"Wireless Integrated System using IEEE 802.15.4"

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Abstract:
The demand for wireless technology in automation systems has widely been increased due to its inheritable advantages like reduce installation cost , minimum space consumption, easy extension, aesthetic benefits, and its increased connectivity options. Due to number of standard profiles available ZigBee provides wide scope to develop globalize & customize solutions over other wireless technologies. The paper describes the development strategy for the project intending to develop a new proposed model for an IEEE 802.15.4 based Wireless Integrated System for short range real time GIS applications. The new proposed model will mainly focus on receiving the GPS data in NMEA (National Marine Electronics Association) format as provided by the sensors & decode it for the required GIS applications. Wireless connectivity along with positioning options also forms the complementary concern to develop this new application proposed model.

Key Words: ZigBee, Wireless Sensor Network, Microcontroller, GPS, GIS, NMEA.

I. INTRODUCTION:
There are a number of standards that address mid to high data rates for the application specific devices such as PC LAN's, video, etc. but until now there has not been a wireless network standard that meets the unique needs of devices such as sensors and control devices. Sensors and control devices which are mostly used in industry and home distinguish themselves with low data rates and in needs of very low energy consumption. Out of number of wireless devices manufactured today which satisfies these requirements have the problem of interoportability in order to meet globalize product scenario. To meet these requirements a standards-based wireless technology which have the good performance graph for reliability, security, low power and low cost will always be preferred.

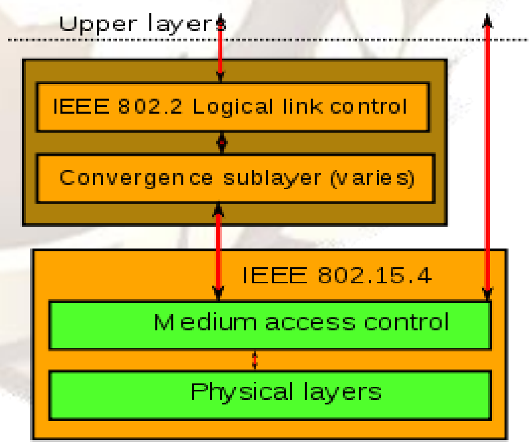
A. IEEE standard 802.15.4:
It intends to offer the fundamental lower network layers of a type of wireless personal area network (WPAN) which focuses on low-cost, low-speed ubiquitous communication between devices (in contrast with other, more end user-oriented approaches, such as Wi-Fi). The emphasis is on very low cost communication of nearby devices with little to no underlying infrastructure, intending to exploit this to lower power consumption even more.

The basic framework conceives a 10-meter communications range with a transfer rate of 250 kbit/s. Tradeoffs are possible to favor more radically embedded devices with even lower power requirements, through the definition of not one, but several physical layers. Lower transfer rates of 20 and 40 kbit/s were initially defined, with the 100 kbit/s rate being added in the current revision.

Even lower rates can be considered with the resulting effect on power consumption. As already mentioned, the main identifying feature of 802.15.4 among WPAN's is the importance of achieving extremely low manufacturing and operation costs and technological simplicity, without sacrificing flexibility or generality.

Important features include real-time suitability by reservation of guaranteed time slots, collision avoidance through CSMA/CA and integrated support for secure communications. Devices also include power management functions such as link quality and energy detection.

B. Protocol architecture:



IEEE 802.15.4 protocol stack:
Devices are conceived to interact with each other over a conceptually simple wireless network. The definition of the network layers is based on the OSI model; although only the lower layers are defined in the standard, interaction with upper layers is intended, possibly using a IEEE 802.2 logical link control sublayer accessing the MAC through a convergence sublayer. Implementations may rely on external devices or be purely embedded, self-functioning devices.

