Data Offloading for Effective Rescue Operations During Fire Disaster Management

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Abstract: ***Disasters such as fire, earthquake and tsunami, etc. often result in precious loss of life as well as pose great economic challenge to developing countries like India. Of late, fires in moving vehicles such as trains and buses have become very common in India leading to loss of life and property. As we cannot predict or control the disaster, we can at least make efforts in minimising loss and some effective rescue operations post disaster. It is very important to perform post disaster analysis of the event to have better rescue operations and also to analyse the reason behind the occurrence of such disaster if possible. So that if it is man-made disaster preventive measures could be prescribed in future. Many Wireless Sensor Networks were proposed in the past for disaster management. But, fire leaves the network disconnected and important data is left unused in the damaged network. So, we propose Internet of Things (IoT) which is a promising technology that can be used to solve some of the problems mentioned above. To date, the application of IoT in post-disaster management is still an unexplored problem. In this paper, we propose data offloading mechanism for effective rescue operations post disaster from damaged network. The network is partially damaged in case of disaster and using fog computing we retrieve data and transfer to cloud for better data analytics. We propose a data flow framework built for effective post-disaster management.***

Keywords: ***Disaster management, Fire, Wireless Sensor Networks, Fog computing, Crowd sourcing, data offloading.***

I. INTRODUCTION

Around the world, there are numerous natural and man-made disasters [1], [2] such as Earth quake, Tsunami, Floods, Landslides, Forest fire and leakage in oil pipeline, industrial explosion, leakage in gas production, terrorist attacks respectively leading great loss to human life. Disasters lead to a great loss in economy of a country and such events are unpredictable and happen beyond human control. As a matter of fact, there is no concrete preventive measure that can be adopted but there are many prediction systems and post disaster management systems for event analysis and speedy rescue of victims.

Many disasters can be predicted based on certain natural phenomenon happening before the event based on certain parameters like rector scale for earth quakes, humidity and pressure for Tsunami etc. The meteorological station employs technology for continuous monitoring of such events. But Fire Disaster [3], [4], [5] is one of its kinds of disaster which can neither be predicted nor be monitored due its quick spreading nature resulting in huge loss of life and property. If a fire disaster happens in a running train, then nothing could be as disastrous as the fire spreads rapidly due to its speed. Many such events happen in India every year leading to great human loss. We cannot bring back life but certain rescue measures can be taken quickly to mobilize victims and for efficient post disaster management. It is shocking to find that the Indian Railways don't have even simple precautions like installing a fire detector in trains. This solution even if followed, however, may not help solve the problem since trains often move at a high speed and fire spreads almost instantaneously. Thus there is an urgent need to develop some devices which can adapt advanced technologies that can handle fires in dynamic environments and help prevent such disasters.

It is an era of Internet of Things (IoT) [6], where embedded devices can be communicated, managed, and monitored with its counter parts. IoT has been deployed in a variety of disaster scenarios and have also proven to be very effective. IoT technology can combine heterogeneity, interoperability and distributed processing in real-time. IoT originated from the primary idea of sense and send strategy of the Wireless Sensor Networks (WSNs). Among the applications of WSN, fire disaster management is one of its important applications. In addition, IoT can greatly help to perform some valuable data analytics helpful to perform post event analysis. This is because of the ability of the IoT devices to collect data from heterogeneous environment, and heterogeneous devices and push to the network or cloud or the external world for necessary action. Hence, IoT is ideally suitable to monitor disasters in real-time and therefore take steps to mitigate them and save precious lives and resources. We plan to use IoT in this paper to perform Fire disaster monitoring.

In section 2, we brief on the various existing fire disaster management systems in literature. We give the details of our proposed system in Section 3. The dataflow diagram depicts the flow of information in the entire system in Section 4. Finally we present the conclusion in Section 5. Now, we give the literature survey in the proceeding Section 2.

II. LITERATURE SURVEY

Many WSN based fire disaster management systems [7] were proposed in the past. But, WSNs are lack of interoperability, support for heterogeneous devices, energy efficiency etc. Also, in case of fire, many nodes in the network are damaged and data in the nodes become useless.

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So, the WSN based networks are not fault tolerant in case of fire disaster. The WSN based monitoring network works fine as long as there is no disaster. Disaster leaves the network disconnected and there is no chance of connecting the network back as fire leaves the network components damaged. It can serve only as an alert system in case of disaster. With addition of IoT technology, the network can be of great help in effective post disaster analysis.

Open MTC [8] is the first platform using IoT for forest fire disaster management. Many IoT based post disaster management were proposed in [9], [10] with advances in hardware, communications technology in contrast to the existing WSN based solutions. IoT as a technology evolved to cater many changing needs and make human life smart. The IoT [11] can remotely monitor sensor networks and report via cloud service to the central monitoring stations. Also, there are Ariel vehicles like drones are employed which can monitor the disaster region for critical data collection to perform data analysis and report via cloud to the monitoring stations. In particular for fire disaster in moving vehicles there is no such IoT device or mechanism used. So, till date an IoT application for effective post disaster management is unexplored. Hence, we intend to research on this and propose an innovative solution that is robust and dynamic for Fire disaster. We present the proposed methodology in Section 3.

