CHAPTER 1. INTRODUCTION

In the recent past years, natural disasters are happening more frequently and have become hazardous. The amount of destruction, devastation and loss of human life has been massive in many of these natural disasters, whether it was himalayan floods of Uttarakhand, Tsunami of Tamil Nadu, earthquake of Japan to name a few. One of the prime reasons of such a high scale of devastation which mainly is aftermath of disaster is communication failure. The Himalayan Tsunami of June 2013 is considered to be one of the biggest disaster[1, 2] It is also known as 2013 North India floods. As reported, more than 5000 lives were lost or missing. Rajputana flood in 1943 recorded death of around 5000-6000 people. And most hazardous 1931 china floods recorded 2,500,000–3,700,000. To provide basic help especially to people who have been trapped in this type disasters, first 72 hours are very much important. It has been observed that scenario become more dangerous and uncontrolled post disaster as there is a lack of communication in between the trapped people and rescue teams. The traditional communication network become unavailable once such disaster occurs[3]. As almost all the communication networks are based on infrastructure which is highly affected in the disaster. The rescue teams are not able to provide help to trapped people and even sometimes fail to manage the post disaster scenarios thereby leading to more panic situations. It has been reported that due to lack of communication after Kedarnath tragedy, many people died as in some of the areas rescue teams are not able to send food packet for three days[4] From the study it has been emphasized that communication is the most important factor one must have to operate in such scenarios for smooth operations. Technology is one point and could be a destination for post disaster management. Keeping in view of the existing

communication technology and its loop hole in post disaster scenarios, a standalone network has to be developed. Lot of researches has been acknowledged specially for pre and post disaster scenarios. Wireless sensor networks play an important role in restoring the lost communication in between the trapped person and rescue teams. In one of the research [3] it has been stated that after the disaster happens one can set up a temporary network to restore the hampered network. But to set up such network lot of difficulties may occur as the environment and location is unknown and also the network has to be scalable, flexible and adaptive with respect to those particular disaster scenarios. To consider these aspects, RDN (Rapidly deployable networks)[5] helps in establishing such networks. RDN networks originally designed for military troops so that they would maintain the connectivity in unknown territories. After this novel approach many more researches come up to locate the targets. As the technology is continuously growing, there has been a lot of research in wireless sensor network to set up a virtual network apart from the traditional cellular network. Wireless sensor network have become popular as it is having worldwide applications in the field of military, habitat, business, environmental, health etc. Broadly, it is used for monitoring and tracking purposes. WSN technology is very less infrastructure dependent. WSN consists of nodes from ten to thousands in numbers to either gather data (monitoring) or tracking purposes. There are two kind of sensor network that can be link up i.e. HR- WPAN and LR- WPAN [6]. Both of these WPAN are short range communication. But for long range communication link/ network we have to set up wireless sensor network [7]. WSN is also having some constraints like design and resource. For example WSN is having short range communication, low bandwidth, less energy, limited storage facility within the node, low processing speed etc. While setting up the network, location also plays an important role. For indoor locations few nodes are sufficient to from a network while in outdoor locations large no. of nodes are needed to cover the large area. When the no. of nodes is larger in outdoor location, then ad-hoc based deployment is preferred over planned deployment.

