A Public Transport System Based Sensor Network for Fake Alcohol Detection

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Abstract. Illicit and spurious alcohol consumption is leading to numerous deaths in rural India. The aim of this paper is to reduce the death due to the consumption of spurious alcohol by reducing the production of spurious alcohol. A Vehicular Ad-Hoc Sensor Network, MovingNet, is used to detect the production of spurious alcohol. Multiple sensors capable to detect the presence of methanol content or diazepam in a wide geographical area, is incorporated on the available public transport system that traverse through the rural areas of India, where high rate of spurious alcohol production is observed. The data received from the wireless sensors will be transmitted using the delay tolerant, public transport vehicular ad-hoc network, and analyzed at the central data management center. The results of the data analysis will provide the details of geographic information, the amount of presence of methanol content or diazepam, and the warning degree. This will be sent to the excise department which will help them to locate the position and stop the production of spurious alcohol. Thus the implementation of MovingNet will reduce the production of spurious alcohol and contributes the reduction in hazards due to the consumption of spurious alcohol. MovingNet is a cost effective solution since it uses a very few sensors and the available public transport system for data collection and transmission.

Keywords: Alcohol Sensorl Fake Alcohol, GPS, MovingNet, Sub Stations.

1 Introduction

The production and consumption of spurious alcohol causes severe health problems or even leading to death in rural parts of India. Statistical studies proved that the rate of the casualties is increasing day by day. The objective of this paper is to control the production of spurious alcohol and thereby cut down the deaths due to the consumption of spurious alcohol. In order to control the production of spurious alcohol, a wide geographical area needs to be monitored in a periodical basis.

A Vehicular Ad-Hoc Sensor Network, MovingNet is used for the monitoring of geographical area to detect the production of spurious alcohol. In many countries, the public transport buses cover almost all areas of a territory[1]. In the MovingNet architecture, multiple sensors which are capable of sensing the presence of methanol or diazepam content in air is incorporated on the public transport system.

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In MovingNet, each vehicle can be considered as a mobile unit that consists of sensor node and external memory. Each sensor node consists of one or more sensors for the detection of alcohol content and the GPS for locating the coordinates of the place being monitored. The data collected by the sensor nodes is being aggregated in a central place, analyses it and issues warning whenever necessary. Depending upon the sensors used in the sensor nodes the MovingNet architecture can be used for variety of terrain monitoring applications that are delay tolerant in nature.

MovingNet alerts concerned authorities to the existence and location of spurious alcohol; thus, enabling the much needed reduction of the production, consumption and hazardous effects of spurious alcohol.

2 Related Works

The DakNet[3] provides digital communication services to remote villages using buses as a mechanical backhaul [4] for data transfer. The use of buses in DakNet is purely for data transfer between Internet access points and Internet kiosks in villages. In MovingNet the buses provide the means to sense, collect and transfer data necessary for reduction in alcohol hazards.

DataMULEs[5] architecture uses mobile entities, including buses, to collect data from sensors deployed in an environment and ferry them to access points. In contrast the buses in MovingNet are not simple ferries; they carry the sensors and they are the data collection source. DakNet and the Data MULEs are examples of delay tolerant networks [5]. They are proposed as solutions for the lack of better communication infrastructure. However, the MovingNet is proposed purely as a low cost solution, and uses the capability to reach most appropriate place data collection such as rural India.

Even if a good communication infrastructure exists, the data collection and transporting buses in the MovingNet are the most natural form of communication infrastructure for the road surface monitoring system. MovingNet provides physical security for the sensors, reduces the cost of deploying sensors, and also simplifies the management and maintenance of the sensors.

In ZebraNet [6] Zebras carry collars that contain sensors and the collected data are transferred to other Zebras and collection points opportunistically. ZebraNet is conceptually closest to the MovingNet. However, there is a crucial difference between ZebraNet and MovingNet. Whereas ZebraNet is an ad-hoc opportunistic network, in the MovingNet there is a stable fixed infrastructure for data transfer. The bus routes are regularly serviced by scheduled buses barring a major disaster which is an exception rather than the rule. Therefore, the MovingNet is a stable network and it has stable network routes. If not for the mobile buses it can even be called a fixed network.

