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CHAPTER 1

INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

A wireless sensor network is a collection of nodes organized into a cooperative network (Wendi Rabiner Heinzelman et al., 2000) Wireless sensor networks provide the bridge between the actual physical real time entity virtual worlds. WSN has the vast advantage to observe the observable at a range of fine resolution over large scale spatial and temporal measures (Ian F. Akyildiz et al., 2002, Hui Dai et al., 2004, Jonathan L Bredin et al., 2010, Gaurav Gupta et al., 2008, Garcia- Alfaro et al., 2010, Dazhi Chen et al., 2011, Karim, L et al., 2012).

WSN has wide range of application and application career to the industry in the active domains like military, computer science, GIS, security etc. Wireless sensor nodes consists of the components such as memory (RAM, ROM), transceivers, GPS, processor, sensors, power source (battery) (Park, S. J et al., 2004, Patwari, N et al., 2003, Rahman, M. A et al., 2008, Rout, R.R et al., 2012). The main challenges arise here, due to limited resource (power), the energy consumption should be minimized, transmission rate should be probably robust in nature and the node should be highly reliable during scalability. According to the stat by the universal WSN forum, the growth of sensor networks is reached up to 2635 million on 2013. Wireless sensor networks are distributed connected networks with similar characteristics such as less energy level, closed circuit etc. Generally Wireless sensor networks are used for various applications such as hospitals, military etc. The main component of WSN are sub system, information processing and information routing. In this work our context is fully on information routing and analysing the routing performance metrics in WSN. When the networks of sensor nodes are highly in increased order, then the routing protocol leads to be the key area of research.

The main motto and work of this research is to model the two optimistic data centric protocol for information routing. During information routing the performance metrics are calculated. The unique key id the proposed methodology is to measure the packet jitter within the routing parameters. The two protocols implemented and compared are SPIN and Directed diffusion protocols. The results obtained reveal the delivery ratio of data packets within the inbound and outbound of the network.

Each node consists of processing capability (one or more microcontrollers, CPUs or DSP chips), may contain multiple types of memory (program, data and flash memories), have a RF transceiver (usually with a single Omni-directional antenna), have a power source (e.g., batteries and solar cells), and accommodate various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. Systems of 1000s or even 10,000 nodes are anticipated. Such systems can revolutionize the way we live and work. Currently, wireless sensor networks are beginning to be deployed at an accelerated pace. It is not unreasonable to expect that in 10–15 years that the world will be covered with wireless sensor networks with access to them via the Internet. This can be considered as the Internet becoming a physical network. This new technology is exciting with unlimited potential for numerous application areas including environmental, medical, military, transportation, entertainment, crisis management, homeland defence, and smart spaces. Since a wireless sensor network is a distributed real-time system a natural question is how many solutions from distributed and real-time systems can be used in these new systems?

Unfortunately, very little prior work can be applied and new solutions are necessary in all areas of the system. The main reason is that the set of assumptions underlying previous work has changed dramatically. Most past distributed systems research has assumed that the systems are wired, have unlimited power, are not real-time, have user interfaces such as screens and mice, have a fixed set of resources, treat each node in the system as very important and are location independent. In contrast, for wireless sensor networks, the systems are wireless, have scarce power, are real-time, utilize sensors and actuators as interfaces, have dynamically changing sets of resources aggregate behaviour is important and location is critical. Many wireless sensor networks also utilize minimal capacity devices which places a further strain on the ability to use past solutions.

One of the most vital problems in wireless sensor networks is finding optimal routes for transmitting data between sources to destination. Generally it pairs in a multi-hop fashion. Several algorithms have been proposed for routing. The previous research for routing scheme was explained clearly in the section “State of the art”. Many researchers have undergone for solving the routing problem in Wireless sensor network (Ayad Salhieh et al., 2001, Akyildiz I., et al., 2002, Chu, M et al., 2002, Adam Dunkels et al., 2004, Catovic et al., 2004, Cheng, K. et al., 2005, Chellappa Doss, R et al., 2006, Gaurav Gupta et al., 2008, Garcia-Alfaro e al., 2010, Dazhi Chen et al., 2011, Andrea Munari et al., 2013, Chakraborty, A et al., 2013).

