An RFID based Toll Payment System for Green World

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Abstract: As the urbanization and fast-i.mproving quality of life raises the energy consumption, over 72% of carbon emissions come from cities. With the current petrol-powered cars on the road, there are large amounts of CO2 emissions, which pollute the atmosphere resulting in what is called global warming. At the same time, the advent in technology has brought up emerging technologies like Radio Frequency Identification (RFID), wireless sensor networks, and Internet of Things (IOT), which found their way in tracking everything particularly in supply chain and manufacturing. In this paper, the research focuses on the state-of -the art technologies used to reduce Greenhouse Gases (GHG) emissions in traffic congested areas. It is based on developing a prototype of a wireless sensor module based on RFID technology to mitigate the CO2 footprint in the environment interfaced to an access control toll payment system in parking lots.

1 INTRODUCTION

As people are increasingly aware of the relevance of carbon emission cuts worldwide, the global efforts to reduce carbon emissions are on the increase. Since the Kyoto protocol was adopted in 1997, international organizations have been making lots of efforts to cut down carbon emission through various international pacts such as Bali road Map in 2007 and Copenhagen Climate Change Conference in 2009.

Currently, the urban population accounts to about 50% of the entire global population and consumes 60% to 80% of energy. The urban population is expected to reach 60% of the entire global population and to consume 73% of energy in 2030. Urban carbon emission reduction projects and researches in city transportations, energy systems and other areas are required to cope with the accelerating urbanization (Choi, 2012). Many cities in US, Japan and Europe have already launched eco-friendly urban projects to cope with climate changes. The issue of traffic congestion as a direct result of urbanization has been widely investigated (Elkin, 2010)(Levinson, 2010). The general acceptance of the nearly universal consensus on climate change, promotes a low-carbon scenario regarding motivating local economy towards less carbon emissions. (Wang, 2011)(Chang, 2011)(Lin, 2010). Toll payment in transit fare & parking has been used for some time utilizing smart cards to reduce traffic congestion. (Ranki, 2000), but rarely this is used in conjunction with eco-friendly environment.

Lately, environmental policies began to prohibit the use of toxic & harmful substances in the automotive industry complying with the requirement of eco-friendly environment. In this context, the automotive industry has been investigating the possible use of emerging technologies like RFID and the IOT, to ensure proper tracking of each component in the automotive industry and record all material information and recyclability/recoverability information of each component for vehicle emission inspection, to ensure that all cars can be examined for their engine emissions continually (Vong, 2011).. RFID has been widely used in many fields as a wireless automatic identification and capture (AIDC) technology. It is emerging as the hottest information tracing technology in supply chain management. RFID has the potential to enable machines to identify objects, understand their status, and communicate and take action if necessary, to establish “real time awareness”. Identification technologies such as RFID, wireless sensor technologies, allow objects to provide information about their environment. Smart technologies that allow everyday objects to “think and interact” establish an IOT that connects and enables intelligent interaction between objects around the world. Identification technologies such as RFID,

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allow each object to have a unique identifier that can be read at a distance allowing automatic, real-time identification and tracking of individual objects (Finkenzeller, 2010)(Khoo, 2010).

In this paper, we present a novel toll payment solution eco-friendly environmental, named green (IOT) for an urban community using active RFID interfaced with environmental sensors. The solution was developed in KFUPM RFID lab as a proof of concept targeted to be used as a toll payment to be placed on the windshield of a car. Since RFID tags are used nowadays everywhere for toll payment and transit & parking fares, this could constitute an ideal infrastructure to use the toll payment in conjunction with the eco-friendly or green environment requirements in an urban city. Whenever a car stops at the gate of a parking lot or a toll payment gate, the active RFID tag with the CO & CO2 sensor placed under the windshield of a car sends a measured level of gas concentration wirelessly to the interrogator installed at the gate to add an extra fee to the toll payment or transit fare in case the gas emission level does not comply with the environmental requirements.

2 ENABLING TECHNOLOGIES

There are currently several enabling technologies for IOT and mainly categorized into wired and wireless aspects. For the wired part, we use environmental sensors and an I/O board with built-in controller. Wireless technologies such as radio frequency identification (RFID) or wireless sensor network (WSN) can be considered. Taking into consideration the goal of our application where only few kilobytes of information (sensor data plus the tag ID) are retrieved from the active tag under the windshield of the car, RFID may be more cost effective solution.

2.2 RFID TAGS

Since there are five classes of RFID tags (9), the appropriate RFID tags have to be chosen based on the requirements of the target application. For passive RFID, the communication range is limited by two factors:

1) The need for very strong signals to be received by the tag to power the tag, limiting the reader to tag range.
2) The small amount of power available for a tag to respond to the reader, limiting the tag to reader range.