Zhao et al.[7] also present a vehicle assisted data delivery system for vehicular ad-hoc networks. In that work the vehicles are used as data carriers and the route to the destination is set up based on the ad-hoc connectivity of the vehicles. In contrast, the MovingNet not only delivers data it also generates data and furthermore in MovingNet we use the stable transport infrastructure and does not rely on the ad-hoc connectivity between vehicles.

MovingNet, which implements a sensor network on top of the public transport network, is ideal for monitoring the road surface condition; the sensor mounted buses use the very roads that we want to monitor. We designed the road surface monitoring system based on the MovingNet. In this system one of the heavy users of the road system and hence a major contributor to the deterioration of the road surface helps in

monitoring of the road system. A few hours of latency in MovingNet is not an obstacle to this application because the data gathered on road surface condition are not needed in real time.

3 System Design

MovingNet is designed for monitoring the presence of fake alcohol in a wide geographical area. Effective monitoring of wide geographical area requires large number of static sensor nodes spread over the monitoring location. Such a sensor system with large number of static sensors poses several problems. It would be quite expensive to develop a system with large number of static sensors when each sensor is expensive. Maintaining and managing a system that has large number of static sensors is quite difficult. The regular replacement of batteries and replacement of faulty sensors are costly and labor intensive tasks. In addition, locating faulty sensors to replace them is not an easy task. Protecting a large number of sensors scattered throughout a large terrain is a daunting task. Sensors can be damaged by animals, heavy rains, and there is also a possibility of vandalizing.

It is observed that most countries have a public transport system that spans the country. MovingNet makes use of the existing public transport system as the backbone of the proposed network architecture. MovingNet has several sensors mounted on the vehicles of the public transport system as a replacement for a network consisting of large number of static sensors. These vehicle mounted moving sensors gather data that covers a large geographical area. When the buses arrive at bus stations, which also function as data collection centers, gathered data are transferred over a wireless link to the collection point. Data gathered in regional collection points are transferred to buses traveling between the regional centers and the main collection center. In this scenario the public transport system functions as a data delivery network as well as a data collection network. It is assumed that the gathered data are not required in real time. The data collected by the alcohol sensors are not immediately transferred to the data processing unit. Therefore this network is delay tolerant.

3.1 MovingNet Architecture

Fig. 1 depicts the architecture of the MovingNet. The MovingNet has three main components; Sensor Units, Sub- stations, and Main Station.

1) Sensor Unit: The sensor unit consists of a Crossbow MICAz mote [2], and several sensor boards including a GPS sensor board. The sensor boards contain sensors to gather the information regarding methanol level, temperature, carbon monoxide level, location etc. This sensor unit will be mounted on top of a bus and is powered from the battery of the bus. The sensors gather the required data along the bus route. The sensed data together with the GPS coordinates will be stored in the memory of the sensor mote. Extra storage device, such as a flash drive, can be added to the sensor unit.

The sensor unit is capable to act as a sensing unit and also as a router. The buses that travel towards the sub-station will collect the data from the buses travelling in the opposite direction and delivers the data to the sub-station. This will reduce the delay in data transfer.

