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Smart Phone Assisted Location Identification System for Natural Calamities

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Abstract:
Recent climate change has increased the danger of natural catastrophes across the globe. Lack of communication and location of survivors in disaster areas is a major barrier in disaster mitigation (particularly in rescue operations). This article proposes a framework for disaster rescue operations that uses direct communication on smart hand-held devices like Bluetooth and Wi-Fi for fast and precise rescues. Instead of depending on centralised cellular networks or wireless access points, we're attempting to build an application-layer, ad hoc network for use with smart devices. A mobile localization technique is also included in this research to further aid in disaster rescue efforts. These goals include finding survivors with more accuracy, speeding up the search for victims, and cutting down on the amount of computation required to save energy on mobile devices. With simulation and implementation data compared to previous research, this paper validates the suggested method.
Keywords: Ad hoc network, disaster relief, mobile communication and device-to-device

1. Introduction:

As global warming continues, the danger of natural catastrophes is increasing. The financial toll and the number of people killed or injured as a result of weather-related catastrophes have risen significantly in recent decades. As a result, many studies have focused on creating frameworks for overcoming the challenges associated with catastrophe rescue operations. Without communication and location of survivors in disaster areas, one of the most difficult challenges for disaster mitigation (and particularly for rescue operations) arises. When a tornado or earthquake hits, for example, a large number of people may be buried or trapped under the rubble of collapsed buildings or bridges. Survivors would utilise their smart hand-held gadgets in this scenario to contact rescuers and broadcast their positions so they can be found. However, it is very probable that those who survive will be unable to access any kind of network infrastructure, including cellular networks and Wi-Fi access points (APs), due to the devastation illustrated in Figure 1. Many academics have recently dedicated their time and energy to tackling this problem. Some of them use wireless ad hoc networks to replace broken infrastructure[1-6] by using Wi-Fi Direct7 and/or device-to-device (D2D) services in 5G cellular networks. A wireless ad hoc network is one in which the backbone isn't made up of specialised equipment. Devices such as smart phones and other hand-held computers function not only as clients, but also as backbone nodes in the network. Ad hoc networks are decentralised since existing infrastructure is not required to centrally control communication in such a network.

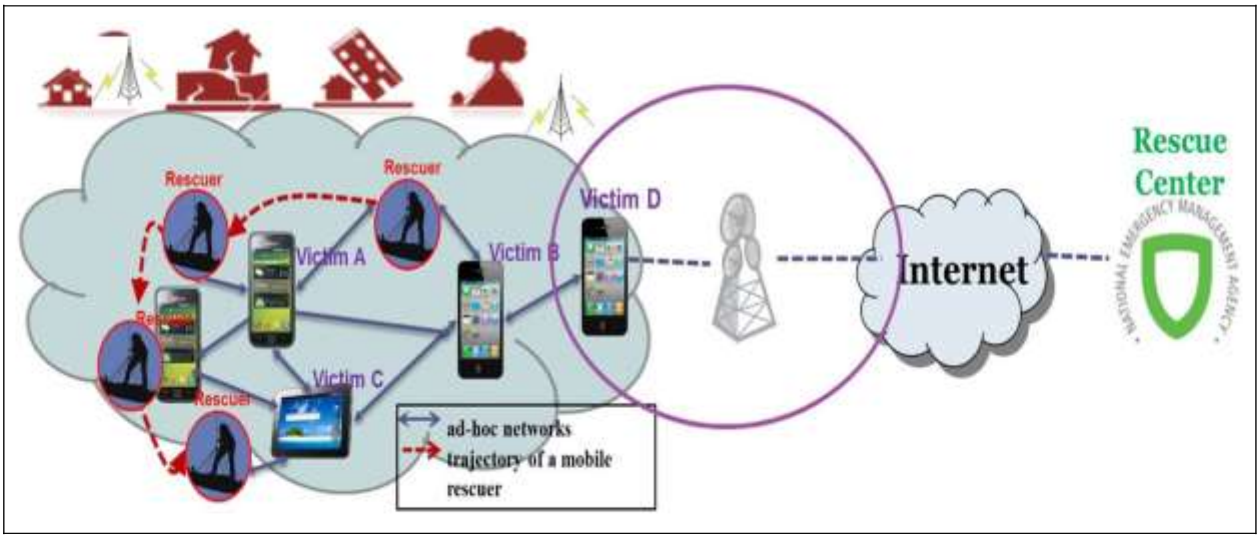

Figure 1. Target scenario: victims and a rescuer are all on ad hoc networks without GPS and infrastructure networks, and a rescuer moves around searching victims.