The purpose of WSN routing is to propose a least cost of route in fleet of reliable communication between sensor nodes to server . Many routing algorithms are proved with P-compete (Muneeb Ali et al, 2004). When the stated problem is non-deterministic, if so it is under the problem of less ambiguity and deterministic and transfer rate be at polynomial time, then it is proved to NP-compete and run time execution (data transfer between sensor nodes to server) be at polynomial time (Cheng, K. et al., 2005, Chu, M et al., 2002). Here we combined the Swarm intelligence (SI) technique to optimally route the data packets from the sensor nodes to base station. Particle Swarm Optimization technique is one of the peculiar computational intelligence which has the property of infinite size and easy flexible computational implementation and have solution for many optimal problem. PSO is inspired by the particle behaviour of external creatures (birds, bees, ants, fish etc). It is one of the stochastic based optimization model proposed by (Kennedy and Eberhart, 1995).

In this hypothesis we are going to discuss about finding optimal path between source and destination using particle swarm optimization algorithms. A new family of algorithms emerged inspired by swarm intelligence (SI). Which provides a novel approach to distributed optimization problems. The expression "swarm intelligence "defines any attempt to design algorithms inspired by the collective behaviour of social insect colonies and another animal societies .Swarm intelligence provides a basis with which it is possible to explore distributed optimization problems without explore centralized control or provision of global model.

Initial research has unveiled a great deal of matching properties between the routing requirements of sensor networks and certain feature of SI (Younis, M. et al., 2002, Zheng Yao et al., 2007). There are some notable algorithms which uses ant like mobile agents to maintain routing and topology discover for wireless sensor networks. In this work we order the nodes based on their energy efficiency and their focusing towards node path. Tilak S. et al. (2002) specifies Swarm intelligence boasts a number of advantages due to the use of mobile agents.

The advantages are as follows:

1. *Scalability*: Population of the agents can be adapted consistently to the network size. Scalability is also promoted by local and scattered agent interactions (Chellappa Doss et al., 2006).
2. *Fault tolerance:* Swarm intelligent processes do not rely on a centralized control mechanism. Therefore the loss of a few nodes

or links does not result in catastrophic failure, but rather leads to graceful, scalable degradation.

3. *Adaptation:* Agents can alter, expire or replicate, according to network changes.
4. *Speed:* Changes in the network can be propagated very *fast*, in contrast with the Bellman-Ford algorithm (Garcia-Alfaro et al., 2010).
5. *Modularity:* Agents act independently of other network layers (Kevin (2003)).
6. *Autonomy*: Little or no human supervision is required.
7. *Parallelism*: Agent operations are inherently parallel. These properties make swarm intelligence very attractive for ad-hoc wireless networks. They also render swarm intelligence suitable for a variety of other applications, apart from routing, including robotics (Patwari, N et al., 2003, Muneeb Ali et al., 2004, Park, S et al., 2004, Rahman, M. A et al., 2008).

Wireless sensor networks is advanced cutting edge which was booming day by day. In recent years various researchers and research forums have gone a wide range of research in these areas. Basically sensors are light weight hardware devices used for various application such as military, medical, biological, GIS etc. Recent research which attracts future scope on wireless sensor networks is termed as MEMS combined with computational intelligence called SWARM.

The sensor device generally has three main systems namely

1) An advent subsystem which sense the environment
2) Computational logic which converts the sensed raw into computational data
3) Message exchange protocol.

Figure 1.1 denotes a robust methodology to exchange data packets with less energy consumption and with high processing of data exchange.

Each sensor has large number of sensing region with high compatibility, average power consumption, resources and high computation. Computational complexity has reached a wide range of resource utilization and high intensity of power consumption this may leads to failure of nodes. Energy utilization without degrading the network performance will increase the robustness of the sensor nodes.

In this proposed work a robust methodology is used to exchange data packets with less energy consumption and with high processing of data exchange.

