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Design and Implementation of Zigbee-RFID Based Vehicle Tracking

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Abstract: Intelligent transportation systems have become increasingly important for the public transportation, industries and service sectors. The Economy in big cities is soaring today and the growing traffic has become a serious challenge. In response for that to provide a solution to improve the traffic condition zigbee based vehicle monitoring is used. This paper seeks to design the RFID and zigbee based system architecture at the network level for tracking the vehicle information which has been sent to the centralized server. The aim of the design is to provide a simple and easy solution to track the location of the moving vehicle. Compared to the old systems, Zigbee based network architecture is able to provide information about the vehicle accurately. The vehicle will be having a unique RFID tag (Radio Frequency Identification).The RFID reader is placed in particular places. For the beneficial features of RFID, we integrate RFID readers into the Vehicle tracking Information System. This RFID reader can check or collect the data and the information is given to the control station through the Zigbee protocol. The Zigbee protocol is used for the messaging service between the control station and the vehicle.

Key words: RFID · Zigbee protocol · Microcontroller Vehicle tracking · Wireless Sensor Network.

INTRODUCTION

INTELLIGENT transportation systems (ITSs) have been evolving rapidly in the past two decades, leveraging advanced computing and communication technologies. ITSs help coordinate traffic condition, improve safety, reduce environmental impact and make efficient use of available resources. According to the paper, wireless access points (APs) and RFID readers will be deployed throughout city. Exploiting the pervasive deployment of these devices, location and status information of vehicles can be actively captured and logged in a large number of distributed local nodes. The goals of the project are twofold. First, it tries to make the available transportation infrastructure to be used more efficiently. Second, it aims to provide the public with a wide spectrum of ITS applications ranging from real-time traffic information, trip planning and optimal route selection, to congestion avoidance [1, 2]. Traffic management poses many critical challenges in most modern cities, including congestion, traffic violations, vehicles theft and illegal vehicles. During the past few years, researchers have used GPS, radar sensors, or digital cameras to measure average vehicle speed and maximum flow on a road in order to determine whether a driver is over the speed limit or to provide traffic information to remind drivers to avoid congestion [3]. However, these systems do not systematically collect information to be used in a dynamic traffic guidance system to solve traffic congestion. In 2003, Wal-Mart first instructed one of its suppliers to start using radio frequency identification (RFID) for managing its supplies (RFID Journal, 2003).Next, the US Department of Defence (DOD) announced a similar RFID mandate for its suppliers in 2004 (Wyld, 2006). With the backing of retail and military giants, RFID is a growing market that is becoming widely important [4]. The widespread use of RFID can automatically track pallets, cases, individual products and reusable assets such as bins and containers throughout the supply chain. Chao, Yang and Jen (2007) reviewed the history of RFID in supply chain management, the supermarket checkout process and private issues. They wrote that RFID global sales are expected to reach US$70 billion by 2008. Tajima (2007) developed a theory of how RFID can be used in supply chain management to sustain a competitive advantage. Under the theory, he

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developed four propositions. Through them we can see that RFID technology has strategic competitive value. He mentioned 15 benefits that have been realized and divided them into two parts, throughout the supply chain (specifically, reduced shrinkage, reduced material handling, increased data accuracy, faster exception management and improved information sharing) and major supply chain participants (specifically, production tracking, quality control, supply and production continuity, material handling, space utilization, asset management, reduced stock outs, customer service, lower inventory). RFID applications have been studied in many areas as well. Recently, RFID has even been applied in the health care industry to improve efficiency of operation. Fisher and Monahan (2008) emphasized that RFID technology has become the standard for hospitals to trace inventory, identify patients and manage personnel. RFID reader to monitor vehicles at a read distance of 17 feet travelling at speeds of 160 mph (RFID, 2004). When a vehicle with a passive tag passes an RFID reader at a speed not exceeding 250 km/h, the vehicle can be read accurately. Thereaders cost less than US$1000 and can sense up to 7200 vehicles per minute [5]. The cost of each passive tag is only 60 cents for an order of 5 million tags. However, real-time vehicle tracking in the metropolitan scale The huge number of simultaneous queries is a serious issue. In addition, as the city is continuously expanding, the system is required to be highly extensible to such expansion. Third, the system should be robust to node failures. In such a large-scale distributed system consisting of thousands of local nodes, system maintenance is not a system is very challenging because of several rigorous requirements. First, users (or high-level applications) often pose a real-time requirement on tracking a certain vehicle. That is, any query for the vehicle must be answered within a certain bounded time. Otherwise, the returned answer may become invalid or useless [6]. For example, a query tries to locate the current location of a stolen car. If the query fails to be answered within a short time, the car could actually be far away from the returned location because it may be moving at a high speed. Second, the system should be scalable to support hundreds of thousands of vehicles. In addition, it aims to serve millions of users every day. The huge number of simultaneous queries is a serious issue. In addition, as the city is continuously expanding, the system is required to be highly extensible to such expansion. Third, the system should be robust to node failures. In such a large-scale distributed system consisting of thousands of local nodes, system maintenance is not a trivial issue.