Another important point is the obstruction present in environment which in turn limits the communication between the nodes within the network. The WSN research targets to such constraints and focusses on improved and easy solutions so that a reliable network can be deployed for large real life applications. The top most priority is to provide a reliable communication among the trapped person and rescue teams which has to be executed on demand[8]. The range of applications of wireless sensor networks can be found from the very recent past to age old fields where sensors have been networked to cater a wide variety of applications. One of the recent applications of WSN can be found in Urban Train Transportation System as mentioned in [9]. Few other interesting recent applications can also be found in the field of home automation as given in [10]. In this, the authors discuss the data communication between smart textiles with the smart electronic equipment which are available in home environment. On the other side the application of Wireless Sensor Networks in the field of smart grids is also promising. One such recent application is discussed in [11]. In this work, the authors discusses about the optimization technique for both the transmission power and the size of data packet. As per the data available in history the first time any kind of wireless network made any resemblance to the existing modern wireless network was way back in the year 1950, in which a system named as sound surveillance systems abbreviated as SOSUS was developed. This system was used in US defense to track the submarines of Russian [12]. As the electronics engineering has advanced, there has a proportional increase in the fields where wireless sensor networks were applied. Few of these fields with respect to finding the position of a target and/or to track the motion of a target that can be mentioned are tracking of enemy in the battlefield [13], monitoring the habitat[14] to check and assist in finding the location of endangered species. WSN has also been used in coal mines for the purpose of localization as mentioned in [15]. WSN not only fulfills the purpose of outdoor environments but also it is very much suitable for application in indoor environment that too with a specific requirement of object or target finding. One such application is

mentioned in [16]. Also as discussed in [17, 18] WSN are used for the purpose of location finding of an object in indoor environments.

The application of Wireless Sensor Network in today's world in ubiquitous. In most of the applications of WSN, localization is very important. The process of fixing or locating a target is defined as localization. The target that has to be localized may be stationary or in motion. As localization is a priority, it has always attracted significant research interest in the field of WSN. The generalized classification of localization techniques adopted in WSN are divided into four categories i.e.,

1. *Range-Based Localization techniques*
2. *Range-Free Localization techniques*
3. *Anchor-Based Localization techniques*
4. *Anchor-Free Localization techniques*

In range based localization technique, an non-isotropic antenna known as anisotropic antenna is considered and the target position is calculated in terms of distance between two nodes.[19] The distance which exists between two nodes will always be proportional to the hop count. More is the distance more will be the number of hops required for communication. Similarly localization in range-free techniques is computed by considering isotropic antenna which is non-realistic due to fact that the propagation of radio waves is irregular, presence of obstacles such as buildings etc. Examples of range-free localization techniques as given in[20] are based on Angle of Arrival (AoA), Time of Arrival (ToA), Time Difference of Arrival (TDoA), Global Positioning System (GPS) and Received Signal Strength Indicator (RSSI). These methods estimates the distance between two nodes.

Range free techniques estimate the position of target with respect to a fixed node which already exists in the region of interest. This fixed node is known as anchor node and the method used is called as anchor-based localization. Range free

techniques do not give the distance between the target and the fixed node. They achieve localization without the estimation of distance. In [21] the author has classified the measurements of localization into three categories which are

1. Angle of arrival measurements
2. Distance estimation based
3. Received Signal Strength based.

Angle of arrival measurements uses highly directional antennas to receive signals of interest and these antennas are rotated either electronically or mechanically to obtain omnidirectional reception. Distance estimation based methods are dependent on the arrival time of signals. By estimating the time delay in the signal reception the distance is estimated. Received Signal Strength based methods are combination of both anchor based and anchor free localization techniques. In this both anchor and non-anchor nodes are used. Position of target is estimated by plotting a large number of points throughout the coverage area. A node which is non-anchor will obtain its position from the RSSI value of anchor node. Also authors in [19] present one hop localization techniques based on Angle of Arrival (AoA), Time Difference of Arrival (TDoA), Distance based, Light house approach, RSSI profiling and hybrid based techniques.

Signal strength is one of the crucial parameter which determines efficiency of the receiver in wireless communication. Sensitivity of the receiver is directly proportional to the signal strength. In turn, signal strength is inversely related to attenuation. In wireless sensor network (which is usually deployed in hostile conditions), attenuation of the signal transmitted or received by the node determines the overall efficiency of the sensor network. While localizing a target attenuation of signal leads to a very high mean square error (MSE) which causes a high deviation in the position estimation of target. As mentioned in [22] the level of attenuation increases with frequency and the operating frequency of a node which is usually 2.4GHz always gives a high degree of attenuation. Apart from frequency, attenuation also depends on the environment viz., indoor or outdoor.

