Ad hoc wireless Sensor Network Architecture for Disaster Survivor Detection

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Abstract

Wireless Ad hoc sensor nodes are playing a vital role in wireless data transmission infrastructure. Due to its compact size and energy efficient structure these nodes can be successfully deployed in wireless Ad hoc infrastructure where these nodes can be efficiently transmit the disaster related sensed data to Sink nodes via Ad hoc relay stations. In this Research study we are going to propose a Model for the Disaster survivor detection based on extremely critical Disaster situation where this energy efficient Architecture can successfully trace and locate thousands of people in critical circumstances. The emphasis of the research focuses on earth quake based disasters. Our proposed Model can also be successfully integrated with Telemedicine based infrastructure for emergency response authorities to take necessary measures in a limited span of time.

Keywords: *Wireless Sensor Networks, Sensor Network Protocols, Network Architecture, Disaster Management*

1. Introduction

The advent of modern science and technology had focused researchers towards wireless network technologies towards emergency response situations where critical disaster condition occurs.

Many of the researchers had focused their research towards different protocols and schemes for disaster management, among them well known architectures are WSNPDM and LEACH [3].The major focus of their research moves towards deployment of cost effective wireless ad hoc sensor networks including sensor nodes and RFID based tag devices which are capable to transmit disaster effected condition to nearby Ad hoc Relay Stations with in adjacent cells for rescues operation and in trace of route discovery specially for the people which are trapped beneath rubble [5].

There has been great amount of work done by researchers on Clustering Scheme and data Routing techniques where multiple clusters are composed of sensor nodes that are coordinating with each head node within each cell are responsible for transmitting the disaster affected conditions to Ad hoc Relay stations or Base Stations to rescue the disaster effected people in critical circumstances [3], [8].By keeping in mind the deployment and performance evaluation of the Network based architectures. Saha et al [5] has proposed the Algorithm for next head selection. The major emphasis of his research depicts the calculation of cluster head distance, angle measured in radians within each cell. The proposed algorithm is also capable to broadcast messages especially to Ad hoc Relay Stations.

By keeping in mind the energy consumption factors among multiple sensor nodes working in ad hoc infrastructure, Silva et al [15] focuses its research towards mathematical Energy model where they had proposed energy saving mechanism in dissemination stage, when a particular node transmits a packet from one specific node location to another.

Section 2 gives us an overview of ad hoc wireless sensor network technologies used for emergency response situations in case of disaster conditions including earthquakes, storms, fire and floods. Section 3 provides us in detail about existing models and network based architectures. We had proposed a new WSN architecture for disaster survivor detection based on enhancements in previous models discussed in section 4. Section 5 provides in details about proposed model integration with Telemedicine based infrastructure. Finally conclusions and future outcomes are discussed in section 6. In last the References are given.

2. Fundamentals of Wireless Sensor Networks

Many of the authors had focused their research towards performance analysis of Sensor network deployed in particular effected regions. For this reason many of the authors had proposed different network protocols including WSNDM [3], [5] named as wireless sensor network protocol for disaster management, its another modified version including WSNPDM [8], wireless sensor network protocol for disaster management which uses a unique addressing scheme which identifies a node location and type based on its unique ID. The polar coordinates (r, Θ) in locating the position of sensor node with respect to the head node within each cluster are used to identify the relevant parameters. The proposed protocol also supports the capability of sensor nodes for movement and thermal sensing. The clustering and scheduling scheme used by this protocol can be implemented by CDMA, code division multiple access schemes in which each cluster can be uniquely identified by a specific number or a specific digit code. The outcomes of research depend upon uniform distribution of energy among multiple sensor nodes and minimized hopping mechanism to reduce the route at maximum extent.

SENDROM [7] architecture has also been proposed for data dissemination and localization of effected people. One of the major strength of this research focuses on power management issues related to particular sensor node. The embedded sensor node is capable to detect vibrations during an earthquake, particularly designed for emergency rescue operations after the disaster. The route establishment algorithm proposed by authors is responsible for route establishment process of particular neighboring node in a network.

One of the most important aspect of the research emphasis on using multichannel MAC protocols for media access control and routing. [1] focuses on using energy efficient routing mechanism based on body area network, vehicle ad hoc network, Team and area network for the deployment of sensor nodes within a specified area to detect the victims in the damaged buildings based on 802.15.4 and 802.11 segments of Distress network protocol.

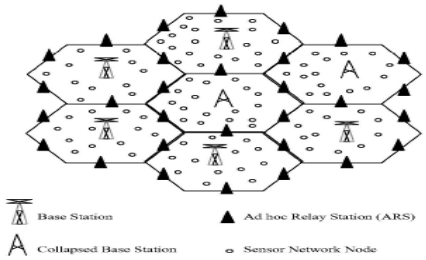

Figure 1: Ad hoc WSN for Disaster Management [5]

The network frame work as mentioned in the previous figure 1 is composed of multiple cells adjacent to each other and is responsible for providing disaster affected conditions in the particular coverage area using ad hoc relay interface and cellular interface. [3][5][8] The proposed architecture supports multi hopping mechanism to transfer the information among multiple cells using Ad hoc relay stations that collects the data from sensor nodes. Some of the nodes also used base stations in order to route the data from one location to another in critical emergency conditions but the bottle neck arises at the point when base station collapse.