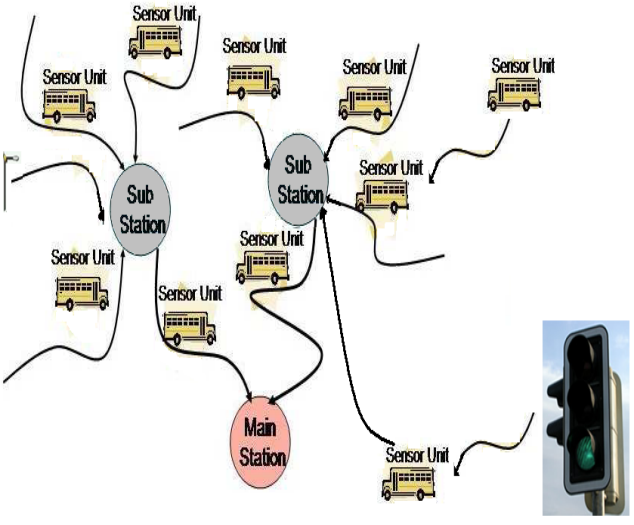

Fig. 1. MovingNet System Architecture

2) Sub-station: The sub-stations are the collection nodes located at the regional bus stations. Regional bus routes span out from the sub-stations. Buses going out and coming towards the sub-stations collect data about the alcohol content beyond the threshold level at regular intervals and store them together with the GPS coordinates. Once the buses reach the sub-station the data are transmitted over a wireless network to the data collection unit. The data analysis is done only at the main station. Therefore the sub- stations route these collected data to the main station over the bus network. This routing can be done by transferring the collected data from the sub-station to the sensor unit of buses heading to the main station.

3) Main-Station : The collected data from all sub stations reach the main station and it is stored in a central database at the main station. Further these data are analysed and issues an alarm whenever a coordinate with high methanol content is identified. The main station also has a list of coordinates where the licensed production of methanol is permitted. This will help in avoiding false alarms.

3.2 Data Transfer Protocol

When the bus reaches the sub-station or main station the data is transferred to the data collection unit through the wireless network. The main bottleneck associated with this data transfer is that, the buses may not wait at the station until the completion of the data transfer. To handle this problem a protocol which prioritizes the data transfer is designed. It transfers data collected at 1 kilometer intervals first and the bus stays in the station for longer time it transfers data collected at 500 meters interval and so on.

The protocol prioritizes the data based on the spatial coordinates so that the data collected over a large area is transferred first and only covers the points in between if the time permits. In addition to this, when there is more than one bus transferring

data, the station must make sure that it collects data from all the buses in a round robin basis to ensure that it collects data from all the routes in a fair manner.

The proposed data transfer protocol does not stop to retransmit lost packets; that is, if a packet is lost its retransmission is delayed and retransmission starts only after the first attempt transmission of all the packets. Therefore, retransmission takes place only if the bus stays long enough to retransmit. Priority is given to the first attempt packets to ensure transmission of data to cover a large terrain as much as possible. The main station is similar to the sub-stations but it has a direct connection to the data processing centre and it does not have to route data to other stations. The data analysis and alarm issuing is done in the main station.

3.3 System Operations and Control Flows

Fig. 2 shows the control flows of the MovingNet system for alcohol detection. The sensor units, S1, S2,…….....Sn, are fixed on top of n vehicles. Whenever the methanol or diazepam content in air crosses the threshold level the GPS associated with the sensor unit records the co-ordinate position and stores it in the memory. The data collected in the sensor unit can be transferred to the processing centre by the following methods:

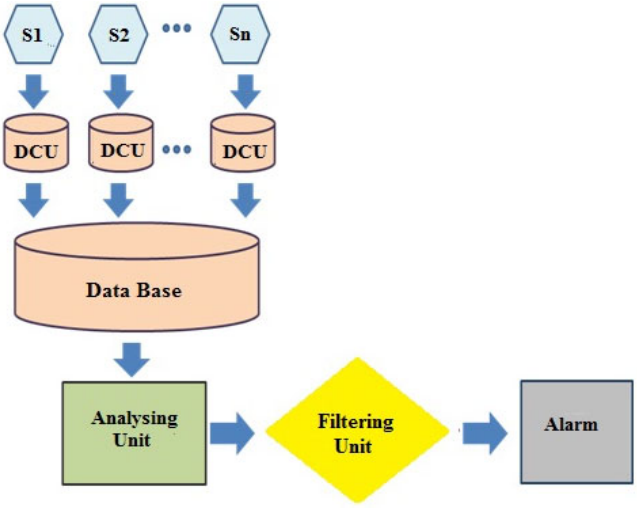

Fig. 2. MovingNet Flow Control Diagram

1) Store and Forward: The data stored in the sensor unit is transferred to the data collection unit placed in the substations, Fig 1. All data analysis is done in the main station. Therefore the data collected in all the sub-stations need to be transferred to the main station. In store and forward method, as on Fig 3, the sub-stations collect data from the vehicles, say V1,V2,V3 and V4, when they reach the station. The data analysis is done at the main station. Therefore the collected data are forwarded to the main station by sending it back to the vehicles that head to the main station.

