Safe Bicycle Parking Platform Based on RFID Technology

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Abstract. In order to deter bike thieves, we have designed and implemented a theft prevention system for bicycles based on RFID technology. Bikes can be stored in areas monitored by custom designed base stations without the need for visual or contact identification. The system is implemented with Web of Things technology, using a RESTful and a streaming server API, to facilitate communication between the embedded electronics and the back end service. The system is tested by deploying RFID technology in several environments to determine the viability of the platform.

Keywords: RFID · Theft prevention · Mobility · Web of Things · Urban cycling

1 Introduction

As cities put emphasis on bicycles as a modern form of transportation, the safety of cyclists becomes a critical concern, but so does the security of the bicycles themselves. Traditional means of theft mitigation comprise mainly bike locks, or ideally locking the whole bike inside a bike shed. Modern alternatives are bike alarms, as well as personal bike trackers with GPS and GSM functionality to help keep track of a bike in the event of theft. These devices are of course battery powered, and depending on use, have to be recharged within weeks to months of continued use. The fact that only a small percentage of stolen bikes are ever recovered provides a strong argument for the implementation of active measures to prevent bike theft. To supplement the conventional safety precautions currently available to bike owners such as high-quality bike locks, bike theft insurance, coding and registration, etc. the project Safe Bicycle Parking sets out to provide bike owners with yet another anti-theft option. What we are aiming at, is a modern system that utilizes the latest web technologies to create a theft prevention system that allows long battery operation or even battery free operation. For our program, we are using active RFID transponders to provide a stable, long-range solution.

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Inconspicuous and tamper proof mounting solutions are very important for this application, and RFID technology provides a great basis for explorations in this direction, as the necessary transponders can be very small and can be powered by coin cells for months or years. Stem-mounted cases, within handlebars or handlebar grips, inside a saddle or even in bike tires would all be possible places for the transponders.

2 Web of Things Platform: Safe Bicycle Parking

The Web of Things is an effort to create seamlessly interacting embedded devices that are accessible through open web standards to facilitate interconnectedness of sensors, actors and control devices. By relying on radio frequency identification (RFID) technology and Web of Things technology, we aim to make it safer to leave a bike parked in a secure zone. One transponder is securely attached to the bike, another is carried by the person, for example along with the bike lock keys. When entering the parking area, the RFID readers will query both transponders which will trigger the checking-in of the bike. As the person leaves the bike in the parking area, the bike's transponder will be continually monitored. The hardware (transponders, base station) for safe bicycle parking is based on a two-frequency system. The uplink the communication from the base station to the transponder takes place by means of a LF RFID interface at 125 kHz, which has a range of effectiveness that can be adjusted for maximum efficacy and remains largely unaffected by potential electromagnetic disturbances or attenuations caused by metal or by weather conditions. When activated either by means of the uplink through the wireless interface or when a mounting sensor in the transponder detects removal from the bike, the transponder responds to the basis station by means of a UHF signal at 434, 869 or 915 MHz.

The alarm possibilities are versatile and can be adapted for use in diverse places. Additional alarm possibilities include the following:

- Interaction with a local computer system equipped with a camera and the ability to save video or picture files in the case of theft.
- Directly driving an acoustic or visual alarm (sirens, flashing lights)
- Notifications sent to additional people such as doormen, security guards, neighbours, etc.
- Notifications sent to users of social media (Facebook Places, Foursquare) who are currently in the vicinity of the unit.

The software part of the web of things platform is divided into three main parts, namely the base station and the back end services of the Web of Things Platform, including the event manager. The base station software is executed on the base station, the other parts are split into micro services, running in encapsulated containers.

2.1 The Base Station

The purpose of the base station is to read all the transponders that are in the safe area and to forward this information to the event manager. The base station can also trigger a visual and acoustic alarm or signal a CCTV camera to permanently store image data in the event of a bicycle theft. The base station is an outdoor metal enclosure which houses all the electronic hardware required to read transponders and establish a communication with the event manager. Low frequency (LF) and a high frequency (HF) readers are used to read the transponders. As the transponders are active (battery powered) a low frequency (LF) communication is established first to wake the transponder up, and the subsequent data transfer between the transponder and the base station will be carried out through a high frequency (HF) link. The LF system is designed to provide maximum penetration to activate transponders partially occluded by bike frames or other metal parts in the area. The base station reads all transponders that are currently in this area and sends periodic read-outs to the event manager. UMTS communication (3G) is used for data transfer between the base station and the event manager where a wired ethernet connection is not available. In Fig. 1 the base station is depicted with all hardware components labelled.

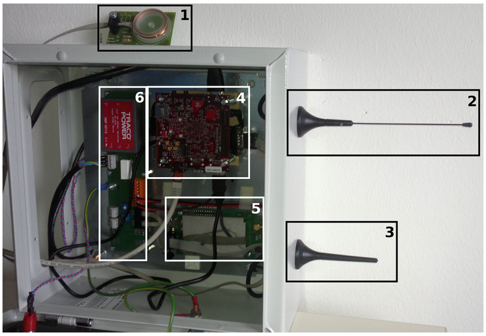

Fig. 1. Development Base Station, Components labelled: 1. Test Low Frequency(LF) antenna, 2. Ultra High Frequency(UHF) antenna, 3. GSM/3G antenna, 4. BeagleBoard, 5. RFID reader, 6. Power supply

2.2 The Event Manager

The event manager is the part which receives all data events and processes them. It is split into several different services, each implemented as a microservice with a common interface. The main program is implemented by using Akka[1]

[1] http://akka.io/.

streaming technology which handles all events received from the base stations. Each event contains the base station ID and a list with all serial numbers of all transponders that are currently in the secure area of this base station. It updates the information about which bicycles are parked at a base station based on the submitted information.