Considering indoor environment, authors in [23] predicted the level of attenuation in dB for building floor and a wall in 914MHz band. Also authors in [24] calculated values of attenuation in dB for concrete wall, wall made of bricks which slightly thicker than the concrete wall, plaster board and glass for the frequency band of 1-2GHz. Considering outdoor environment, signals from transmitter to receiver reaches in four different ways: penetration, diffraction, reflection and scattering each of which causes signal attenuation. Penetration is caused say for example when a signal travels through the house, and diffraction of signal is caused by sharp edges. Reflection is a result of solid matter like wall and scattering is a result of matter like tree. Scattering of signal is related to its wavelength[25] and also there are many studies done on tree scattering[26].

In localization the distance between the target and a reference node, termed as range can be estimated by using the equation given in [20]

$$R = 10^{\frac{P_o - F_m - P_r - 10\times n\times log_{10}(f) + 30\times n - 32.44)}{10\times n}} \qquad 1.1$$

In equation 1 f= signal frequency in MHz

P_o = transmitting power of one node including the gain of antenna if any in dBm

P_r = Receiver sensitivity of another node capturing message from Node 1 in dBm

n= pass loss exponent

F_m = Fade margin

R = estimated range in meters.

There are certain techniques to improve the range between two nodes. The techniques which are common are to increase the output power of transmitter and/or to improve the sensitivity of receiver. One more techniques mentioned in [20] is the use of hopping. By increasing the hop count, range can be increased.

Location of target can be estimated by three different types of signals. Firstly, by the use of ultrasound signals, second by the use of infrared signals and lastly by the use of RF signals. Infrared signals although travels with the speed of light it cannot penetrate the objects. Ultrasound signals on the other hand travels with the speed of sound. Systems which use infrared and ultrasound signals can only estimate only location of target without implementing any additional feature. Systems which use RF signals for location estimation can provide additional features such as information exchange and control.

Table 1-1Path Loss exponent for different environments

S.No	Path Loss Exponent (n)	Environment
1	2.0	Free Space
2	1.6-1.8	Inside Building (Line of Sight)
3	1.8	Super Market Store
4	2.09	Conference Room with table & Chairs
5	2.2	Factory
6	2-3	Inside Factory (no line of sight)
7	2.8	Indoor residential area
8	2.4	Outdoor environment (in our paper)

In present work, the main focus is laid on to establish the communication network in post disaster scenario. To localize the trapped person there are two methods in WSN i.e. range based localization[27] and range free localization, as mentioned earlier. Range based localization consists of TOA[15] Time of Arrival, TDoA [28]Time difference of arrival, AOA[29] angle of arrival and RSSI [30] Received signal strength Indicator. On the other hand, in range free localization one can use proximity sensing to estimate the position of the nodes or can use GPS. The designed node is low cost using ISM band which is free of cost while GPS has

high power consumption and expensive when it is deployed in a large quantity. In comparison, the developed system consumes very less power in the order of 2mW for sending one packet. The research aims at RSSI (Range based localization) based localization. RSSI based localization does not require any extra hardware to implement unlike other range based localizations. RSSI is an inbuilt feature in many wireless modules like Xbee based on ZigBee protocol. Similar sensor in range based solutions are RFID, Bluetooth etc. which however have low range (few meters) [31] and are not capable to establish wide area network. Though RSSI values and distance estimation through ZigBee is very noisy but can be solved with modeling the wireless channel established in between nodes like log normal shadowing model[20]. LNSM (Log Normal Shadowing Model) technique will be discussed in detail in coming chapters. In this research, log normal shadowing model is used as this model is the only model that can allow configuring the environmental parameters depending on the geographical conditions. The wireless network for post disaster communication link established using two algorithms, Location Fingerprinting[21] and Unilateral [32]. Location Fingerprinting is the well-established classical algorithm to set up the WSN in initial stages and unilateral is the improved and optimized technique than trilateration algorithm. The location fingerprinting is based on storing all RSSI values and representation of those values in logarithmic scale. The stored values of RSSI in array also known as radio map. The array of stored RSSI values for all locations is also known as RF signature and fingerprinting. In this research, the network is established for predefined path with location fingerprinting technique. The RF signature for all travelers across the disaster prone area is stored in the nodes and to the main center node. This helps in tracking the real time positioning of the travelers. Even when disaster happens, the last location can be known through the RF signature of the traveler. Unilateral technique comes into role only after the disaster happens. In unilateral technique, the pursuit node estimates the probable distance of the anchor node through RSSI values. The pursuit node starts

searching the anchor node from the location tracked from RF signature of the anchor node as discussed above in location fingerprinting technique.