Related Work: In recent years, radio frequency identification (RFID) technology has been utilized in the field of mobile robotics and a number of approaches have been introduced which employ this for localization and different navigation tasks. The Globe system has constructed a static worldwide search tree for mapping object identifiers to the locations of moving objects. It is not flexible to expand or adjust the structure and may have the bottleneck problem near the root of the directory tree structure. Several crucial reasons prohibit this initial effort from being extended for vehicle tracking.First, with crowded high buildings squeezed along most of the narrow streets in the city, it is very difficult for the GPS system to work accurately without any other assistant devices. It is often the case that the reported GPS position of a vehicle can be more than 100 m deviated from its actual location. To make things worse, a large number of major roads are covered by viaducts that prevent satellites from seeing the vehicles running under them. Second, the intervals of location information reports can be notably long. Due to the GPRS communication cost for transmitting.In contrast,Zigbee needs no dedicated directory servers and achieves good scalability and flexibility. Despite the large number of existing methods, there is no applicable one for update-intensive applications, where it is infeasible to continuously update the index and process queries at the same time.Zigbee does not need any centralize routing information is distributed to every node in the system. In structured peer-to-peer (P2P) networks, various DHT schemes have been proposed to map objects to peers in a decentralized way, thus enabling the system to satisfy queries efficiently. However, DHTs may cause large computation and traffic overhead for a large number of rapid updates of moving objects. In unstructured P2P networks, the most typical query methods are based on flooding. Furthermore, none of these schemes provides real-time guarantees for queries.Zigbee introduces minimal updating cost to guarantee the real-time constraints desired by the applications.

Framework for the Intelligent Traffic Management Expert System: The framework for the system comprises a passive tag, an RFID reader, two antennas, a personal computer or a control card with a microprocessor, a pair of infrared sensors and a high-speed server with a database system (Fig. 1). The type of the reader is an Alien 9780 (915 MHz) and the tags are Types 1, 2 and 3, as shown in Fig. 2a. The tags belong to Class 1, which is written only once but read multiple times. Their power comes from the reader's RF transmission [7, 8]. The infrared sensors use

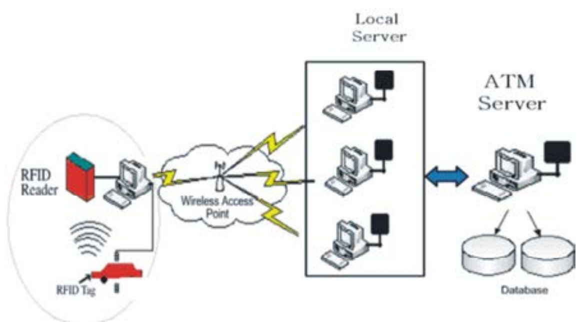

Fig. 1: Framework for the intelligent traffic management Expert system.

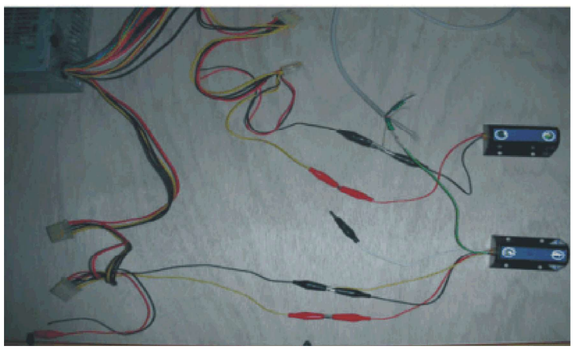

Fig. 2(a): The RFID reader and tags, Types 1,2 and 3

Fig. 2(b): The connection between power supply and infrared sensor.

