# WSN Applications: Automated Intelligent Traffic Control System using Sensors

**Rashid Hussian, Sandhya Sharma, Vinita Sharma, Sandhya Sharma**

***Abstract—In this new Era the growing Vehicle population in all developing and developed country calls for a major improvement and innovation in the existing Traffic Signaling systems. The most widely used automated system uses a simple time based system which working on a time interval basis which is now inefficient for random and non uniform Traffic. Advance automated systems in testing use image processing techniques or advance communication system with an intelligent information gathering systems in vehicles to communicate with signal and ask for routing. This might be implementable in developing countries as they are more complex and expensive also.***

***The Concept Proposed in this paper involves use of Wireless sensor network technology to sense presence of Traffic near any circle or junction and then able to route the Traffic based on Traffic availability or we can say density in desire direction. This system does not require any system in vehicles so can be implemented in any Traffic system quite easily with less time and less expensive also. This system uses Wireless sensor networks Technology to sense vehicles and a microcontroller based routing algorithm programmed for excellent Traffic management.***

***Keywords—Intelligenttrafficsignals, intelligentrouting, smart signals, wireless sensornet works.***

## I. INTRODUCTION

The Traffic density is increasing at an alarming rate in developing countries which call for the need of Advance intelligent Traffic signals to replace the Conventional manual and time based Traffic signal system. Experimental system in existence involve image processing based density identification for routing of traffic which might be inefficient in situation like fog, rain and dust etc. The Other Conceptual System which is based on interaction of vehicles and cannot be practically implemented in countries like India which have almost more than 100 million vehicles on Road [1].

The system proposed here involves localized Traffic routing for each intersection junction based on wireless sensor Networks. The proposed system has a central microcontroller at every junction which receives data from tiny wireless sensor nodes place on the Road. The sensor nodes have sensors that can detect the presence of vehicle and the transmitter wirelessly transmits the traffic density to the central programmable microcontroller. The Microcontroller makes use of the proposed programmed algorithm to find ways to manage and regulate traffic in a systematic manner efficiently.

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## II. THENEEDFORANALTERNATESYSTEM

The Most commonly used Traffic Signaling System in developing countries is the time based system. This system involves a predefined time interval setting for each junction road at an every junction. While this might be effectively work for light Traffic System, Heavy Traffic requires an adaptive system that will work based on digital image processing techniques. This system works based on the captured visual input from the roads and processing them to find which road or way has highly dense Traffic. This system fails during environmental interaction like rain, fog and ice fall etc. Also this system testing does not prove efficient and quite expensive also.

The advanced system in testing involves [2] signals communicating with each other and also with vehicles. The proposed system does not require a network b/w signals and vehicles and it is a standalone system at every junction which is quite easy to install and maintain also.

## III. COMPONENTSINVOLVEDINTHESYSTEM

The proposed system involves sensor networks which are made of tree basic components. 1. The Sensor nodes or Motes, 2. Power sourceand 3.Central processing unit Microcontroller.

The motes in turn are made of sensors and transceiver module. The sensor sense the presence the vehicles at intersection and transceiver transmit the sensor's data to the central processing microcontroller through a wireless medium. The power source provides the power needed for the sensor nodes and it is the most regenerative. The central microcontroller performs all the computations for the sensor networks. The microcontroller receives the input from all sensors and processes simultaneously to make the required decision.

**Sensors**

Sensors are hardware devices that produce a measurable response to a change in a physical condition like Temperature or Pressure. Sensor measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog to digital converter and send to controllers for further processing. A sensor node should be small in size, consume extremely low energy, operate in high volumetric densities, be autonomous and operate automatically, and be adaptive to the environment. As wireless sensor nodes are typically very small electronic devices, they can only be equipped with limited power source of less than 0.5 – 2 amp per hour and 1.2 – 3.7 volts. Sensors are implemented in this system placed beneath the roads in detectors that detect the presence of vehicles in their vicinity.