3. Existing Network Model

The purpose of using MANETS Mobile Ad hoc Networks in multichannel cluster based architecture is to provide efficient routing topology among multiple sink nodes that are responsible for intra cluster communication. Each sink node is responsible for maintaining a cluster tree structure by sending a signal to neighboring node in process of establishing a channel for message sharing and in broad cast of information form one node to another [4]. Some of the authors had focused their research towards using hybrid network including base stations, terminal nodes, sink nodes and relay nodes deployed inside a particular building for data collection in particular disaster conditions [11].The strength of the research work depends upon energy storage capacity of sensor nodes which provides efficient mechanism to broadcast the messages for the long period of time. kung et al [12] had proposed a capability maturity Model Integration for Drought Forecast and the possible decision making using the Intelligent decision support system. The authors had proposed Drought Forecast and Alert System using ecology monitoring sensors that senses and transmits the specified environmental conditions to specific data base server which is responsible for passing this information to integrated services server for intelligent decision making. The mobile and satellite users are also attached with the main integrated services server which is responsible for decision making depending upon the environmental conditions.

In addition to above mentioned network protocols and architectures miyazaki et al [9] has proposed an efficient mechanism for surveillance of Disaster effected people in mission critical applications. The authors has suggested that using graph coloring algorithm based on time division multiplexing provides a strong mechanism transfer the packets of information from one node to another. The enhanced performance capability of sensor nodes allows handling the fault tolerant capability in case of damaged node, the next adjacent nodes takes the functionality of damaged sensor node. The particular capability helps the network architecture to work in critical conditions. One of the authors [13] has proposed the energy consumption model based on mathematical parameters to transmit the packets of information from one corresponding node to another. The energy consumption between the sending node and the receiving node depends on transmission capability of sender with in a particular network otherwise multiple receiving nodes will collect the data that results in huge energy consumption overhead.

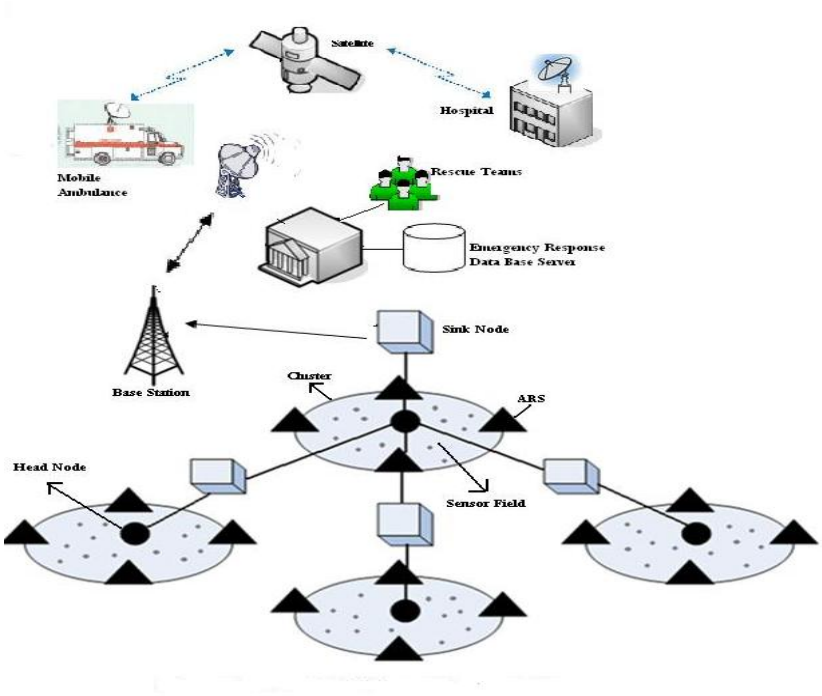

Figure 2: WSN for Rescue Operation in Case of Disaster

4. Proposed Enhancements in the Existing Network Model

Due to some shortcoming in the existing network models for rescue operations in case of disasters especially when the disaster situation occurs the base stations are unreachable or base station destroys. In this case Ad hoc relay stations are responsible for transmitting the information specifically to sink node. The sink node in this network architecture is responsible for forwarding this information to base station that will be GSM based if cellular network is available otherwise wimax based Antenna is responsible for further broadcasting the information to Emergency operation center as mention in Figure 2.

The Proposed network architecture for rescue operations in case of disaster circumstances can further be classified into three sub types elaborated as wireless sensor network field, emergency response data base center and satellite communication infrastructure.

(a) Wireless sensor network field

The wireless sensor network field in case of disaster consists of four adjacent cells in a neighboring hood network. Each cluster in particular network architecture consists of four ad hoc relay stations covering each cluster. The sensor nodes within each cluster are surrounded by ARS and in middle the head node is responsible for communicating with all the nodes within the sensor field. Each cluster with in a network is directly interfaced with Sink node that is responsible for maintaining communication path between head nodes within each cluster towards base station. The base station uses GSM based or wimax based communication system that is responsible to transfer disaster affected information from cluster based network architecture towards emergence response center.