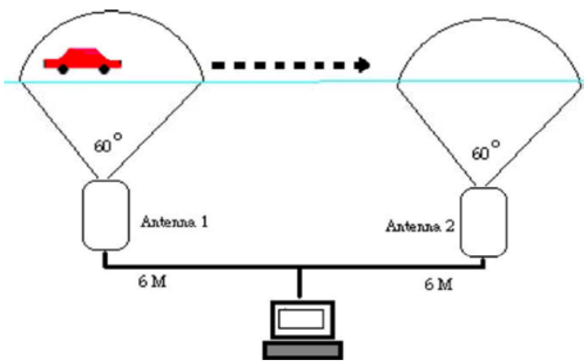

Fig. 3: A method for calculating the average speed on a road.

a 6-V cut-off filter. The connection between the infrared sensors and the power supply is presented in Fig. 2b. The front-end device connects to the backend server via a wireless network. The tag is pasted on the windshield a car. The reader detects data and sends it back to the high-speed back-end server via a wireless network, storing it in the database. The software we used includes LABVIEW and PICDERM.The server then calculates the average speed and maximum flow. For building the system, we must make two assumptions: (1) An electronic plate is adopted nationwide. (2) RFID readers exist in urban areas and in all highway toll stations.

For calculating the average speed of a car, we deployed two antennas (Fig. 3). The effective sensing angle is 60_. The maximum detected effective distance is 15 m. The distance between the two antennas is 12 m. Thus, we set d = 12. Vehicle speed is calculated by the equation speed ¼ d t1_t2, where t1 is the detected time of the antenna 1 and t2 is the discovered time of the antenna 2. d is the distance between the antennas. Since the distance between antennas 1 and 2 is known, it is easy to determine the vehicle's speed. After 30 samples of the vehicle's speed have been collected, the system computes the average speed. Actually, we need only use one antenna to measure car speed. Hence if the first discovered time of a car, t1 and the last discovered time of a car, t2 and the detected distance of an antenna, diameter of the circle (d = 2 radius), are known, then the car speed is very easy to get. Wen and Hsu developed and implemented an automatic navigation system with a dynamic algorithm to avoid congested roads with a very low speed (for example, speed 15 km/h).

System Description: As RFID technology continuously evolves, it has been widely used in tracking various mobile objects such as vehicles. RFID readers and wireless APs will be deployed throughout the urban area of city typically installed at crossroads. A local node is responsible for collecting data from several close RFID readers and wireless APs within its own domain and accepts queries from nearby users or applications. A local node is basically a server which connects to a dedicated underlying network for communication. The vehicles' information is gathered both actively and passively. In the initial prototype, a vehicle is captured passively using active RFID technology. An active RFID tag emits its ID at a fixed interval and has an effective communication range of about 2 to 80 m. The battery can sustain the operation of an active RFID tag for about 6 years [10]. A moving vehicle attached with an active RFID tag can be captured if the emitted signal reaches some reader.

Besides active RFIDs, a vehicle can actively communicate with wireless APs as it passes by them. A Cisco Aironet 1240AG AP working under IEEE 802.11g has an effective outdoor communication range of about 280mat the transmission rate of 2Mbps.The vehicle can actively push important vehicle status information, such as vacancy status, to local nodes. Precisely speaking, we aim at providing real-time guarantee of tracking a vehicle by bounding the maximum number of hops that a query could traverse in the system. Since the provision of such a real-time service depends on the underlying network for communication, a dedicated network such as an ATM can be used which provides a reliable and predictable data transmission between any two endpoints. With the bounded maximum number of transmission, such a system for the purpose of tracking vehicles can guarantee rigid real-time requirements. A vehicle actively reports its location information back to a centralized database through a wireless cell-phone data channel (i.e., GPRS). Several crucial reasons prohibit this initial effort from being extended for vehicle tracking. First, with crowded high buildings squeezed along most of the narrow streets in the city, it is very difficult for the GPS system to work accurately without any other assistant devices. It is often the case that the reported GPS position of a vehicle can be more than 100 m deviated from its actual location. To make things worse, a large number of major roads are covered by viaducts that prevent satellites from seeing the vehicles running under them. Second, the intervals of location information reports can be notably long. Due to the GPRS communication cost for transmitting the GPS location information back to the data centre drivers prefer to choose relatively large intervals [9]. The typical value would be from 1 to 3 minutes. Third, the expense of a GPS receiver as well as data communication cost is quite high, which limits the wide deployment of this technology. However, the trace data of vehicle movements in the urban area of Shanghai obtained from this prototype using GPS technology is very valuable for study of traffic conditions.

