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Middleware Architecture of VASNET and Its Review for Urban Monitoring & Vehicle Tracking

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Abstract-

Vehicular ad hoc Sensor Networks (VASNETs) are emerging as a recent field which inherit its characteristics from Vehicular ad hoc Networks (VANETs) and Wireless Sensor networks (WSNs). Rapid increase of vehicular traffic and congestion on the highways create problems for safe and efficient movement of traffic. VASNET is a network which utilizes wireless sensor features for vehicular network and it comprises of a large number of sensor nodes located in vehicles and elsewhere. A sensor node is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. In a VASNET, constituent mobile vehicles continuously generate a huge amount of sensed data. This sensed data is the real time phenomena like density of vehicles, number of vehicles, size of vehicle and any other relevant data. This sensed data helps in traffic safety administration, reduce the number of accidents by warning drivers about the danger before they actually face it and useful for crime scene investigation. However there is a problem of searching sensed data in an enormous, movable and decentralized storage when scalability may be up to thousands of nodes in a mobile environment. In this research we will review middleware architecture. This architecture will help in detecting the vehicles and permit tracking.

Keywords: VASNET, VANET, WSN, WANETs, SINA, COSMO, V-BIS

I. INTRODUCTION

Wireless telecommunications refer to the transfer of information between two or more hosts that are not physically connected. Distances can be short, such as a few metres for television remote control, or as far as thousands or even millions of kilometres for deep-space radio communications. It includes various types of fixed, mobile, and portable applications including two-way radios, cellular telephones, personal digital assistants (PDAs) and wireless networking. Wireless systems operate with the help of a centralized supporting structure such as an access point. These access points assist the wireless users to keep connected with the wireless system, when they roam from one place to the other. Wireless telecommunications networks are generally implemented and administered using a transmission system called radio waves. This implementation takes place at the physical layer of the OSI model network structure [1].

Ad hoc is a Latin word which means “for this”. It generally signifies a solution designed for a specific problem or task. Figure 1 depicts the hierarchy of wireless ad hoc networks. Wireless ad hoc Networks (WANETs) which may consist of (i) Wireless Mesh Networks (WMNs), which is a communication network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may but need not connect to the Internet, (ii) Mobile ad hoc Networks (MANETs), which is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. Nodes in a mobile ad hoc network are free to move and organize themselves in an arbitrary fashion, and (iii) Wireless Sensor Networks (WSNs), which consist of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as density of vehicles, number of vehicles, size of vehicle and any other relevant data and to cooperatively pass their data through the network to a main location. Vehicular ad hoc Networks (VANETs) are a part of MANETs [1]. Vehicular Sensor Networks inherit their features from both Wireless Sensor Networks (WSNs) and Vehicular ad hoc Networks (VANETs) [2].

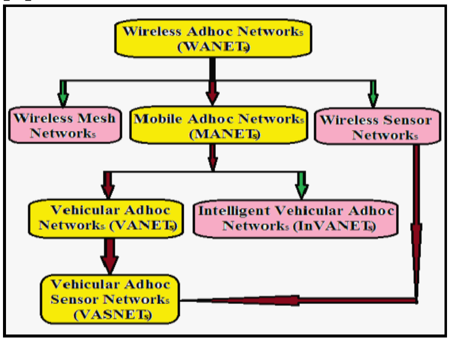

Figure 1: Hierarchy of Wireless ad hoc Networks.

II. VANETs

VANETs (Vehicular ad hoc Networks) use moving cars as nodes in a network (Figure 2) to create mobile networks. VANETs are used for communication among vehicles and between vehicles and roadside equipment. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 metres apart to connect and, in turn, create a network with a broad range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created. It is estimated that the first systems that will integrate this technology are police and fire vehicles to communicate with each other for safety purposes [3]. Figure 2 shows the inter-vehicle communication, vehicle-to-roadside communication and inter-roadside communication in a Vehicular ad hoc Network.

Vehicular ad hoc Networks (VANETs) turn each constituent vehicle into a wireless router or nodes. This depends upon the routing protocol used by the VANET. In VANET, the routing protocols are classified into five categories: (i) Topology based routing protocols, (ii) Position based routing protocols, (iii) Cluster based routing protocols, (iv) Geo-cast routing protocol (Geo-cast refers to the delivery of information to a group of destinations in a network identified by their geographical locations and is a specialized form of multicast addressing used by some routing protocols for mobile ad hoc networks), and (v) Broadcast routing protocols. These protocols are characterized on the basis of area and application where they are most suitable. Further, topology based routing protocols are classified into three categories: (a) Proactive, (b) Reactive and (c) Hybrid routing protocols [5]. The onboard sensors' readings can be displayed to the drivers via monitors to be aware of the vehicle condition or emergency alarms, and also can be broadcast to the other adjacent vehicles. VANET can also be helped by some of Roadside Units (RSU) like Cellular Base Stations, to distribute the data to the other vehicles. VANET makes widespread use of wireless communication to achieve its aims [2].