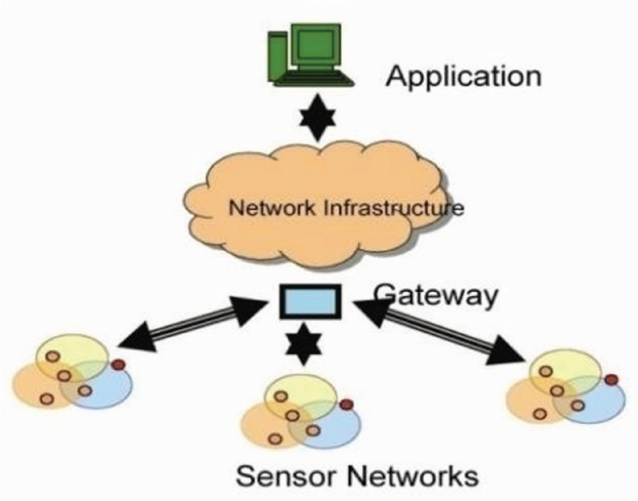

Figure 1.1. Typical Architecture of Sensor Network.

A medium access control (MAC) protocol coordinates actions over a shared channel. The most commonly used solutions are contention-based. One general contention-based strategy is for a node which has a message to transmit to test the channel to see if it is busy, if not busy then it transmits, else if busy it waits and tries again later. After colliding, nodes wait random amounts of time trying to avoid re-colliding. If two or more nodes transmit at the same time there is a collision and all the nodes colliding try again later. Many wireless MAC protocols also have a doze mode where nodes not involved with sending or receiving a packet in a given timeframe go into sleep mode to save energy. Many variations exist on this basic scheme. In general, most MAC protocols optimize for the general case and for arbitrary communication patterns and workloads. However, a wireless sensor network has more focused requirements that include a local uni-or broad-cast, traffic is generally from nodes to one or a few sinks (most traffic is then in one direction), have periodic or rare communication and must consider energy consumption as a major factor. An effective MAC protocol for wireless sensor networks must consume little power, avoid collisions, be implemented with a small code size and memory requirements, be efficient for a single application, and be tolerant to changing radio frequency and networking conditions. One example of a good MAC protocol for wireless sensor networks is B-MAC (Lieckfeldt, D et al., 2008). B-MAC is highly configurable and can be implemented with a small code and memory size. It has an interface that allows choosing different functionality and only that functionality as needed by a particular application. B-MAC consists of four main parts: clear channel assessment (CCA), packet back off, link layer acks, and low power listening. For CCA, B-MAC uses a weighted moving average of samples when the channel is idle in order to assess the background noise and better be able to detect valid packets and collisions.

The packet back off time is configurable and is chosen from a linear range as opposed to an exponential back off scheme typically used in other distributed systems. This reduces delay and works because of the typical communication patterns found in a wireless sensor network. B-MAC also supports a packet by packet link layer Acknowledgement. In this way only important packets need pay the extra cost. A low power listening scheme is employed where a node cycles between awake and sleep cycles. While awake it listens for a long enough preamble to assess if it needs to stay awake or can return to sleep mode. This scheme saves significant amounts of energy. Many MAC protocols use a request to send (RTS) and clear to send (CTS) style of interaction. This works well for ad hoc mesh networks where packet sizes are large (1000s of bytes). However, the overhead of RTS-CTS packets to set up a packet transmission is not acceptable in wireless sensor networks where packet sizes are on the order of 50 bytes. B-MAC, therefore, does not use a RTS-CTS scheme.

The state of the art, the review of WSN protocols yields the better solution for optimistic routing and information processing, since to evaluate the performance during routing, the protocol is evaluated with certain metrics like throughput, jitter, bandwidth, reliability etc. here the detailed scope of various protocol and its algorithm is studied and out of that the optimistic algorithm is taken into the review consideration and evaluated.

Recently, there has been new work on supporting multi-channel wireless sensor networks. In these systems it is necessary to extend MAC protocols to multi-channel MACs. One such protocol is MMSN .These protocols must support all the features found in protocols such as B-MAC, but must also assign frequencies for each transmission. Consequently, multi-frequency MAC protocols consist of two phases:

- channel assignment
- access control

The details for MMSN are quite complicated and are not described here. On the other hand, we expect that more and more future wireless sensor networks will employ multiple channels (frequencies). The advantages of multi-channel MAC protocols include providing greater packet throughput and being able to transmit even in the presence of a crowded spectrum, perhaps arising from competing networks.