Dynamic Guide System to Avoid Congestion: As ITMES collects essential traffic information such as average speed and maximum flow, a dynamic guide system can avoid congested areas. In Wen and Hsu's paper, their system mainly avoids red roads, which means the average speed of the section of the road is less or equal than 15 km/h. However, it still considers yellow roads, which means that the average speed of that section of the road is less than or equal to 30 km/h and ignores green roads, which means the average speed of the section of the road is greater than 30 km/h.

The revised Wen–Hsu's routing algorithm is as follows (Wen & Hsu, 2005):

Step 1: Construct a distance matrix. First let each distance, di,j, of every pair be the entries of the matrix where di,j = 0 if i = j and di,j = M if there is no direct link between i and j.

Step 2: Set all no-left-turn nodes as dummy nodes. Then directly connect each pair of the adjacent nodes of the dummy nodes. Calculate the distances of all pairs of routes that are adjacent to the dummy nodes. Meanwhile, build an index for all the pairs of routes.

Step 3: Find the minimal values between the old value and the new value.

Step 4: Generate the revised distance matrix (replace the values with the minimal values).

Step 5: Based on the revised distance matrix, put the start node 1 in a list called OPEN. Set g(1) 0 and f(1) h(1)

Step 6: If OPEN List is empty, exit with failure; otherwise continue.

Step 7: Remove from OPEN List that node n whose value of f function is minimal and put it on a list called CLOSED.

Step 8: If n is a goal node, exit with the solution path obtained by tracing back through the pointers; otherwise continue.

Step 9: Expand node n, generating all of its successors (if there are no successors, go to Step 6). For each successor ni,compute gi g(n) + c(n, ni). c(n, ni) is the distance from node n to its ith successor.

Step 10: If a successor ni is not already on either the OPEN List or the CLOSED List, set g(ni) gi and f(ni) gi + h(ni). Put nion the OPEN List and direct a pointer from it back to n.

Step 11: If a successor ni is already on OPEN or CLOSED and if g(ni)?gi, then update it by setting g(ni) gi and f(ni) gi + h(ni). Put ni on the OPEN List if it was on the CLOSED List and redirect to n the pointer from ni.

Step 12: Go to Step 6.

The definition of the equation, f(n) = g(n) + h(n) is as follows:

n the current arrived node (i.e., the frontier node)
g(n) the shortest distance from the starting node to node
h(n) the shortest distance from node n to destination
f(n) the minimum distance from the source node to destination via node n

Knowledge Reasoning for Tracing Suspected Vehicles: In this paper, we adopt a rule base in the knowledge base. Therefore, we represent every rule in the rule base as a set of rules. Each rule is in the form of if < antecedent clauses > then < consequent clauses > statements. If the antecedent clauses are true, then the consequent clauses are true. Some rules are presented below:

Rule 0: If Code = ‘‘Stolen car” and Alert = ‘‘Alarm” and Map = ‘‘Trace” then Action = ‘‘Stop the car”

Rule 1: If Code = ‘‘Stolen car” and Sensor = ‘‘Passed” then

Alert = ‘‘Alarm”

Rule 2: If Code = ‘‘Stolen car” then sound an alarm and print = ‘‘This is a stolen vehicle”

Rule 3: If Sensor = ‘‘Car passed” and Reader = ‘‘No responds” then Alert = ‘‘Alarm” and print = ‘‘WARNING: Vehicle Passed without Tag”.

Rule 4: If Code = ‘‘Stolen car” then Map = ‘‘Trace” and show on an electronic map

Rule 5: If Code = ‘‘has no fuel” then sound an alarm and print = ‘‘WARNING: Has No Fuel”

Design Issues: This section discusses some design issues that Zigbee may encounter in practice.