VANET is a kind of Mobile ad hoc Networks (MANET) with some differences like (i) In a MANET mobile phones have power limitation while this is not a limitation in a VANET because vehicles have their own relatively large battery, (ii) Moving pattern is random in the MANET, while vehicles tend to move in an organized fashion in a VANET, and (iii) Mobility is high in a VANET in comparison to MANET. However, self-organization and lack of infrastructure are similarities between MANET and VANET [2].

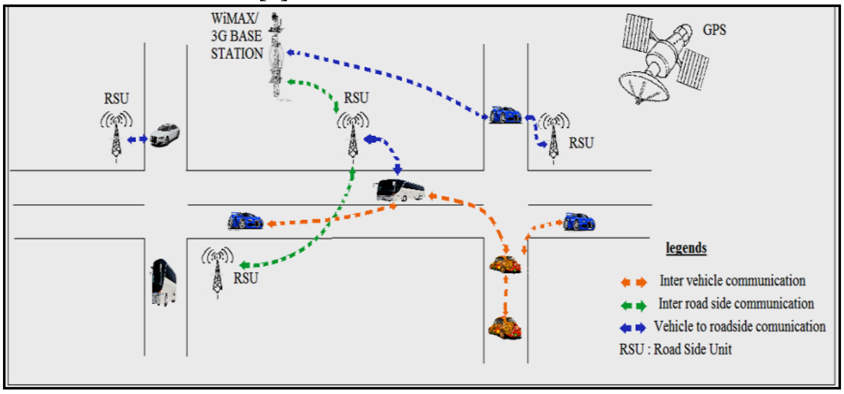

Figure 2: Vehicular ad hoc Networks.

III. VASNETs

Vehicular Adhoc Sensor Networks (VASNETs) inherit their features from both Wireless Sensor Networks (WSNs) and Vehicular ad hoc Networks (VANETs). VANETs are the most important component of Intelligent Transport System (ITS), in which vehicles are equipped with some short-range and medium range wireless communication as shown in Figure 3. In VANETs two kinds of communication are possible: Vehicle-to-Vehicle and Vehicle-to-road side units, where the road side units might be cellular base station. There are two types of sensor nodes in VASNET, some are implanted in the vehicles- known as Vehicular Nodes (VN) and others are deployed in predetermined distances besides the highways known as Road Side Sensor nodes (RSS) [2].

A. Components of VASNET

1) Vehicular Sensor Nodes (VSNs):

Vehicular Sensor Nodes are carried by the vehicles. These nodes sense the real time phenomena e.g. density of vehicles, number of vehicles, size of vehicle and any other relevant data. A sensor node is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. The sensor readings are sent to the base stations via Road Side Sensor nodes (RSS). These sensor nodes can communicate with each other or the roadside sensor via short-range communication.

2) Road Side Sensors (RSSs)

Road Side Sensors (RSSs) are at fixed distances along the roads. RSSs act as cluster heads or head of the Cluster for vehicular nodes. Clustering is grouping of similar objects or sensors in perspective of distance or logical distribution. There are different types of Clustering like (a) static: A static cluster is a group of application servers in an Application

Server Network Deployment environment that participates in workload management, (b) dynamic: (i) In dynamic clustering network parameters are changeable, (ii) use single hop and multi hop to convey information from source to destination, (iii) may be built with homogeneous and heterogeneous architectures. RSS nodes receive the data from mobile nodes and retransmit towards the Base Stations (BSs). These nodes are equipped with two kinds of antenna, unidirectional and bidirectional. Unidirectional antenna is for broadcasting and bidirectional antenna are intended for geo-casting. Geo-casting here refers to the delivery of information to a group of destinations in a network identified by their geographical locations. It is a specialized form of multicast addressing used by some routing protocols for mobile ad hoc networks.