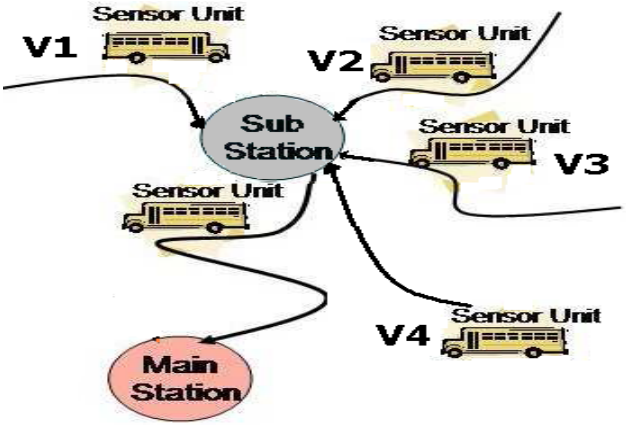

Fig. 3. Store and Forward Data Transfer

2) Mobile Data Transfer: In this method, as shown in Fig. 4., the data stored in the sensor unit associated with a vehicle, V1, is transferred to the sensor unit of another vehicle,V2, which crosses V1 and is expected to reach a sub-station before V1 reaches a sub-station.

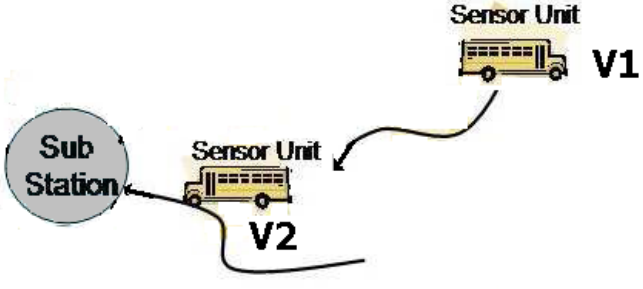

Fig. 4. Mobile Data Transfer

3) Intermediate Store and Forward: Intermediate store and forward method is a combination of the above mentioned methods. In this method, as shown in Fig 5, the data stored in a vehicle,V1 is transferred to the memory unit connected to stationary objects like street light, traffic light or mobile tower. These data can be transferred to vehicles, like V2, that cross the unit and is expected to reach a sub-station or main station before V1. In the main station the collected data are analysed and issues an alarm in the form of an emergency call or SMS. The comparison unit helps to avoid unnecessary alarms if the GPS coordinate value matches the flagged coordinate values of licensed production units of the ingredients of fake alcohol.

On receiving the alarm the concerned authority is expected to take the necessary action.

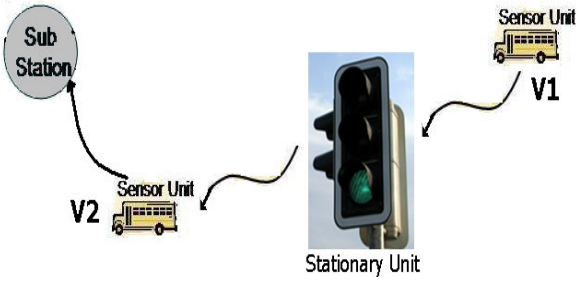

Fig. 5. Intermediate Store and Forward Data Transfer

4 Advantages of the System

MovingNet has several advantages over a traditional sensor network system and it solves the problems associated with a large number of sensors spread over a large terrain as follows.