1.2 ROUTING

Multi-hop routing is a critical service required for WSN. Because of this, there has been a large amount of work on this topic. Internet and MANET routing techniques do not perform well in WSN. Internet routing assumes highly reliable wired connections so packet errors are rare; this is not true in WSN. Many MANET routing solutions depend on symmetric links (i.e., if node A can reliably reach node B, then B can reach A) between neighbours; this is too often not true for WSN. These differences have necessitated the invention and deployment of new solutions. For WSN, which are often deployed in an ad hoc fashion, routing typically begins with neighbour discovery. Nodes send rounds of messages (packets) and build local neighbour tables. These tables include the minimum information of each neighbour's ID and location. This means that nodes must know their geographic location prior to neighbour discovery. Other typical information in these tables includes nodes, remaining energy, delay via that node, and an estimate of link quality.

Key issues of routing paradigm in WSN

1. Reliability
2. Integrating with wake/sleep schedules
3. Unicast, multicast and any cast semantics
4. Real-time
5. Mobility
6. Voids
7. Security
8. Congestion

Reliability: Since messages travel multiple hops it is important to have a high reliability on each link, Otherwise the probability of a message transiting the entire network would be unacceptably low. Significant work is being done to identify reliable links using metrics such as received signal strength, link quality index which is based on errors, and packet delivery ratio. Significant empirical evidence indicates that packet delivery ratio is the best metric, but it can be expensive to collect. Empirical data also shows that many links in a WSN are asymmetric, meaning that while node A can successfully transmit a message to node

B, there verse link from B to A may not be reliable. Asymmetric links are one reason MANET routing algorithms such as DSR and AODV do not work well in WSN because those protocols send a discovery message from source to destination and then use the reverse path for acknowledgements. This reverse path is not likely to be reliable due to the high occurrence of asymmetry found in WSN.

Integration with wake/sleep schedules: To save power many WSN place nodes into sleep states. Obviously, an awake node should not choose an asleep node as the next hop (unless it first awakens that node).Unicast, multicast and any cast semantics: As mentioned above, in most cases a WSN routes messages to a geographic destination. What happens when it arrives at this destination? There are several possibilities. First, the message may also include an ID with a specific unicast node in this area as the target, or the semantics may be that a single node closest to the geographic destination is to be the unicast node. Second, the semantics could be that all nodes within some area around the destination address should receive the message. This is an area multicast. Third, it may only be necessary for any node, called any cast, in the destination area to receive the message. The SPEED (Catovic and Z. Sahinoglu, 2004) protocol supports these 3 types of semantics. There is also often a need to flood (multicast) to the entire network. Many routing schemes exist for supporting efficient flooding. In Real-Time: For some applications, messages must arrive at a destination by a deadline. Due to the high degree of uncertainty in WSN it is difficult to develop routing algorithms with any guarantees. Protocols such as SPEED (Catovic and Z. Sahinoglu, 2004) and RAP (Kevin, 2003) use a notion of velocity to prioritize packet transmissions. Velocity is a nice metric that combines the deadline and distance that a message must travel.

Mobility: Routing is complicated if either the message source or destination or both are moving. Solutions include continuously updating local neighbour tables or identifying proxy nodes which are responsible for keeping track of where nodes are. Proxy nodes for a given node may also change as a node moves further and further away from its original location.

Voids: Since WSN nodes have a limited transmission range, it is possible that for some node in the routing path there are no forwarding nodes in the direction a message is supposed to travel. Protocols like GPSR (Hui Dai and Richard Han, 2004) solve this problem by choosing some other node “not” in the correct direction in an effort to find a path around the void.

Security: If adversaries exist, they can perpetrate a wide variety of attacks on the routing algorithm including selective forwarding, black hole, Sybil, replays, wormhole and denial of service attacks. Unfortunately, almost all WSN routing algorithms have ignored security and are vulnerable to these attacks. Protocols such as SPINS (Karim, L. and Nasser, N., 2012), has begun to address secure routing issues.