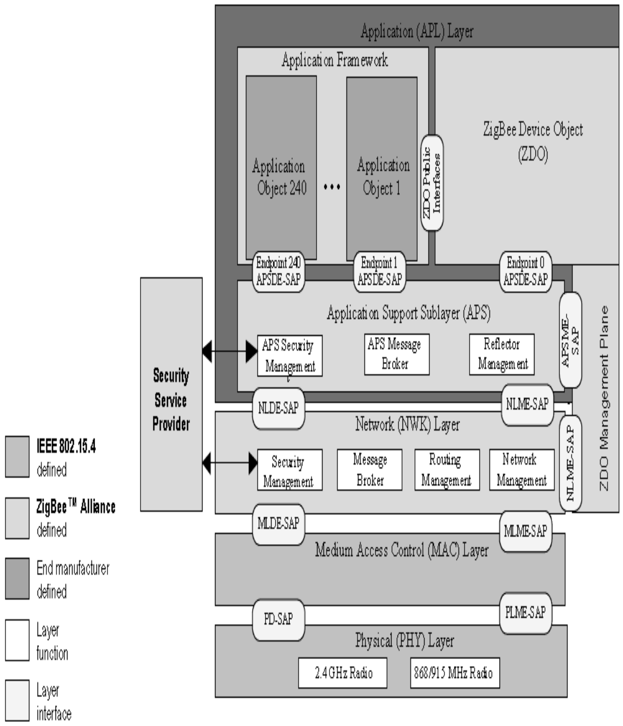
II. ABOUT ZIGBEE:

The ZigBee Alliance has developed very low-cost, very low-power consumption, two-way, wireless communications standard. Solutions adopting the ZigBee standard will be embedded in consumer electronics, home and building automation, industrial controls, PC peripherals, medical sensor applications, toys, and games

The ZigBee stack architecture is made up of a set of blocks layer called layers.Each layer performs a specific set of services for the layer above. A data entity provides a data transmission service and a management entity provides all other services.

The IEEE 802.15.4-2003 standard defines the two lower layers: the physical (PHY) layer and the medium access control (MAC) sub-layer. The ZigBee Alliance builds on this foundation by providing the network (NWK) layer and the framework for the application layer. The application layer framework consists of the application support sub-layer (APS) and the ZigBee device objects (ZDO).

Manufacturer-defined application objects use the framework and share APS and security services with the ZDO.



A. ZigBee: Working with Wireless Control

Wireless monitoring and control applications for industrial and home markets require longer battery life, lower data rates, and less complexity than those available from existing wireless standards. An IEEE 802.15 task group is investigating a low data rate solution with multi-month to multi-year battery life and low complexity. A highly integrated single-chip approach is the preferred solution of semiconductor manufacturers developing IEEE 802.15.4 compliant transceivers. The IEEE standard at the PHY is the significant factor in determining the radio frequency (RF) architecture, and topology of ZigBee-enabled transceivers.

ZigBee defines the network, security, and application framework profile layers for an IEEE 802.15.4-based system. ZigBee's network layer supports three networking topologies: star, mesh, and cluster tree. Star networks are common and provide for very long battery life operation. Mesh, or peer-to-peer, networks enable high levels of reliability and scalability by providing more than one path through the network. Cluster-tree networks use a hybrid star/mesh topology that combines the benefits of both for high levels of reliability and support for battery-powered nodes.

With a reduced stack size, it needs less memory, and thus a less expensive IC. ZigBee RFDs are generally battery powered. RFDs can search for available networks, transfer data from its application as necessary, determine whether data is pending, request data from the network coordinator, and sleep for extended periods of time to reduce battery consumption. RFDs can only talk to an FFD, a device with sufficient system resources for network routing. The FFD can serve as a network coordinator, a link coordinator, or as just another communications device. Any FFD can talk to other FFD and RFDs. FFDs discover other FFDs and RFDs to establish communications, and they're typically line powered.

B. Devices and networks:

To provide for low-cost implementation options, the ZigBee physical device type distinguishes the type of hardware based on the IEEE 802.15.4 definition of reduced function device (RFD) and full function device (FFD). An IEEE 802.15.4 network requires at least one FFD to act as a network coordinator.

An RFD sees implementation with minimum RAM and ROM resources as a simple send or receive node in a larger network.

The ZigBee logical device type distinguishes the physical device types (RFD or FFD) deployed in a specific ZigBee network. The logical device types are ZigBee coordinators, ZigBee routers, and ZigBee end devices. The ZigBee coordinator initializes a network, manages network nodes, and stores network node information. The ZigBee router participates in the network by routing messages between paired nodes. The ZigBee end device acts as a leaf node in the network and can be an RFD or FFD. ZigBee application device types distinguish the type of device from an end-user perspective as specified by the application profiles.