The MovingNet uses only a few moving sensors instead of large number of static sensors. This brings down the cost of the monitoring system. Power management is the main problem as far as any Wireless Sensor Network(WSN) system is concerned. In MovingNet the sensor node takes power from the battery of the vehicle to which it is fixed. Therefore no periodical replacement of battery is needed. The GPS stores the coordinates of the location only when the sensor reading crosses the Minimum Resistance Limit(MRL). This will minimise the utilisation.

MovingNet architecture is flexible to change in accordance with the application requirement. The mobile units, carrier of the sensor node, can be a Public Transport Vehicle, a Military Vehicle or a Boat. Also the change in sensors used in sensor nodes makes the system useful for monitoring the terrain for different types of data.

Since the sensors eventually come to a Sub-station or the Main Station, maintenance work such as battery replacement, if needed, and the replacement or repairing of faulty sensors can be done at these stations. Buses are parked in secured areas when they are not in operation and this reduces the possible theft and damages to the sensors.

5 Challenges

The sensor should be able to withstand the tropical conditions – they are to be mounted on top of the buses. However, ruggedizing the sensor units is beyond the scope of this work and will not consider this for the prototype designing. A real world deployment certainly needs a robust sensor unit. In addition, the data gathered would be useless unless the authorities responsible for taking action establish a system to monitor the collected data and respond accordingly.

There may be situations in which similar ingredients should be present in the atmosphere when it is used for some other licensed purposes. In such cases the coordinates correspond to those places are marked and can be ignored during the analysis phase eventually avoiding from issuing alarms.

6 Conclusions

MovingNet, which implements a sensor network on top of the public transport network, is ideal for terrain monitoring. MovingNet is a novel approach in building vehicle based data network in the sense that the sensor system which collects the data and the data themselves travel in the vehicles. The intermediate collection of data in stationary sensors, such as traffic lights or electric posts, and data transfer while in motion, from vehicle to vehicle, increases the speed of data transfer. Even though the system is a delay tolerant one this can be used for applications like Urban-Rural data transfer in situations in which Internet connectivity is not available. The MovingNet reduces the cost of deploying a large number of static sensors by replacing them with a very few moving sensors. It also solves the management, maintenance, and the security problems associated with a sensor network deployed over a large terrain. MovingNet has got the flexibility to use in different applications only by changing the sensor(s) used in the sensor node. The basic architecture of MovingNet can also be modified by changing the mobile units, such as vehicles, related to the application.

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References

[1] Zoysa, K.D., Keppitiyagama, C.: A Public Transport System Based Sensor Network for Road Surface Condition Monitoring

[2] Crossbow Technology Inc. MPR-MIB user's manual (2006), `http://www.xbow.com`

[3] Pentland, A.S., Fletcher, R., Hasson, A.: Daknet: Rethinking connectivity in developing nations. Computer 37(1), 78–83 (2004)

[4] Seth, A., Kroeker, D., Zaharia, M., Guo, S., Keshav, S.: Low-cost communication for rural internet kiosks using mechanical backhaul. In: MobiCom 2006: Proceedings of the 12th annual international conference on Mobile computing and networking, pp. 334–345. ACM Press, New York (2006)

[5] Shah, R., Roy, S., Jain, S., Brunette, W.: Data mules: Modeling a three-tier architecture for sparse sensor networks. In: Proc. of the IEEE International Workshop on Sensor Network Protocols and Applications. IEEE, Los Alamitos (2003)

[6] Juang, P., Oki, H., Wang, Y., Martonosi, M., Peh, L.S., Rubenstein, D.: Energy-efficient computing for wildlife tracking: design tradeoffs and early experiences with zebranet. SIGOPS Oper. Syst. Rev. 36(5), 96–107 (2002)

[7] Zhao, J., Cao, G.: VADD: Vehicle-assisted data delivery in vehicular ad hoc networks. Technical Report NAS-TR-0020-2005, Network and Security Research Center, Department of Computer Science and Engineering, Pennsylvania State University, University Park, PA, USA (July 2005)