (user ID) after registration;
- registration of the user fingerprint in the database taking into account the assigned user ID ;
- configuration of the user device (s) MAC address(es) in the router's MAC whitelist.

2) User authentication service

Once enrolled, the user no longer needs assistance to park in the parking lot for the following days. He can come in or out of the cars parking space going through the fingerprint authentication process.

a) Initial step: the driver puts his hand on the fingerprint reader.

the entrance/exit gates. Parking information can be browsed in three different ways:
- the parking information is displayed on an LCD screen at the entrance/exit of the parking lots;
- a registered SPGIS user, with a validated MAC address (registered on the router's MAC whitelist), can connect to the web portal to browse information about the parking slots availability when he is in the local wi-fi network coverage area using free charge connection;
- anybody can access to the parking slots availability information (only) on the web portal via internet.

IV. IMPLEMENTATION AND DISCUSSION

A. Implementation

A scale model of the smart parking guidance and information system with security policies is created. The collected data from the sensor subsystem is transmitted by an ARDUINO ATmega 2560 card to the information center

through the ESP8266 module via a secured wi-fi network (figure 3). The SparkFun SEN-08839 is used to scan fingerprints. A local web server is installed using MySql for database management. The web application is developed with PHP programming language and the Bootstrap framework. The communication with the web portal is organized through secured HTTP protocol. All services of the application layer are tested and responded correctly.

B. Discussion

The proposed secured PGIS globally:

- provides parkers with real-time space availability information;
- can help to reduce road congestion and street accidents created by on-street parking practices;
- optimizes the use of existing parking slots;
- guarantees a high level of parking garage/space security.

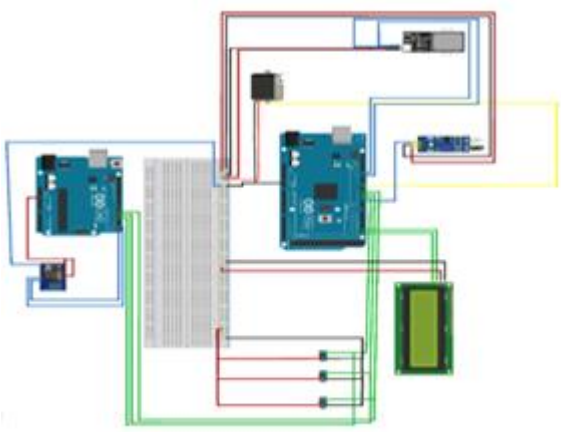

Fig. 3. Entrance and parking slots electronic system

Specifically, the use of a secure network makes it possible to prevent the man-in-middle attacks, which could, by sending non authorized messages, make believe that all the parking slots are occupied all the time. The implementation of the access control in administrative garages can help to limit waste and to reduce government spending by minimizing the abusive use of administrative vehicles.

To ensure the continuity of service of the SPGIS we propose a plan based on the use of an independent power source (solar energy) and the online reserve copy of the local database for recovery in case of failure.

V. CONCLUSION

An IoT and web-oriented parking guidance and information system with users' access control has been described in this paper. The presented system is an innovative component of Intelligent Transport System (ITS) for smart cities based on IoT paradigm.

The implemented security concept can help to guarantee different security parameters such as: i) the integrity of data transmitted between the sensor layer and the application layer of the system, ii) the availability of parking information, iii) the non-repudiation.

For future works, more functionality can be added to the SPGIS such as: parking slot reservation for management effectiveness, parking space geolocation to improve parking experience at a city scale and automatic license plate reading for higher security level guaranty.

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