The sensor is set in four levels on each road signifying four levels of Traffic and signifies higher priority for the road to the controller. The sensors required detection can be either ultrasonic or Infrared Laser based sensors for better higher efficiency.[1]

**Motes**

A mote, also known as a sensor node is a node in a wireless sensor network that is capable of performing some processing like transmitting and receiving that signal, gathering sensory information and communicating with other connected nodes in the network. The main components of a sensor node are a microcontroller, transmitter, receiver, external memory, power source and one or more sensors.[1]

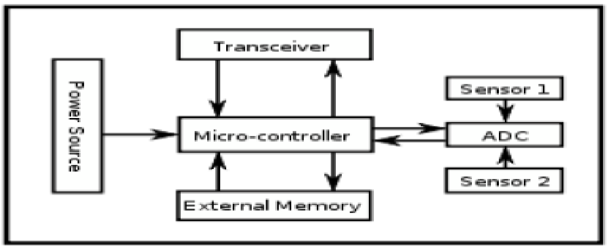


**Fig.1BlockDiagram ofaMote**

**Needfor Motes**

The first and primary responsibility of a Mote is to collect information through a predefine protocol from the various distributed sensors in any junction and to transmit the collected data or information to the central microcontroller for processing. Any type of sensor can be use with these Motes based on the requirement of the Traffic Control system. It is a complete new innovative technology for distributed sensing and its opens up a fascinating new way to look at sensors network.

**Advantages of Motes**

- Thecoreofamoteisasmall in size,low price andlow-power controller.
- The controller monitors one or more sensors. It is easy to interface all sorts of sensors, including sensors for temperature, light, sound, position, acceleration, vibration, stress, weight, pressure, humidity, etc. with the mote.
- The controller connects to the central controller with a radio link. The most common radio links allow a mote to transmit at a distance of about 3to61 meters. Power consumption, size and cost are the barriers to longer distances. Since a fundamental concept with motes is tiny size and associated tiny cost, small and low-power radios are normal.
- As motes shrink in size and power consumption, it is possible to imagine solar power or even something exotic like vibration power to keep them running. It is hard to imagine some thin gas small and innocuous as a mote sparking a revolution, but that's exactly what they have done.
- Motes are also easy to program, either by using serial or Ethernet cable to connect to the programming board or by using Over the Air Programming (OTAP).

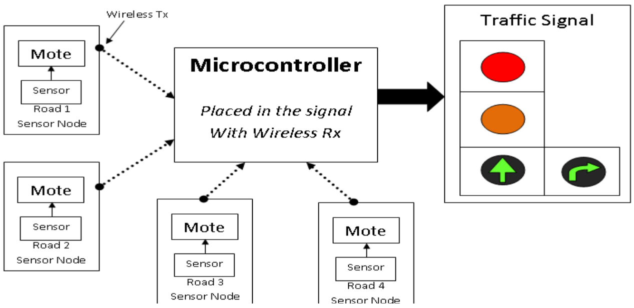


**Fig.2 Block Diagram of the Proposed System**

**Transceivers**

Sensor nodes often make use of Ism band, which gives free radio, spectrum allocation and global availability. The possible choices of wireless transmission media are radio frequency (RF), optical communication and Infrared. Lasers require less energy, but need line of sight for communication and are sensitive to atmospheric conditions. Infrared, like lasers, needs no antenna but it is limited in its broadcasting capacity. Radio frequency based communication is the most relevant that fits most of the Wireless Sensor Network applications. Wireless Sensor network tend to use license free communication frequencies like 173 MHz, 433 MHz, 868 MHz and 916 MHz and 2.4 GHz. The functionality of both transmitter and receiver and combined into a single device known as a transceiver.

To bring about uniqueness in transmitting and receiving to any particular device various protocols or algorithms are programmed. The Motes are often provided with powerful transmitter and receiver collectively known as Transceivers for better long range operation and also to achieve better quality of transmissions or reception in any environment conditions.

**Power Source**

The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. Power is stored either in batteries or capacitors batteries and may be either rechargeable or non rechargeable, are the main source of power supply for sensor nodes. Current sensors are able to renew their energy from solar sources, temperature differences, or vibration. Two power saving policies used are Dynamic power management (DPM) and Dynamic Voltage Scaling (DVS). DPM conserves power by shutting down parts of the sensor node which are not currently used or active. A DVS scheme varies the power levels within the sensor node depending on the non deterministic workload. By varying the voltage along with the frequency, it is possible to obtain quadratic reduction in power consumption.

**Tmote Sky**

Tmote sky is an ultra low power wireless module for use in sensor networks, monitoring applications, and rapid application prototyping. Tmote sky leverages industry standards like USB and IEEE802.15.4 to inter operate seamlessly with other devices. By using Industry standards, integrating humidity, temperature, and light sensors, and providing flexible interconnection with other peripherals,


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Tmote sky enables a wide range of mesh network application like ring topology, star topology, bus topology etc. The Tmote is one of the most commonly used motes in wireless sensor technology. Any type of sensor can be used in combination with this type of Mote.