Active tags have built in battery which powers a microchip or additional sensors. Active RFID, with operating ranges of 100 meters or more, is able to collect thousands of tags from a single reader; additionally, tags can be in motion at more than 100 mph and still be accurately and reliably collected. Detail properties of the RFID tags are shown in table1. Table2 summarizes the technical differences of passive and active RFID Technologies, and Table3 shows the functional capabilities of passive and active RFID technologies.

We have chosen to use the RF code active tag with dry contact for it is convenient and easy to interface with environmental sensors and for its long life battery of (5-7 years). In addition it has a long range of more than 200 feet and it does not suffer from interference compared to passive tags. Once the active tag is connected, it will monitor and report the open and closed state of the sensor. The active tag is configured to beacon the sensor once every 10 seconds.

Table 1: EPC RFID Tag Classes.

Class 0	Passive	Read only
Class 1	Passive	Read only write once
Class 2	Passive	65 KB read-write
Class 3	Semi-Passive	65 KB read-write with built-in battery
Class 4	Active	Built-in battery
Class 5	Active	Communicates with other class 5 tags and devices

2.2 Environmental Sensors

Among the environmental sensors available, we have selected the CO & CO2 sensors since they are directly related with global warming.

The CO2 Gas Sensor Module is designed to allow a microcontroller to determine when a preset Carbon Dioxide gas level has been reached or exceeded. Interfacing with this sensor is done through a 4-pin SIP header and requires two I/O pins from the host microcontroller. The sensor module is intended to provide a means of comparing gas sources and being able to set an alarm limit when the source becomes excessive.

Table 2: Technical differences between passive and active RFID technologies.

	Active RFID	Passive RFID
Communication Range	Long range (100 m or more)	Short or very short range (3 m or less)
Multi-Tag Collection	• Collects 1000's of tags over a 7 acre region from a single reader • Collects 20 tags moving at more than 100 mph	• Collects up to a few hundred tags within 3 meters from a single reader. • Collects 20 tags moving at 3 mph or slower
Sensor Capability	Ability to continuously monitor and record sensor input; data/time stamp for sensor events	Ability to read and transfer sensor values only when tag is powered by a reader; no date/time stamp
Data Storage	Large read/write data storage (128 KB) with sophisticated data search and access capabilities available	Small read/write data storage (e.g. 128 bytes)

3 SYSTEM DESIGN

The proposed system is based on a dry contact active RFID system consisting of a robust Motorolla 433 Mhz active reader & tags with a detectable range of up to 70 meters. The RFID reader or interrogator is installed at the toll payment gate, and connected through TCP/IP to a server. The RFID tag has a dry contact interface directly interface able to any environmental sensor. In our design and to serve the purpose of research, we have chosen a CO2 gas sensor, which has a built-in alarm as shown in figure 1. The R130 Dry Contact Tag features two twisted wires that enable connection to a dry contact device. Once connected, the R130 will monitor and report the open and closed states of the device. While the connected device is in either an open or closed state the tag will beacon the dry contact status once every 10 seconds. When the dry contact state changes the tag will immediately broadcast three beacons at 0.5 seconds apart with the new dry contact status then return to beaconing once every 10 seconds.

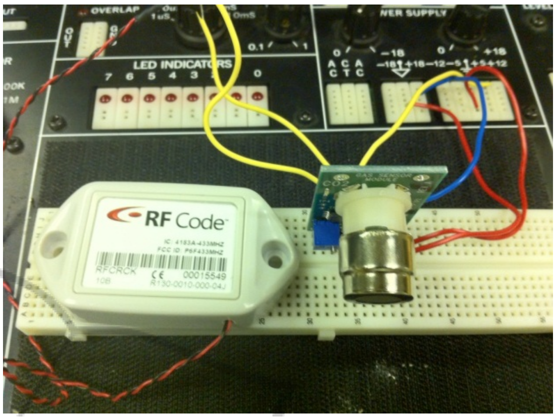

Figure 1: The Wireless CO2 sensor.

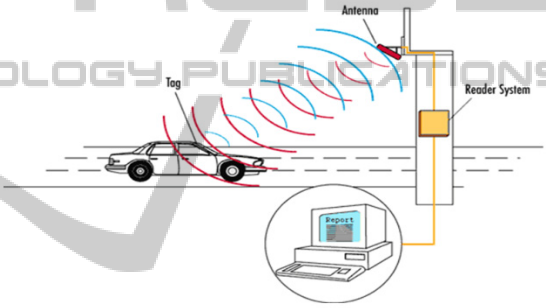

Figure 2: The CO2 emission Toll payment RFID.

A Vellman I/O board with built-in microcontroller and 5 digital input channels and 8 digital output in addition to two analogue inputs and two analogue outputs with 8 bit resolution has been used to cut down development cycle of the research.