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C. Heal thyself:

ZigBee's self-forming and self-healing mesh network architecture permits data and control messages to pass from one node to other node via multiple paths. This extends the range of the network and improves data reliability. You could use the peer-to-peer capability to build large, geographically dispersed networks where smaller networks link together to form a cluster-tree network.

ZigBee networks consist of multiple traffic types with their own unique characteristics, including periodic data, intermittent data, and repetitive low latency data. The characteristics of each are as follows:

1.Periodic data is usually defined by the application such as a wireless sensor or meter. You would typically handle data using a beaconing system where the sensor wakes up and checks for the beacon, exchanges data, and goes to sleep.

2.Intermittent data is either application- or external stimulus-defined, such as a wireless light switch. You can handle data in a beaconless system or a disconnected operation.

3.Repetitive low latency data uses time slot allocations, such as a security system. These applications may use the guaranteed time slot (GTS) capability.

ZigBee networks are primarily for low duty cycle sensor networks (<1%). They may recognize new network nodes and associate them in about 30 ms. Waking up a sleeping node takes about 15 ms, as does accessing a channel and transmitting data. ZigBee applications benefit from the ability to quickly attach information, detach, and go to deep sleep, which results in low power consumption and extended battery life.

D. Network Topology:

The ZigBee network layer (NWK) supports star, tree, and mesh topologies. In a star topology, the network is controlled by one single device called the ZigBee coordinator. The ZigBee coordinator is responsible for initiating and maintaining the devices on the network. All other devices, known as end devices, directly communicate with the ZigBee coordinator. In mesh and tree topologies, the ZigBee coordinator is responsible for starting the network and for choosing certain key network parameters, but the network may be extended through the use of ZigBee routers. In tree networks, routers move data and control messages through the network using a hierarchical routing strategy. Tree networks may employ beacon-oriented communication as described in the IEEE 802.15.4-2003 specification. Mesh networks allow full peer-to-peer communication. ZigBee routers in mesh networks do not currently emit regular IEEE 802.15.4-2003 beacons. This specification describes only intra-PAN networks, that is, networks in which communications begin and terminate within the same network.

III. RESEARCH METHODOLOGY:

This paper is an attempt to transmit the GPS data wirelessly from the moving vehicle at test ground to the stationary PC located at server room & to developed GIS applications.

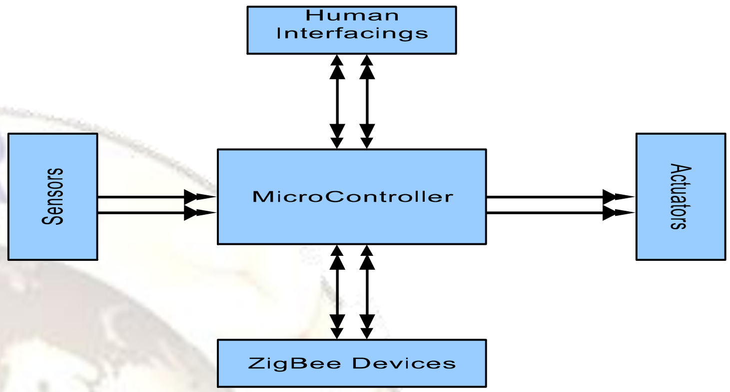


Fig: 1 – Basic Block diagram of project.

The part of the paper work thus can be divided into study; design & development of above specify components which includes:
a) Microcontroller.
b) ZigBee Devices.
c) Sensors & Actuators.
d) Human Interfacing Devices.

In our work microcontroller is a key operating unit as it is a main interactive device for all of other components in proposed work. Theoretically microcontroller can be defined as 'It is a group of CPU, ALU along with all its peripheral & Buses containing limited memory blocks which are programmed as per application requirement. Though number of micro-controllers are available in market only the microcontroller satisfying our peripheral criterion will be chosen.

ZigBee devices interact with microcontroller in order transmit parameter related data which can further be processed for required monitoring.