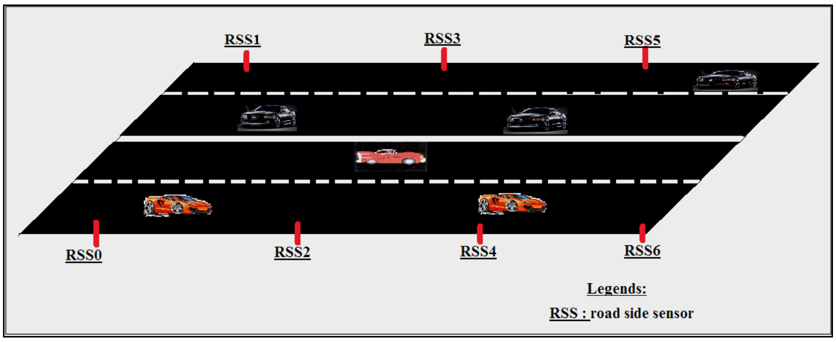

Figure 3: VASNET Networks.

3) Base Station (BS)

Base Station (BS) is a short-range transceiver which connects a cordless phone, computer, or other wireless device to a central hub and allows connection to a network. It facilitates wireless communication between user equipment (UE) and a network. UEs are devices like mobile phones (handsets), WLL phones, and computers. The network can be that of any of the wireless communication technologies like GSM, CDMA or other wide area network (WAN) technology. Base Stations are Police Traffic Control Check-Post, Rescue Team Buildings or Fire Fighting Stations along the roads. There is also some mobile Base Stations like Traffic Police patrolling team, Fire fighting Truck or ambulance [2].

IV. LITERATURE REVIEW

A lot of research has been carried out on Architecture of Wireless Sensor Networks including VANETs and VASNETs.

Piran, M.J., et al [2] proposed a system to utilize Wireless Sensor Networks for vehicular networks employing WSNs as Vehicular ad hoc and Sensor Network, or VASNET. This paper presented a state-of-the-art survey in Vehicular ad hoc and Sensor Networks (VASNETs), a fusion of Wireless Sensor Networks (WSNs) and Mobile Ad Hoc Networks (MANETs), as a promising approach for future intelligent transportation system (ITS). The proposed VASNET was particularly for highway traffic.

Hughes, B., et al [3] designed an event-based middleware, called RT-STREAM, which was based on an implicit event model and had been used for mobile applications and ad hoc networks. RT-STREAM differs from other event based middleware in that it does not rely on the presence of any separate infrastructure and distributed techniques for identifying and delivering events based on location.

Lee, U., et al [4] proposed “MobEyes”, for urban monitoring based on the primary idea of exploiting vehicle mobility to opportunistically diffuse concise summaries describing sensed data. The reconstruction of a crime and, more generally, the posterior investigation of an event potentially monitored by distributed mobile sensors, e.g., the nodes of a Vehicular Sensor Network (VSN), require the collection, storage, and retrieval of massive amounts of sensed data.

Srisathapornphat, C., et al [5] introduced a sensor information networking architecture, called SINA (sensor information networking architecture) that facilitates querying, monitoring, and tasking of sensor networks. SINA plays the role of a middleware that abstracts a network of sensor nodes as a collection of massively distributed objects.

Anthony, A., et al [6] proposed vehicular control system architecture based on dynamic mapping of processes and services to resources to meet the challenges of future in which systems must be flexible to exhibit context-aware behaviour and to permit customization.

Phalak, K., [7] described “CoSMo”, a Cognitively Inspired Service and Model Architecture for situational awareness and monitoring of vehicular traffic in urban transportation systems using a network of wireless sensors. The system architecture combined (i) a cognitively-inspired architecture to internally represent static as well as dynamic models of external world to support a rich class of user and administrative tasks, and (ii) a service architecture to represent and facilitate the interplay between the (a) individual modules of the internal representation, (b) the external world comprising of the sensors and the urban transport system and (c) the individual users, including system managers who were interested in various tasks relating to such infrastructure systems.

Mechitov, K.A., et al [8] designed two techniques for WSN software development: (i) dynamic macro programming and (ii) service-oriented architecture. This programming framework presented a powerful, flexible programming environment for wireless sensor networks.

Leppanen, T., et al [9] developed a middleware for sensor data processing. They developed a platform for traffic based sensor data network. The Global Sensor Network (GSN) was selected because of amount of ready-made features and runtime dynamic changeability. GSN provides access control mechanism for the whole system, or on the level of an individual sensor.

Gnanamurthy, R.K., et al [10] discussed design and analysis of architecture of InVANET (Intelligence VANET). InVANET focused on incorporating intelligence into vehicular system, which can be employed in various safety scenarios such as minimizing vehicular accidents, managing vehicular traffic intensity, information for traffic cops on hit and run, avoiding vehicle theft and locating vehicles on drive way.

Sriborrirux, W., et al [11] defined the communication protocols and software design for middleware components of B-VIS (Burapha Vehicle-Infrastructure System). The proposed B-VIS middleware architecture serves the needs of a distributed sensor network and simplifies some complex details of several communication standards.