1. 1 Wireless Network Description

Firstly a network has to be established in disaster prone area using some fixed nodes known as anchor node, visitor node (movable node) and Rescue operation node (RescOp node). Fixed node will be deployed in the predefined path as acts as a router node which will route the information of visitor node location to the main central node. Visitor nodes are with visitors and act as a coordinator node which will continuously send the data to the anchor node (fixed node), the data refers to the RSSI (Received Signal Strength Indicator).And if the disaster happens then the third node known as Rescue operation Node will starts rescuing acting as an end device node. The fixed nodes are sufficiently intelligent to get the information of vehicles passing across it and making a radio map. As the vehicles are already registered at the registration point (refer Figure 1-1) far away from the disaster prone area, updated information regarding the estimated location of vehicles and also the no. of vehicles can be obtained at each and every point. The Figure 1-1is the block diagram of the system and figure 1-2 will shows the road map of disaster prone area where the network is going to be deployed. The same information is routed through fixed nodes to registration point. So a radio map can be designed in registration point. So in case disaster happens and fixed nodes get damaged, then also the updated estimated location is safe with registration points. The proposed system starts from the authentication point in disaster prone area i.e. Registration point 1 Figure 1-1, where the vehicle entry gets registered and vehicle gets the wireless node. During registration process, it will be noted down the no. of persons and vehicle no. that are going to travel through that disaster prone area. After the handover of wireless node, vehicle enters the disaster prone area and the wireless network is initialized. There are anchor nodes already present and which are communicating with the node present in vehicle. Estimated

location of the vehicle is updated all the time and data is logged wirelessly to the Registration Point. As soon as vehicle crosses the disaster prone area end point, the smart device is handover to the Registration point 2. This technique is capable of making a radio map of the vehicle node. All the vehicle nodes get different node Id. This can be done using X-CTU firmware. If disaster happens then the vehicle node will become the trapped node. The trapped node now localized with rescue team node. The last estimated location can be tracked by radio map and after getting the estimated location further localization will be done using unilateral technique using VPM (Vector Parameter Mapping). It is explained further chapters.