As mention above system is concerned to check & analyze the driving data of the vehicle. So, as system requires it is primarily required to map the path of driving for which test run may be conducted in open ground of around 300meters* 300meters area. The complete system can be divided into two parts:

A) System with GPS & Wireless transmitter to transmit the positional data of vehicle to server room.

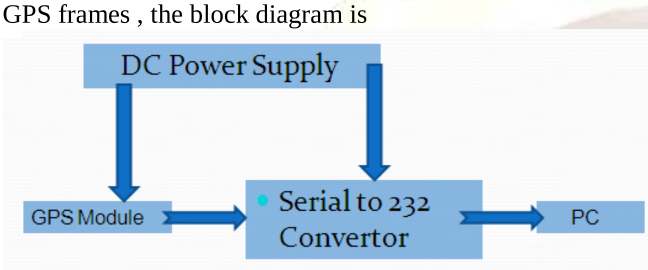
B) System with wireless receiver to receive GPS data and again transmit it to PC for GUI & software utilities.

Approx distance between two Systems will be in the range of 300 to 325 meters.

For the system specified it is predicted that GPS shall provide the positional data with the accuracy of <3m & wireless system shall capable to transmit the data string of approx 64Bytes up to 300-325meters of range with the approx rate of 2samples/seconds.
As to deal with complete proposed work we need to work on both hardware & software part they can be work as below.
Data will be receive with the fixed baud rate of 9600 for the said formats as mention & need to decode that in require format for run time tracings & application development. Software development tools may involve IDE's & wireless serial trace softwares as per component selections.

IV. RESULTS:

Initially, when GPS module interface with PC for receiving GPS frames , the block diagram is



The received GPS frames are:

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$GPGGA,062620.00,2106.58293,N,07906.32860,E,1,08,1.16,302.5,M,-63.8,M,,*71
$GPGGA,062622.00,2106.58180,N,07906.32762,E,1,08,1.16,302.6,M,-63.8,M,,*7C
$GPGGA,062623.00,2106.58146,N,07906.32746,E,1,08,1.16,302.8,M,-63.8,M,,*7F
$GPGGA,062635.00,2106.58173,N,07906.32869,E,1,08,1.68,304.1,M,-63.8,M,,*7A
$GPGGA,062657.00,2106.58145,N,07906.33235,E,1,08,1.16,304.4,M,-63.8,M,,*75
$GPGGA,062658.00,2106.58123,N,07906.33254,E,1,08,1.16,304.5,M,-63.8,M,,*7C
$GPGGA,062702.00,2106.58028,N,07906.33509,E,1,08,1.16,304.2,M,-63.8,M,,*70
$GPGGA,062703.00,2106.58009,N,07906.33570,E,1,08,1.16,304.1,M,-63.8,M,,*7F
$GPGGA,062705.00,2106.57993,N,07906.33706,E,1,08,1.16,303.7,M,-63.8,M,,*7E
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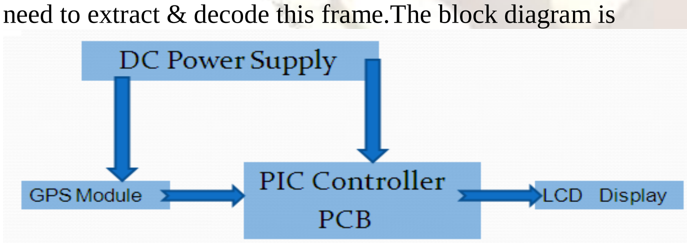
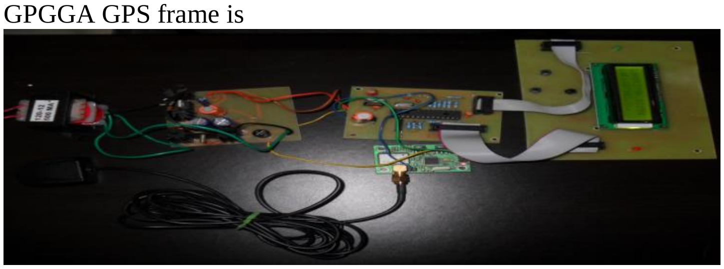
The GPGGA GPS frame is very useful for proposed work.we need to extract & decode this frame.The block diagram is