Scalability: Zigbee is designed to track hundreds of thousands of vehicles in a metropolitan-scale system with a large number of users. Therefore, the system scalability Concern in terms of the number of vehicles, the number of users and the number of local nodes is critical.With zigbee, the system needs to maintain a hierarchy for each vehicle. If every movement of a vehicle will introduce a lot of location updating traffic into the system, the cost can be prohibitively expensive. However, this is where zigbee comes to help [10]. Zigbee leverages the inherent locality of vehicle movements and only updates a small number of nodes nearby the vehicle. Therefore, the location

Fig. 4: Amplification factor k as a function of D.

updating cost should be small. We can also notice that the query cost is modestly low, which is a logarithmic scale to the size of the network. Moreover, each node in the system only needs to maintain the information of several neighboring nodes. It is a lightweight protocol to join and leave the system. We will further investigate the scalability of zigbee by extensive trace-driven simulations. Resilience to unreliable data. It is possible that occasionally a vehicle is not captured by an RFID reader (e.g., when the vehicle is moving too fast). In addition, a local node may also fail from time to time. It is critical to the operations of zigbee if a boundary node misses a vehicle passing by. This inaccuracy can be easily detected in the system. At any time, a node in region should have received an update packet from a boundary node before the node itself captures the vehicle. Otherwise, it is aware that the vehicle has escaped and the corresponding updating process fails.

Tracking accuracy: As a vehicle keeps moving, it may run out of the reading range of an RFID reader while still has not entered the territories of others. This causes the system to have inaccurate vision about the current position of the vehicle before the vehicle re-enters into the system. It also defines the resolution of tracking accuracy of the system to be the uncovered distance between two adjacent RFID readers. In more practical environments, this inaccuracy can be enlarged when RFID readers fail to capture the vehicle as the vehicle passes [11]. To refine the tracking resolution, more RFID readers can be deployed in the system [12, 13]. In order to reduce the cost, readers can be deployed more densely at those places where more accurate location information of individual vehicles is required and less densely at other places [14, 15].

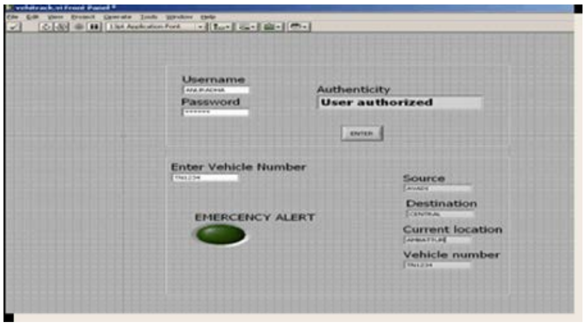

Fig. 5: Authorized users to access the system

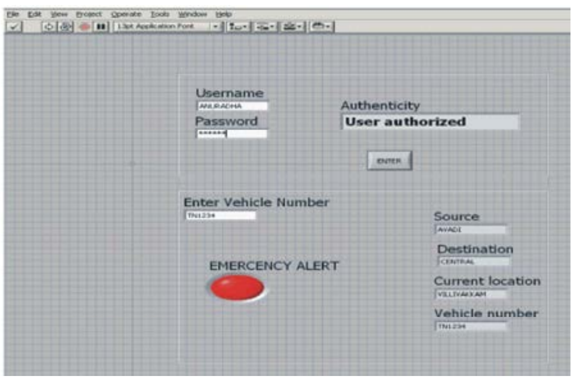

Fig. 6: Emergency alert

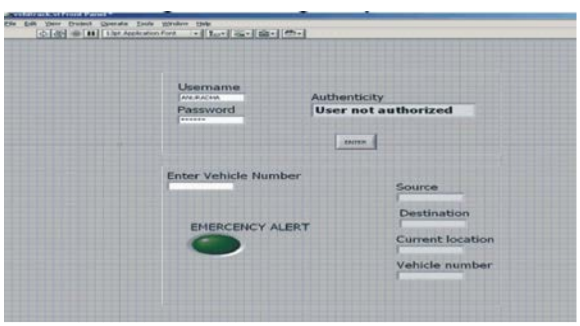

Fig. 7: Unauthorized user login menu

Functions of the System: Through the query, a user can search for basic and critical information such as personal data, vehicle data and fuel level and road condition. It is worth mentioning that individual privacy and security are very important. Thus, the system has a security mechanism that refers to a security where the only authorized can login into the server. Thus, the system only allows access to authorized data

CONCLUSIONS

This paper proposes a framework for an intelligent traffic management expert system (ITMES). The main functions of the system are to trace criminal vehicles and to help the user to find the optimal route to reach the destination and the no signals between the source and destination. Thus, a dynamic guided system can use the information provided by zigbee transceiver to find a path that avoids traffic congestion. To explore the practical efficiency of the system, we implemented the real time vehicle tracking using RFID examine all factors using LABVIEW and PICDERM.

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