Tmote sky features the Chipcon CC2420 radio for wireless communications. The CC2420 is an IEEE 802.15.4 complaint radio providing the PHY and some Mac [3] function with sensitivity exceeding the IEEE 802.15.4 specification and low power operation, the CC2420 provides reliable wireless communication. The CC2420 is highly configurable for many applications with the default radio settings providing IEEE.

802.15.4 Compliance ZigBee specification can be implemented using the built in transmitter in Tmote Sky.

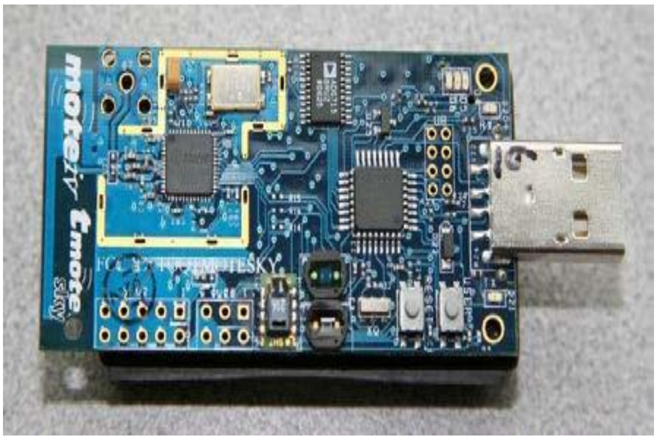



**Fig.3TmoteSky**

**Tmote Key Features**

- ❖ 250 Kbps 2.4 GHz IEEE 802.15.4 chipcon wireless transceiver.
- ❖ Interoperability with other IEEE 802.15.4 devices.
- ❖ 8 MHz Texas instruments MSP430 microcontroller (10 K ram, 48 K ram flash memory).
- ❖ Integrated ADC, DAC, Supply voltage supervisor, and DMA controller.
- ❖ Integrated on board antenna with 50m range indoors 125 m range outdoors.
- ❖ Integrated Humidity, Temperature, and Light sensors.
- ❖ Ultra low current consumption.
- ❖ Fast wakeup from sleep (<6 μs ).
- ❖ Hardware link layer encryption and authentication.
- ❖ Programming and data collection via USB.
- ❖ 16 pin expansion support and option SMA antenna Connector.
- ❖ Tiny OS support mesh networking and communication implementation.
- ❖ Complies with FCC part 15 and industry Canada regulations.
- ❖ Environmentally friendly complies with RoHS regulations.[3]

**ZigBee Wireless Technology**

ZigBee is a specification for a suite of high level communication protocols using small, Low power digital radio based on an IEEE 802.15.4 standard for personal area networks[4].ZigBee devices are often used in mesh Network from to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows ZigBee networks to be formed ad-hoc, with no centralized control or high power transmitter / receiver able to reach all of the devices. Any ZigBee device can be tasked with running the network. ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 Kbps, best suited for periodic or intermitted data or a single signal transmission from a sensor or input device. Application include wireless light switches, electrical meters with in Home displays, Traffic management systems and other consumer and industrial equipment that require short range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPAN's, such as Bluetooth.

**Types of ZigBee Devices**

ZigBee device are of three types.

1. **ZigBee coordination (ZC):**The Most capable device, the coordinator forms the root of the network tree and might bridge to other networks. There is exactly one ZigBee coordinator in each network since it is the device that started the network originally. It stores information about the network, including acting as the trust center & repository for security keys. The ZigBee coordinator the central controller is in this system.
2. **ZigBee Router (ZR):** In addition to running an application function, a device can act as an intermediate router, passing on data from other devices.
3. **ZigBee End Device (ZED):** It contains just enough functionality to talk to the parent node. It cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life.[4] A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or ZC.

**ZigBee Protocols**

The Protocols build on recent algorithmic research to automatically construct a low speed ad-hoc network of nodes. In most large network instances, the network will be a cluster of clusters. It can also form a mesh or a single cluster. The current ZigBee protocols support beacon and non-beacon networks. In non-beacon enabled networks, an un-slotted CSMA/CA channel access mechanism is used. In this type of network, ZigBee routers typically have their receiver continuously active, networks in which some devices receive continuously, while other only transmit when an external stimulus is detected. In beacon enable networks, the special network nodes called ZigBee routers transmit periodic beacons to confirm their presence to other network nodes. Researchers have developed many new protocols specifically designed for WSNs, where energy awareness is an essential consideration; focus has been given to the routing protocols, since they might differ from traditional networks (depending on the application and network architecture).[6] Nodes may sleep between beacons, thus lowering their duty cycle and extending their battery life. Beacon intervals depend on data rate; they may range from 15.36 ms to 251.6582s at 250 Kbps.