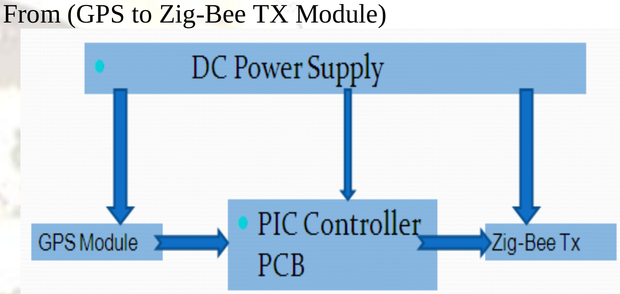
The required hardware for extracting & decoding useful GPGGA GPS frame is



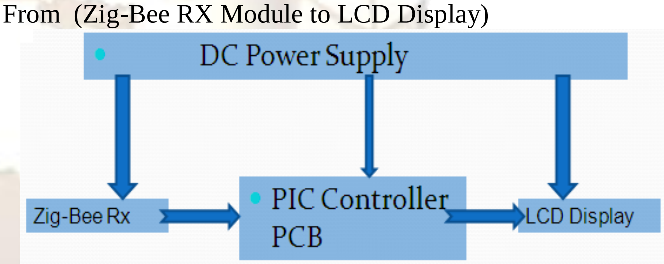
Now with this hardware, extracted & decoded GPGGA GPS frame in terms of LATITUDE & LONGITUDE is

Now this GPGGA GPS frame can be transferred wirelessly with the help of Zig-Bee module. The block diagram is

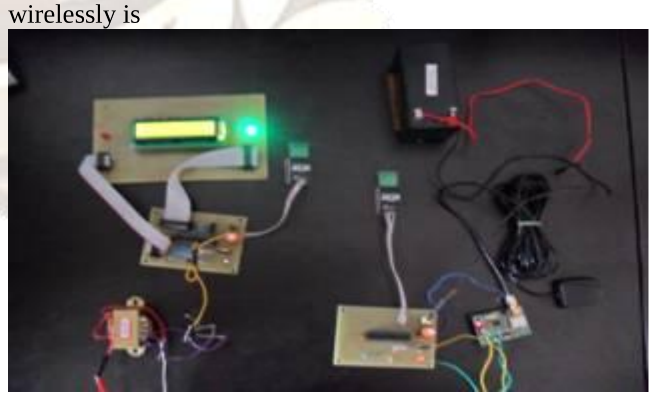
a) From (GPS to Zig-Bee TX Module)



b) From (Zig-Bee RX Module to LCD Display)

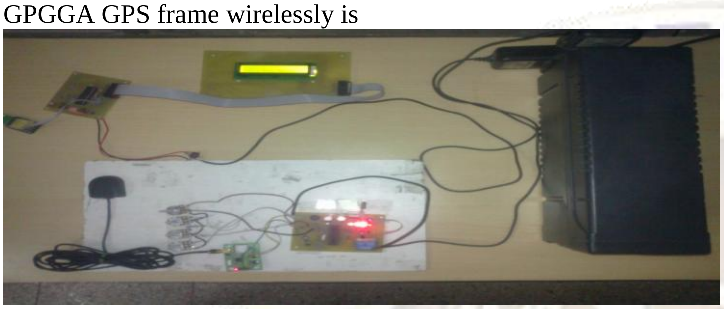


The required hardware for transferring GPGGA GPS frame wirelessly is



From this hardware, the GPGGA GPS frame in terms of LATITUDE & LONGITUDE which is received wirelessly is

The required hardware for transferring Analog data & GPGGA GPS frame wirelessly is



From this hardware, the Analog data in Digital form & GPGGA GPS frame in terms of LATITUDE & LONGITUDE which is received wirelessly is

V. CONCLUSIONS:

From these results, it is conclude that we got the GPS frames & from that frames we have extracted & decoded useful frame which is shown on LCD Display.The useful frame is also transferred wirelessly with the help of Zig-Bee module which is obtained on LCD Display and also analog data is tested and converted into digital form and it is also transferred wirelessly.So the initial work can be used for wireless integrated system for various future works such as Developing GIS application like Short range real time tracking & mapping, Position based switching & operating, Remote alarming ,Short range info mobility systems without external network dependency, GOI application developments for database developments & managements.

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