Caviglione, L., et al [12] implemented a communication middleware for mobility applications on vehicular ad hoc networks (VANETs). The main purpose of such a cooperative sharing is to support infotainment applications, e.g., distribution of multimedia content. The VANET may also play additional roles; for instance, it may allow information to flow back from the data centre to the cars (e.g. delivery of traffic alerts or route prescriptions to individual users or groups) as well as from car to car.

Blair, T.S.G., et al [13] discussed a component framework based middleware architecture designed to meet the challenges of wireless environments. The research challenges were communication model, routing protocol, end-to- end QoS (Quality-of-Service) and fail-safety. They addressed these challenges and provide their solutions as different component frameworks (CF). The middleware platform consists of, Publish-Subscribe CF, Group communication CF and Context CF.

V. RESEARCH METHODOLOGY

Piran, M.J., et al [2] proposed a system to utilize Wireless Sensor Networks for vehicular networks employing WSNs as Vehicular ad hoc and Sensor Network, or VASNET. They explained feasible topology and communication architecture applicable to VASNET and also conceivable applications were introduced. **Hughes, B.,** et al [3] designed an event-based middleware, called RT-STREAM, which was based on an implicit event model and had been used for mobile applications and ad hoc networks. RT-STREAM differs from other event based middleware in that it does not rely on the presence of any separate infrastructure and distributed techniques for identifying and delivering events based on location. RT-STEAM supports decentralized approaches for discovering peers and routing event notifications using a distributed addressing scheme. **Lee, U.,** et al [4] authors had developed MobEyes for VSN based proactive urban monitoring. MobEyes exploited wireless enabled vehicles equipped with video cameras and a variety of sensors to perform event sensing, processing of sensed data, and ad hoc message routing to other vehicles. **Srisathapornphat, C.,** et al [5] introduced a sensor information networking architecture, called SINA (sensor information networking architecture) that facilitates querying, monitoring, and tasking of sensor networks. **Anthony, A.,** et al [6] proposed vehicular control system architecture based on dynamic mapping of processes and services to resources to meet the challenges of future in which systems must be flexible to exhibit context-aware behaviour and to permit customization. **Phalak, K.,** [7] described "CoSMo", a Cognitively Inspired Service and Model Architecture for situational awareness and monitoring of vehicular traffic in urban transportation systems using a network of wireless sensors. **Mechitov, K.A.,** et al [8] designed two techniques for WSN software development: (i) dynamic macro programming and (ii) service-oriented architecture. They developed a suite of robust, energy-efficient middleware services to complement the macro programming environment. **Leppanen, T.,** et al [9] developed a middleware for sensor data processing. They developed a platform for traffic based sensor data network. The Global Sensor Network (GSN) was selected because of amount of ready-made features and runtime dynamic changeability. **Gnanamurthy, R.K.,** et al [10] designed and analysis the architecture of InVANET (Intelligence VANET). InVANET focused on incorporating intelligence into vehicular system, which can be employed in various safety scenarios such as minimizing vehicular accidents, managing vehicular traffic intensity, information for traffic cops on hit and run, avoiding vehicle theft and locating vehicles on drive way. **Sriborrirux, W.,** et al [11] defined the communication protocols and software design for middleware components of B-VIS (Burapha Vehicle-Infrastructure System). The proposed B-VIS middleware architecture serves the needs of a distributed sensor network and simplifies some complex details of several communication standards. **Caviglione, L.,** et al [12] implemented a communication middleware for mobility applications on vehicular ad hoc networks (VANETs). **Blair, T.S.G.,** et al [13] designed middleware architecture to meet the challenges of wireless environments. The research challenges were communication model, routing protocol, end-to- end QoS (Quality-of-Service) and fail-safety. They addressed these challenges and provide their solutions as different component frameworks (CF). The middleware platform consists of, Publish-Subscribe CF, Group communication CF and Context CF.

VI. CONCLUSION

VANETs are the most important component of Intelligent Transport System (ITS), in which vehicles are equipped with some short-range and medium range wireless communication. Vehicular Sensor Nodes are carried by the vehicles. These nodes sense the real time phenomena e.g. density of vehicles, number of vehicles, size of vehicle and any other relevant data. Middleware architecture for urban monitoring based on the primary idea of exploiting vehicle mobility to opportunistically diffuse concise summaries describing sensed data. The reconstruction of a crime and, more generally, the posterior investigation of an event potentially monitored by distributed mobile sensors, e.g., the nodes of a Vehicular Sensor Network (VSN), require the collection, storage, and retrieval of massive amounts of sensed data.

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