In general, the ZigBee protocols minimizes the time the radio is on, so as to reduce power use. In beaconing networks, nodes only need to be active while a beacon is being transmitted. In non beacon enabled networks, power consumption is decidedly asymmetrical. Some devices are always active, while others spend most of their time sleeping.

## IV. PROPOSEDALGORITHM

### 1 . Basic Algorithm

Consider a left side driving system (Followed by UK, Australia,Malaysia, India and 72 other Country). This system can be modified for right side driving system (USA, Canada, Russia etc.) quite easily. Also consider a junction of four roads numbered as node 1, 2, 3 and 4 respectively. Traffic from each node to three other nodes with varied densities. Consider road 1 now given green signal in all direction. The proposed traffic light control system works for both single and multiple intersections.In this section, we present the details of the control algorithm for single intersection case, while the extended version for the multiple intersection case.[9]

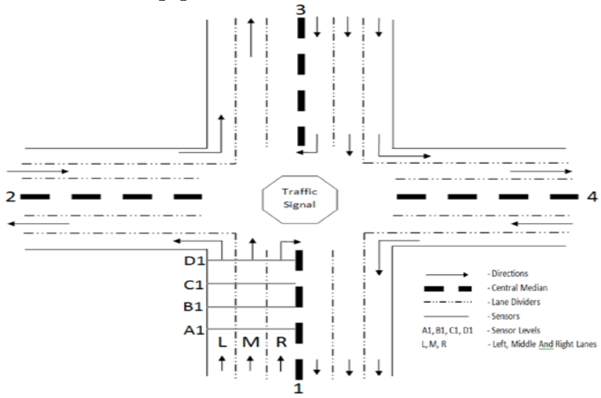



**Fig.4IntersectionunderConsideration**

1) Freeleftturnforallroads(freerightforrightsidedriving system).
2) Checkdensitiesatallothernodesandretrievedatafrom stripsensors.
3) Compare the data andcompute the highestdensity.
4) Allowthe node with highest density for 60sec.
5) Allowednodewaitsfor1timeslotforitsturnagainand the process is repeatedfromstep 3.

### 2. AdvancedAlgorithm

Assume road three is currently given green to all directions. All left turns are always free. No signals/sensors for left lane. Each road is given a time slot of maximum 60 seconds at a time. This time can be varied depending on the situation of implementation. Consider 4 levels of sensor Ax, Bx, Cx and Dx with Ax having highest priority and X representing roads 1 to 4. Also consider 3 lanes of Traffic which is Left (L), Middle (M) and right (R) corresponding to the direction of traffic. Since left turn is free, left lanes do not require sensors. So sensors form 4X2 arrays with 4 levels of traffic and 2 lanes and are named Max, RAx, RBx and so on and totally 32 sensors are employed. The following flow represents the sequence of operation done by the signal.

1. Each sensor transmits the status periodically to the controller.
2. Controller receives the signals and priorities are compared.
3. The sensors Ax from each road having highest priority are compared.
4. If a single road has traffic till Ax, it is given green signal in the next time slot.
5. If multiple roads have Traffic till Ax, the road waiting for the longest duration is given the green.
6. Once a road is given green, its waiting time is reset and its sensor status is neglected for that time slot.
7. If traffic in middle lane, green is given for straight direction, based on Traffic, either right side neighbor is given green for right direction, of opposite road is give green for straight direction.
8. If Traffic in right lane, green is given for right and based on traffic, left side neighbor is given for straight or opposite is given green right.
9. Similar smart decisions are incorporated in the signal based on traffic density and directional traffic can be controlled.In this section, the traffic light control algorithms presented earlier for single inter section are extended to work on multiple intersections to coordinate their operations and to smooth the traffic flow.[9]

**Implementation and Restrictions**

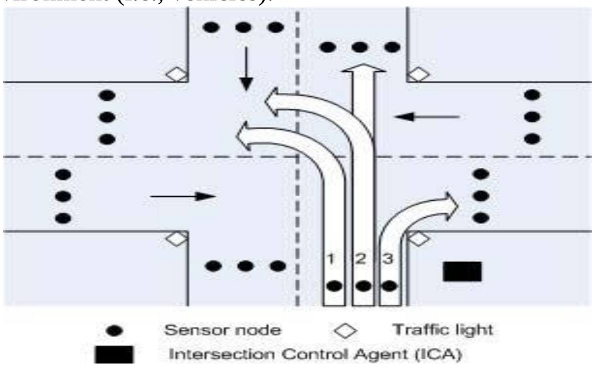
This system can be implemented by just placing or install the sensor nodes into the road or on lane divider and interfacing the central microcontroller to the existing signal lights and connecting the sensor nodes to the controller via the proposed wireless protocol.The sensing and communication range for a vehicle are different. Generally, the sensing range is smaller than the communication range, and it is generally non-isotropic. By exchanging sensed data, via the wireless network, the area of coverage of each vehicle will be enlarged. The area of coverage is a measurement of the quality of service of a sensor network. [7] The only restriction for implementing the system is taking the pedestrians into consideration. This has to be visualized for junctions with heavy traffic such as highway intersections and amount of pedestrians is very less. Also major intersections have underground or overhead foot paths to avoid interaction of pedestrians with heavy traffic.