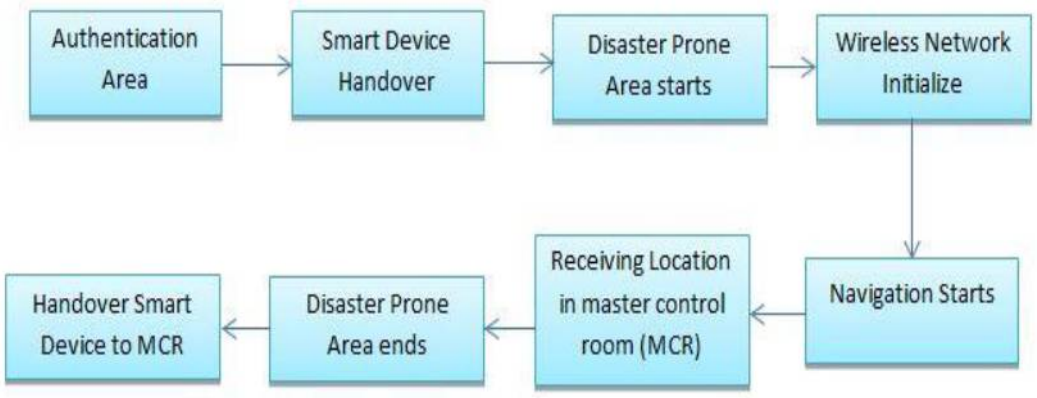

Figure 1-1Basic setup of proposed Architecture

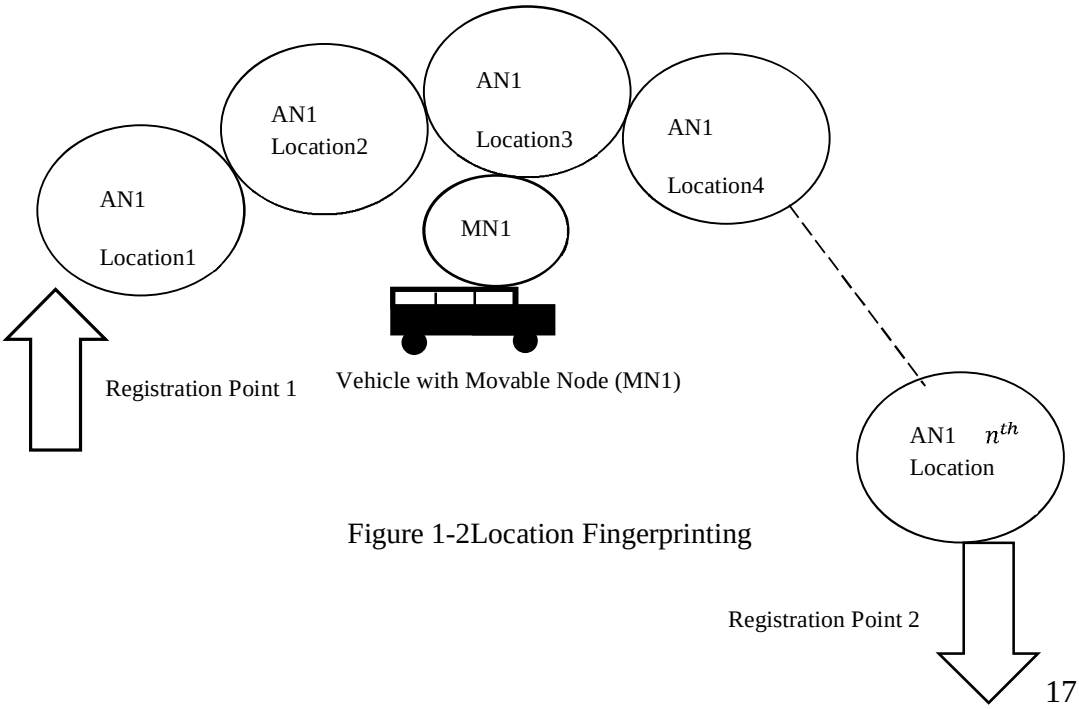

Figure 1-2Location Fingerprinting

1. 2 Thesis Structure

The thesis chapters are structured as

1. The second chapter contains the detailed literature survey of the WSN based on location tracking or localization using RSSI. The survey also focuses on the optimization techniques used for localization like particle swarm optimization, artificial neural networks, TLBO and many more.
2. The third chapter discusses the research methodology which mainly focusses on the algorithm and hardware designing techniques to be used.
3. The fourth chapter discusses the state of the art unilateral technique which is an improved trilateration algorithm.
4. The fifth chapter discusses the optimization algorithm developed using TLBO (Teacher Learning Based Optimization). The chapter discusses the hybrid TLBO-Unilateral Technique.
5. The Sixth chapter discusses the hardware nodes that will be deployed in the network. The nodes designed are fixed node (anchor node), visitor node (movable node), and rescue operation node (RescOp node).
6. The seventh chapter discusses the results and analysis of the system. The system also proves the validation of the system
7. The last chapter- eighth chapter discusses the conclusion and future scope that can be implemented further in various applications.

1. 3 Conclusion of Introduction

1. There is a need to design the less or no infrastructure based wireless sensor network to localize the trapped person in disaster prone area
2. There is a need to design an optimized algorithm for localization.