(b) Emergency Response data base centre

The Emergency Response Data base center is responsible for receiving the critical disaster conditions before or after the disaster and stores this information in the data base storage. The Emergency response authority at the emergency operations center provide Emergency rescue teams at the point of need with in a limited time span for mission critical applications. The Emergency response data base center further route this information via satellite brad cast Antenna towards Satellite Station.

(c) Satellite communication infrastructure

The Satellite communication infrastructure is responsible for transferring the disaster related information towards Mobile Ambulance and Hospital which will be responsible to provide urgent Medical needs including medical first aid services using this Telemedicine based infrastructure [15].

5. Integration of Proposed Model with Telemedicine Based Systems

The era of Telemedicine based systems had moved the world towards new trends where mobile hospitals, Ambulances, emergency rescue staff is available within a limited time span. Sheltami et al [15] had focused the research towards telemedicine based Health care and life saving systems depending upon Ad hoc wireless sensor network technological infrastructure. The research majorly focuses on using medical sensors capable to sense multiple parameters including heart beat, pulse rate, glucose level monitoring blood pressure etc. The small sensor based devices can effectively attached with tiny microcontroller chip works as a small cpu specifically used for processing capability, depending on the received values from the medical sensors. Chu et al [16] has proposed WISTA wireless Telemedicine system for treatment of disaster affected patients. The proposed architecture is based on control center which is connected to multiple sites using wireless local area connection. The telemedicine based system deployed at designated site is responsible to receive the patient health status at remote location via local serer integrated with PDAs, for Patient health status condition in textual from along with ECG and remotely accessed camera. Our focus in this research study is to provide a strong mechanism to facilitate the disaster affected people at the time of need using Telemedicine based infrastructure to rescue the people under critical circumstances, to be able to provide first aid medical services. The modified version of our Network Model as mentioned in Figure 3 uses cluster based approach where each MCU microcontroller unit within a cluster is attached with sink node that has the processing capability to predict multiple known parameters of disaster effected individual using sensor nodes. The sensed information via MCU is passed to gate way node which is responsible for further broadcasting this information to Sensor node base Station. Each cluster with a network model is surrounded via ad hoc relay station which is used to route the data among multiple clusters. The sensor node base station uses Wimax or GSM or RF based infrastructure to further transfer this information to Telemedicine based infrastructure. The MCU serves as a control center among each of the cluster to collect the disaster related information, process this information and to broad cast this information to base station via gateway node. The base station is connected to Telemedicine based infrastructure.chu et al [16] has proposed that using RFID (radio frequency identifiers) and PDAs (personal Digital Assistants) to collect disaster related information in critical emergency conditions where cellular network is unavailable in case of disasters.

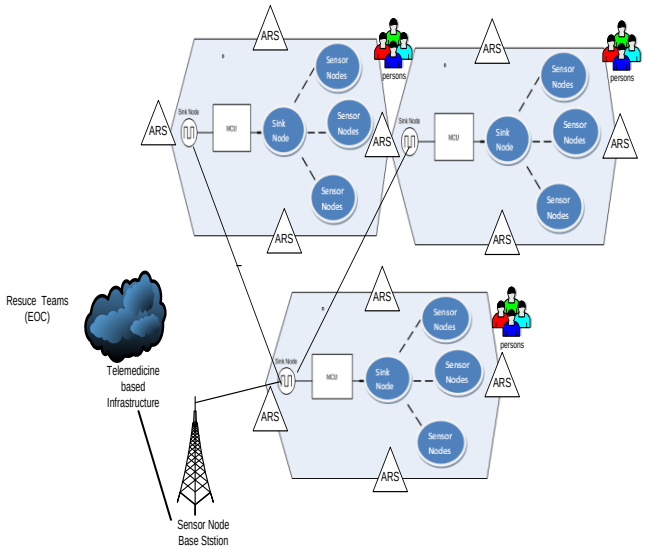

Figure 3: MCU Control System Architecture for Disaster Survivor Detection

6. Comparison of Proposed Model with Existing Model

The proposed Model based on Telemedicine based infrastructure strongly focuses on energy consumption factor. In proposed model we have reduced the number of Ad hoc Relay station. Each cell comprises of four Ad hoc relay stations instead of six which clearly depicts that energy consumption factor of Network frame work is reduced to great extent. Along with energy saving mechanism procedure the proposed architecture is successfully integrated with Telemedicine based infrastructure to trace and locate the disaster affected people in dangerous circumstances and to provide first aid medical needs at the point of need.

7. Conclusions and Future Work

The outcomes of the research study focuses on integration of wireless sensor network architecture with Telemedicine domain which moves the Telecommunication infrastructure very much useful to save the life of thousands of people in critical emergency circumstances. Moreover the research study clearly depicts that using the proposed network architecture the power consumption factor of nodes with in each cluster is reduce to great extent.

The future technology relies on using the diversified network architectures than can support multiple protocols and the capability of sensor node to transmit the sensed information towards long range which improves the performance of network to great extent and increases the life saving process of millions of people to great extent.

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