## V. THEPROPOSEDSYSTEM

This Paper presents the model of Intelligent Traffic Routing using a Wireless Sensor Networks. The first and primary elements of this system are the wireless sensor nodes or motes consisting of sensors and transmitter. The sensors interact with the physical environment means vehicles presence or absence while the transmitter sends the sensors data to the central microcontroller. This system involves the 4*2 array of sensor nodes in each way. This signifies 4 levels of Traffic and 2 lanes in each way. The sensors are ultrasonic or an Infrared based optical sensor which transmits status based on presence of vehicle near it. The sensor nodes transmit at specified time intervals via ZigBee protocol to the central microcontroller placed at every intersection. The Microcontroller receives the signal and computes which road and which lane has to be given green signal based on the density of Traffic. The controller makes use of the discussed and planned algorithm to perform the Intelligent Traffic routing.

In this paper, the primary aim is to gather the information of moving emergency vehicles based on WSN to provide them a clear path till their destinations and traffic signals should switch automatically to give a clear way for these emergency vehicles.[8]

**Speed:-**
There are 3 tracks on the road. They are divided because of their speed rates like 1st track is 40-60 speed, 2nd track is 60-80 speed and the 3rd track is 80-100 speed.
If any vehicle of 2nd track break the rule and it comes into 1st track then due to sensor a horn generate on that vehicle and other horn generate in other vehicles to alert. So, they can save theirselves from the break rule vehicle.
**Intersection Control Agent**:- According to this[5]
The system prototype consists of four elements; 1) the wireless sensor network (WSN), 2) the intersection control agents (ICAs), 3) the actuators (i.e., traffic lights), and 4) the environment (i.e., vehicles).




***WITS*** system is used for the information gathering and data transferring.[5] There are 3 types of WITS nodes installed in this system: the *vehicle unit* on the individual vehicle; the *roadside unit* along both sides of a road; and the *intersection unit* on the intersection. The *vehicle unit* measures the vehicle parameters and transfers them to the roadside units. (Vehicle unit is installed in every vehicle.) The *roadside unit* gathers the information of the vehicles around, and transfers it to the intersection unit

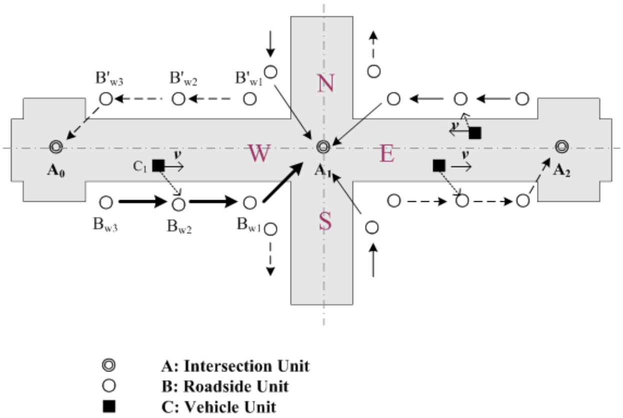



**Figure Intersection units, roadside units, vehicle units and their distribution in the road**

**A Fine Should Be Taken On The Toll Tax:-**
If there are any vehicle Break the rule then that can be sense by the help of sensor.That image, vehicle No.andall.And a horn will be generate still that vehicle ignore the rules then on the toll tax a fine should be taken by that culprit.

## VI. CONCLUSION

The above proposed System for Automated Intelligent Traffic Control system routing using Wireless sensor Networks is advantageous to many existing systems in this heavy population of vehicles. The wireless sensors nodes create a standalone system at each intersection making it easy to implement in the intersection having heavy density of vehicles. It is also cost inexpensive and does not require any system in the vehicles making it more practical than existing system with great results. The use of various systems of sensor nodes can be altered based on the requirement and any type of sensor can be used based on the feasibility of the location.

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