Congestion: Today, many WSN have periodic or infrequent traffic. Congestion does not seem to be a big problem for such networks. However, congestion is a problem for more demanding WSN and is expected to be a more prominent issue with larger systems that might process audio, video and have multiple base stations (creating more cross traffic). Even in systems with a single base station, congestion near the base station is a serious problem since traffic converges at the base station.

1.3 OBJECTIVE

WSNs are envisioned to operate in an autonomous and decentralized fashion. This poses considerable challenges ranging through network organization, topology discovery, communication scheduling, routing control, and signal processing. Also tight energy budgets enforce energy efficient designs for hardware components, network stacks, and application algorithms. The main objective of the proposed hypothesis is to enhance the information routing scheme in terms of optimality in information routing and its paradigm. Short description about the actual challenges is mentioned below.

The data-centric paradigm involves two fundamental operations in WSN information are processing and information routing. Many research efforts are motivated by the fact that information processing and routing are mutually beneficial. While information processing helps reduce the data volume to be routed, information routing facilitates joint information compression (or data aggregation) by bringing together data from multiple sources. However, it is often non-trivial to model and analyse the inter-relationship between information processing and routing. In many situations, the problem of finding a routing scheme in conjunction with joint compression for energy minimization turns out to be NP-hard. The main challenges are stated as

1) Data exchange within a cluster of sensor nodes (or in-cluster information processing).
2) Data exchange over a given multi-hop networks.

Many researchers have undergone for solving the routing problem in wireless sensor network. The purpose of WSN routing is to propose a least cost of route in fleet of reliable communication between sensor nodes to base station. The problem was defined with various attempts by combining using various algorithms such as distributed algorithm, chord algorithm, Rendezvous point (RP) Multicast with standalone routing mechanism and with secured routing mechanism. The approach leads to well defined area by obtaining optimal results in the hybrid approach using distributed algorithm and chord algorithm. The main objective is to propose an optimal solution for information routing. The observation of the thesis is stated as follows:

- To identify the optimality in the route by merging swarm based algorithms with genetic approach.
- To structure an optimal hybrid routing scheme by combining PSO routing protocol with clustering algorithm, the protocol fits perfectly for the homogenous nodes.

The main hypothesis of the thesis is stated below

- To propose an optimal solution for information routing using circular patterns in the form of Voronoi cell. Each functional patterns of the traffic are classified as source and destination in asymptotic rule. Network load is monitored using the traffic inbound rules and the estimation is defined in the circular pattern in the form of Voronoi cell. Each sensor nodes traffic is redirected to the centralized server. Each traffic patterns and sensor nodes are classified and the nodes communication regions are known to the base station by drawing the pattern in Voronoi. The proposed methodology is main aspect of the proposed hypothesis which outperforms in information routing for both the homogenous node and heterogeneous nodes.
- To propose a new framework model, aiming to reduce the software complexity in terms of routing without sacrificing the performance of the network. Since the sensor nodes are connected with base station. In our model the neighbouring node information is considered and maintained, which helps in packet forwarding in frequent intervals when the nodes are in wireless mode. Here, in this model the node holds the neighbour information and relay the next hop information in straight line, hence it is rechecked to next – hop relay.
- To propose a new scheme called circular routing called CBR, here the routing scheme is one of the vast advent where the data packets inter arrival was calculated periodically for every hop. For every

instance the boundary or contour of the network is evaluated which in turn gives an optimality in terms of finding the shortest contour within the circular boundary of network.

The hybrid technique here proposed, called Genetic Swarm Optimization (GSO), is essentially a population-based heuristic search technique which can be used to solve combinatorial optimization problems, modeled on the concept of natural selection but also based on cultural and social evolution. GSO algorithm consists in a strong cooperation of GA and PSO, since it maintains the integration of the two techniques for the entire run. In each iteration, the population is divided into two parts and they are evolved with the two techniques in that order. They are then remerged in the modernized population, that is yet again divided erratically into two parts in the next iteration for another run of genetic or particle swarm operators. The population revise concept can be effortlessly understood thinking that a part of those individuals is substituted by new generated ones by resources of GA, while the enduring are the same of the earlier generation but moved on the solution space by PSO. Since routing using genetic approach does not yield much better accuracy when compared to existing approach.