We propose the wireless sensor node to be placed under the windshield of a car or a van to measure the amount of CO2 or other GHG gas emissions at toll payments gates. Since in an urban city the number of toll payment gates & parking lots are constantly increasing, we found it feasible to add another level of intelligence to the existing toll payment congestion fee by measuring the level of gas emission. Whenever the level of gas emission is above the permissible level specified by the Kyoto protocol, the RFID tag sends the amount of measurement or a command to the reader to take the proper action. Moreover, a fee will be deducted named the CO2 fee. The overall system has been successfully tested in the lab. See figure 2 for the toll payment access control system.

4 DISCUSSION

As about 60% of global population is expected to reside in cities in 2030, the GHG emission is a critical issue for urban residents. Based on the fact that urban development cause climate changes, but also offer solutions to such problems, it is necessary to establish urban strategies to reduce GHG emissions. The EU has the goal of reducing CO2 emissions by 20% within the next decade. The transportation sector is responsible for a large proportion of these emissions because of its reliance on fossil fuel. While the very nature of the industry means the introduction of alternative energy sources is not an immediately useful option, an alternative may be found in improving logistics. While the present global climate debate is to a large extent focused on mechanical solutions like electric cars and wind turbines, such technology is expensive and time-consuming to implement. Better IT-based logistics and planning tools with a focus on the environment may be an attractive alternative, since they do not need large investments, fast to implement, and the underlying techniques are already mature.

Technologies, such as RFID, have been widely used to track material & equipment in the supply chain. They have their impact in the automotive industry in real-time reporting of faults and continuous monitoring of material & components used in cars to make sure they complies with the green environment requirements. RFID integrated with environmental sensors like CO2 sensor not only it motivates car owners to test their car engine frequently to keep the CO2 level down by enforcing a carbon toll payment tax, but also adds an additional value by what we call preventive maintenance. In preventive maintenance, RFID tags can be attached to major components in the car. These tags have the capability to store maintenance history thereby providing prompt inspections and more informed on the spot repair decisions to cut down the unnecessary journeys and mitigate failure rate of the car engine. Carbon tax has been used widely in different countries as a policy to mitigate CO2 emission (Shankar, 2006). Nevertheless, the biggest challenge though is to enforce these measures by governments due to the high cost involved. The benefits of the actions taken by governments outweigh the costs.

5 CONCLUSIONS

In this paper, the feasibility of a wireless sensor based system based on RFID for mitigating CO2 footprint in environment in a toll payment context has been studied. A prototype based on active RFID and environmental sensors has been built and tested. The prototype can be easily mounted on the windshield of cars for constant monitoring of CO2 emissions. Hence, car owners are forced to run regular examination for their car engine. RFID offers lots of benefits by connecting car components through the IOT, thus cutting down the failure rate of car engine and mitigating CO2 footprint. Research is ongoing on studying implementation issues in addition to cost and legislations.

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REFERENCES

Choi, B. Y, Moon, S. J, Pyeon, M. W, Koo, J. H, "Implementation of Smart Green City in Response to Climate Change With focus on the Reference Case of the Ministry of Land, Transport & Maritime Affairs of Korea," in the proceedings of the 14th International conference on Advanced Communication Technology (ICACT), 2012, pp.331-335.

Elkin, S. L. "Politics and Land use planning: the London experience," Cambridge University Press, 2010.

Levinson, D, "The physics of traffic Congestion and Road pricing in Transportation Planning," Bulletin of The American Physical Society, Vol. 55, 2010.

Wang, X. J, Hsu, P. H, Zhow, R, Su, H. L, "Activating Eco-City in China: The System Engineering for Cities' Green Transition," in the proceedings of the 5th International China Planning Conference, 2011,pp.1-7.

Chang, S, Xie, S, "Making Eco-Smart City in the Future," in the Proceedings of the International conference on Consumer electronics Communication & Networks (CECNET),2011,pp.1380-1383.

Lin, Y, Qiun, F, Wu, J, Song, J," Looking for the Green Future of Sustainable City: A Broad Perspective on Ecology Urban Design," in the proceedings of the International conference on management & service Science (MASS), 2010, pp.1-4.

Ranki, W. and Effing, W. (2000), 'Smart Card Handbook,' John Wiley and Sons.

Vong, C. M, Wong, P. K, IP, W. F, "Framework of Vehicle Emission Inspection and Control through

RFID and Traffic Lights," in the International Conference on System Science & Engineering, China, 2011.
Finkenzeller, K, "RFID Handbook," John Wiley & Sons 2010.
Khoo, B, "RFID from Tracking to the Internet of Things: A Review of Developments," In the IEEE/ACM International Conference on Green Computing and Communications, 2010, pp.533-538.
Shankar, K, Mann, M. D, Salehfar, H, "Substitution and Price Effects of Carbon Tax on CO2 Emissions Reduction from Distributed Energy Sources," in proceedings of the Power Systems conference, 2006, pp.236-246.