III. PROPOSED METHODOLOGY

In this Section, it is proposed to explore IoT to understand their suitability for deployment in disaster scenarios such as fire in moving vehicles like buses and trains. While there have been several similar efforts made earlier, they have mostly been in static environments and thus may not be too challenging. However, fire events in moving vehicles such as trains not only occur in shorter time scales but also make monitoring and mitigating difficult due to the dynamic and noisy environment. Thus test bed architecture is going to be a crucial issue while addressing such scenarios.

The first aim is to design suitable IoT network architecture to detect fires in moving vehicles such as trains and buses. It is proposed to set up a test-bed consisting of sensor nodes to address the issues involved.

Disasters such as fire often spread rapidly and more so in moving vehicles such as trains. Thus the latency between the occurrence of the event and its completion tends to be very small. This demands that the event itself be detected quickly and the network respond in real time. Thus issues such as sampling the parameters of interest at a higher rate on occurrence of the event are crucial.

Also, high intensity fires are associated with light and humidity changes. Thus simultaneous monitoring of not only temperature but also light and humidity would help to truly detect the occurrence of fire. Since the system is deployed in a dynamic environment, it is also important that vibrations be monitored and background noise be eliminated for accurate detection of fire.

Thus, it is not only important that the test bed should facilitate monitoring the events but it is also necessary that all possible sources of noise be eliminated. In addition, since multiple parameters are being monitored, it is essential that techniques such as multivariate analysis be employed on the collected data to clearly bring out possible correlations between the parameters to eliminate false alarms and accurately detect the event. This gives rise for some data analytics.

In disaster scenarios, there is a great likelihood that sensing nodes themselves may fail but it is equally important that they do not fail since it will defeat the very purpose of deploying the network. Also, quality of service is important since false alarms need to be avoided as well as radio link be maintained at all costs. Thus the third objective of the proposed work is to develop techniques to build fault tolerance in to the network and ensure quality of service under all circumstances.

It is proposed to build an IoT network and examine its utility to monitor and mitigate fire accidents in dynamic environments such as moving trains and buses. However, since such environments also create noise due to continuous vibrations, accurate monitoring of the phenomena becomes difficult. Thus it is important that any noise related to vibrations must be eliminated.

Further, since any fire is accompanied with changes in light intensity and humidity in addition to the temperature, it would be useful to monitor these parameters as well simultaneously to accurately detect the occurrence of fire and avoid spurious alarms. In Section 4, we give the data flow in a flow chart for effective post disaster analysis.

IV. POST DISASTER DATA ANALYTICS& RESULTS

In this Section, we show the data flow in the proposed system for effective post disaster data analytics. A flowchart has been depicted in Figure 1, as follows. The sensor nodes are employed for sensing various parameters aiding for fire disaster like sudden change in temperature, light intensity, humidity, pressure etc.

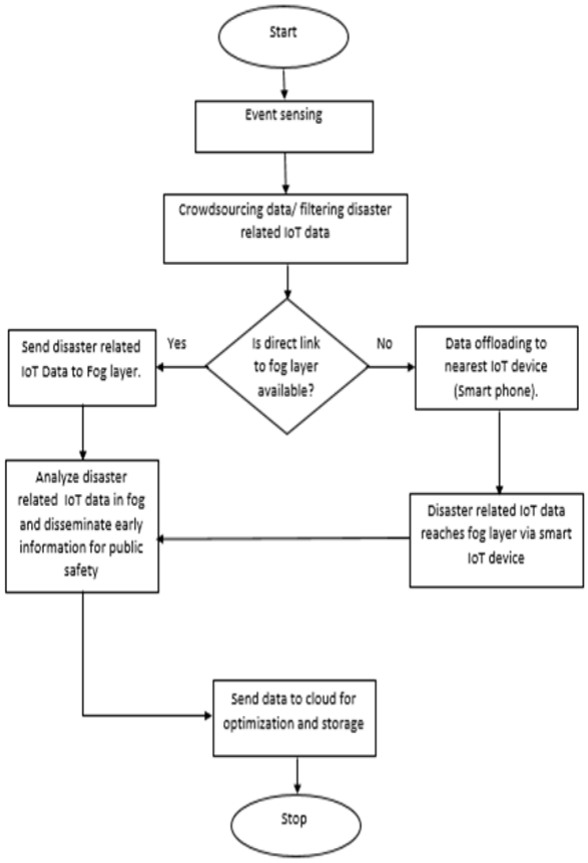

Figure 1. Flow Chart showing the operation of the System

The fire event is detected and the geographic location co-ordinates are communicated to the nearby hub/switch. The boundary region where data gets collected we employ fog computing to transfer data to the cloud. So that the data reaches cloud making a permanent copy for better data analytics. In case of absence of fog nearby, we employ crowd sourcing for critical event detection. We utilize the smart phones where people can also respond to critical situation by transferring data to the cloud. In case of absence of a direct link to cloud, we employ data offloading mechanism to effectively stream data to the nearest IoT device. Once the data reaches the fog layer, data analysis is performed and disaster related information is disseminated for public safety and early warning of the same. Further the data is streamed onto cloud for some valuable data analytics.

V. CONCLUSION

In this paper, we have proposed a data offloading mechanism for effective rescue during post disaster operations. However, in case of fire disaster the crucial factor for any monitoring device is delay. So we have proposed algorithm development and testing to verify routing of the data through the network and pushing into cloud for real time monitoring and mitigation. Also, these models will ensure fault tolerance and quality of service of the network. In our methodology, we employ fog computing to retrieve data from the damaged network through data offloading mechanism for early warning and public safety.

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