Initial level of research in WSN routing start up with genetic approach was discussed deeply in the work "Optimizing Localization Route Using Particle Swarm-A Genetic Approach". Several algorithms exists in literature, since some are of in vital role other may not. Since WSN focus on low power consumption during packet transmission and receiving, finally we adopt by merging swarm particle based algorithm with genetic approach. Initially we order the nodes based on their energy criterion, and then focusing towards node path; this can be done using Proactive route algorithm for finding optimal path between S-D (Source-Destination) nodes. Fast processing and pre traversal can be done using selective flooding approach and results are in genetic. We have improved our results with high accuracy and optimality in rendering routes. GSO algorithm consists in a strong cooperation of GA and PSO, since it maintains the integration of the two techniques for the entire run. In each iteration, the population is divided into two parts and they are evolved with the two techniques in that order. Next start up with the hybrid model in combining k-means and PSO.

The thesis comprises with the clustering setup of each node and how reliably routing takes place within the clusters. The main challenge of the proposed model using K-means and PSO is discovering neighbour nodes and during node failure the clustering algorithm fails to predict the neighbour node. The next level of the research is continued with the above stated challenge and proposed a new routing scheme with discovering neighbour node by deploying the sensor node region within the cell region by using Voronoi cell structure. Here the routing scheme was well adapted for the nodes within the single cell region when the region is deviated, the routing becomes complex in positioning the homogeneous sensor nodes.

In multi hop networks, the routing is very critical and node behaviour is not at stable range. Hence we proposed a new routing scheme called straight line routing with ACO (Ant colony optimization algorithm) to find the straight line of the nodes. The main problem defined here was node discovery in which the following scheme is used to utilize it, RTS/CTS are two reliable request response messages broadcasted to find the neighbour nodes. Initially the root node sends the ARP RTS message to all the nodes. Once the node within the range receives the request, then the node replies with the node identity (PMAC address. The node starts to send the ACK reply/response with CTS message. Once the CTS message is received at the root node, based on common evaluation the neighbour nodes are identified.

1.4 SCOPE OF THE THESIS

The main scope of the thesis is to find the optimal solution for information routing in wireless sensor networks. The thesis entitled "Designing Simulation Framework for Multi-Hop Routing in Wireless Sensor Networks "defines clearly about the various proposed and extended routing protocols for WSN. The observation is made for two proposed protocols and the main routing protocol using circular patter with VORONOI diagram outperforms with 78% accuracy and its enhancement CBR outperforms with 83% accuracy in homogeneous and heterogeneous networks. The proposed thesis was sub divided into 7 chapters.

Chapter 1 discuss on basics about the Wireless sensor network and sensor architecture etc. Literature survey is discussed clearly in the chapter 2. In chapter 3, the proposed hybrid schemes are discussed. The observation is made on the two proposed hybrid protocols. The first protocol is combining swarm intelligence with Genetic approach entitled as "Optimizing route using particle swarm-A genetic approach". The second protocol is combining PSO algorithm with K-means clustering entitled as "Swarm-Cluster based routing scheme for heterogeneous nodes".

Chapter 4 discuss about the base hypothesis of the thesis, in which a new information routing scheme was proposed and the methodology outperforms with 78% accuracy, the proposed scheme was entitled as "Analysis of Shortest Route for Heterogeneous Node in Wireless Sensor Network". The key idea of the proposed scheme was to estimate the actual traffic among the sensor node, which is defined clearly as the traffic packets, controlled at each server. Network load is monitored using the traffic inbound rules and the estimation is defined in the circular pattern in the form of Voronoi cell. Each functional patterns of the traffic are classified as source and destination in asymptotic rule. Each sensor nodes traffic are redirected to the centralized server acting in the real world, where the sensor data's are patched periodically and the data packets travelling from the node to node are updated. Each traffic patterns and sensor nodes are classified and the nodes communication regions are known to the base station by drawing the pattern in Voronoi.