All requests to the event manager are made through the RESTful service implemented for this purpose. This RESTful service provides a stateless communication which reduces memory usage and solves the session expiration problems and is easier to support. All of those features are essential for the platform due to the need for reliability, stability and ease of use. The communication is encrypted using Transport Layer Security (TLS) and uses API keys to authenticate the base stations. If an alarm occurs, the event manager notifies the base station and also sends a warning message to the owner via email or SMS. The event manager is also in charge to check the integrity of the actives base stations.

2.3 Web of Things User and Management Interface

In this web interface, the users can manage information associated with their bikes. The user interface shows different information based on the type of profile associated with a user. There are four types of profiles:

- User: Only the information related to this user is shown. The users can see the history of their bicycles and check what the current status of these bicycles is.
- Security Personnel: The people who are associated with this kind of profile can check all data from the base stations they watch. If an alarm is detected, both base station and its associated security personnel will be noticed.
- Company: All bicycles which are included in the fleet of a company are handled through this profile.
- Administrator: This profile has access to all information included in the system. All users, bicycles and base stations can be modified by this kind of profile.

All information is updated in real time through websockets which updates all active clients that are currently viewing the information as soon as any changes occur. This method provides us with a simple and lightweight way to get all clients updated without spending too many resources. More detailed description of system architecture of the underlying Web of Things platform can be found in the recent publication [1].

Additionally, a smartphone application has been created which allows display of the bike status, and checking the bike in or out of the system, with only one transponder mounted to the bike. In Fig. 2, the whole system setup is pictured in an FMC[2] diagram.

[2] http://www.fmc-modeling.org/.

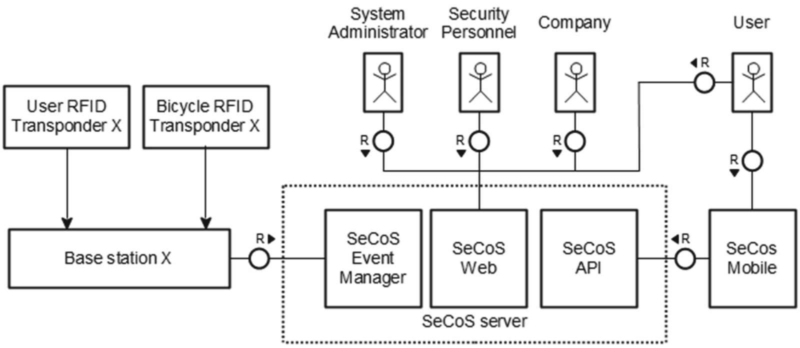

Fig. 2. Diagram of the safe bicycle parking system.

3 Evaluation

First initial tests were performed in April 2015 at the JOANNEUM RESEARCH bicycle parking area with a small group of 20 people. The first tests we encountered some open issues with the communication between the base station and the event manager, but using a RESTful service instead of an SSL socket for communication enabled a stateless communication with the base station which provides us with a more stable and reliable system for the future when the number of base stations grows. After this change the system works stable and is ready for more exhaustive tests. The next step planned for the evaluation is installing the system with more base stations and a few hundred users where more users will test and review the system.

4 Related Work

Early works have already described ways to communicate efficiently with home automation devices [2], but in this work the focus has been put on effortless and hands off operation of the whole system, notwithstanding an initial setup procedure.

Recently, some researchers have proposed an architecture for the Web of Things [3]. The proposed architecture is based on the usage of resource-oriented (REST) principles using HTTP as the application protocol. An HTTP connection is initiated by the client and thus fits the needs of control-oriented applications. However, applications in the Web of Things are often rather monitoring-oriented, which means that connected things will push data to the clients autonomously. Web syndication protocols like Atom have recently been investigated in this context. However, this web of things approach lacks an adequate scalable streaming support.

Complex event processing can also be implemented in a Web of Things platform as is shown in [4]. The paper describes a management system, EcoPark, which is built on combining Event Processing with the EPCGlobal architecture framework. The framework is divided into three parts. The data collection and transmission, in which the RFID sensors collect the data and send it to the system; the application service and event repository, in which the events are handled and transformed into complex events; and the complex sensing event process mechanism, in which the complex events are processed to use in the management platform. Complex event processing can be used in our system design. However, there was no need for such a component in this application.

Related to the event processing on RFID systems, this paper [5] shows a solution for minimizing the impact of out-of-order events on the system. The development of dynamic algorithms that allow the best performance even if there are network problems is the main issue being discussed.

Compared to other Internet of Things platforms [6], our platform fits the general direction other have taken, with the majority employing REST platforms, with only one other platform even utilizing RFID, but without a REST interface, making our platform the first of its kind.

5 Conclusion

As the Web of Things is gaining momentum, creating applications becomes a necessity for facilitating adoption. Our work shows the feasibility of a system in preventing bike thefts. The system is responsive and can alert the bike owner or security personnel to a theft without delay. We have also shown the issues that might come up in an application like this finding and researching new methods to guarantee a secure and reliable system.

Further opportunities for study could be investigations into the desirability of such a system for further applications such as electronic bike identification, providing additional value to businesses that cater to environmentally conscious customers.

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