In Chapter 5, an enhancement level of routing strategy has been proposed and method has a quite bit variation in routing strategy. According to the observation and simulation results, the proposed methodology "Designing Simulation Framework for Multi hop routing in Wireless Sensor Network using PSO algorithm" produces the same results as off the results produced by the protocol in chapter 4 but the protocol supports multi-hop routing strategy in distributed environment. The background idea was modeling the neighbouring node information, which helps in packet forwarding in frequent intervals when the nodes are in wireless mode. Here, in the proposed model the nodes holds the neighbour information and relay the next hop information in straight line; hence it is rechecked to next-hop relay. If the next hop is closest to the neighbour node or relay is hold on the neighbour node, then the hop will be considered as the node entity and routing packets are greedy in nature and forwarded to the next hop. CTS and RTS messages are sent to the neighbour node to discover the node and its identity.

In Chapter 6, an enhancement level of the above mentioned protocol was achieved with higher accuracy rate of 83%. The main key idea of the proposed methodology "CBR-Contour based routing in Multi Hop Wireless Sensor Network" was to propose a new scheme circular routing called CBR, here the routing scheme is one of the vast advent where the data packets inter arrival was calculated periodically for every hop. For every instance the boundary or contour of the network is evaluated which in turn gives an optimality in terms of finding the shortest contour within the circular boundary of network. Experimental results demonstrate the actual working procedure of the routing scheme in WSN which outperforms with 83% accuracy in data routing. The proposed method was much better in terms of optimal resource utilization and routing based on the hop to hop in multi hop networks.

Finally Chapter 7 discuss about the conclusion and future scope of the research in context to the proposed methodologies. A typical architecture is stated in Figure 1.2 which clearly denotes the future scope of WSN in real world in terms of Internet of Things.

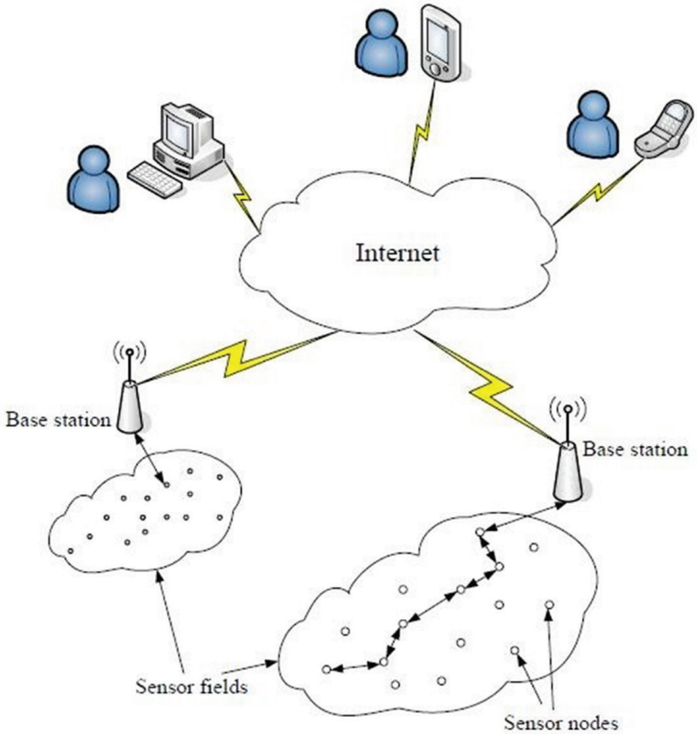

Figure 1.2. Future scope of the Wireless sensor network.

1.5 CONCLUSION

Issues in wireless sensor networks on the MAC layer and the existing solutions were discussed in this chapter. The solutions obtained using various routing schemes and how it is entirely different from the existing routing protocol is also stressed in this section.

The Chapter also provided a short description about WSN systems. The topics explored in this section are the major issues related to routing in WSN. For example, security and privacy are critical services needed for these systems. The chapter includes the discussion about the context of the hypothesis specially in "routing" paradigm. All of this sensor network research is producing a new technology which is already appearing in many practical applications. The future should see an accelerated pace of adoption of this technology.