D2D communication, in particular, is a new 5G cellular network technology. Direct-to-Device (D2D) connectivity eliminates the need for a centralised eNodeB. Using P2P technology, mobile devices rapidly and easily establish a reliable network amongst themselves, no matter where they are or when they are. This capability enables it to be used in disaster and rescue situations. In addition, one of the most widely used P2P protocols is Wi-Fi Direct [7]. Wi-Fi Direct is built on the same Wi-Fi technology that most smart devices utilise to connect with wireless access points. A "software AP" is loaded on every Wi-Fi Direct smart device, making it possible for them to act as access points. This Wi-Fi Direct smart gadget may be immediately connected to by other Wi-Fi enabled devices. This discovery led to the development of an article that utilises a wireless ad hoc network over smart devices to efficiently conduct search and rescue operations in disaster areas. The main concept is to allow both rescuers and victims to join an ad hoc network for rapidly locating and rescuing people. It is suggested in this article that catastrophe survivors use a programme called RescueTalk to communicate with one another and maybe even contact others outside of the disaster area to beg for assistance. This paper also offers a technique of localization via this ad hoc network that is tailored to search-and-rescue operations in disaster areas without GPS service or infrastructure. There have been many indoor localization techniques suggested, including ours [8]. Nevertheless, the most of them need hand-held devices in daily life to be further fitted with other modules such as ultrasonic, and therefore these works are not suitable for disaster rescue scenarios.

2. Related Work

CodeBlue is a framework that makes advantage of both wired and wireless ad hoc networks. Victims of catastrophe may get medical attention from this organisation. Nearby paramedics and emergency technicians are alerted to changes in the patients' vital indicators. In addition, the positions of rescuers and victims are estimated using the received signal strength from infrastructure like Wi-Fi APs. Traditional infrastructure, on the other hand, is prone to destruction and/or malfunction in the event of a catastrophe. As a result, there are practical limits to deploying these infrastructure-dependent systems. Other research don't use infra-structure at all. Multiple heterogeneous networks are established by DistressNet [4], including disaster management-specific ones (802.11, 802.15.4, and IPv6). However, such a platform requires the installation of extra network modules, making it impossible for ordinary smart devices to utilise.

In contrast, the RescueMe project [5] creates a rescue framework that uses little extra infrastructure. The framework uses common infrastructure to gather secure location data from everyday network activities of ordinary net-work users. Whenever a catastrophe strikes, ad hoc networks are formed to help those who have been evacuated before the disaster strikes. However, the focus is on the "previous" places that existed before the catastrophe. As a result, if victims are on the move when a natural catastrophe occurs within a structure with no GPS accessible for an extended period of time, the information provided would be inaccurate.

Services for locating locations

Various localization methods have been suggested by many scholars. There are two kinds of localization algorithms: those that use anchors and those that don't. Anchor-based algorithms rely on a large number of anchor nodes that have been precisely located using GPS or other infrastructure-assisted techniques. Using this data, computers can determine the positions of unknown nodes [9-13]. It's related to distance vector routing, as Niculescu and Nath [9] developed an ad-hoc positioning system (APS). However, this approach only works when nodes are very connected to one another. For non-line-of-sight (NLOS) situations, researchers like Horiba et al.10 and Kim et al.11 have developed indoor localization methods. There have also been many multilateration algorithms [12], [13] referred to as MLAT, including but not limited to. MLAT techniques primarily rely on the anchor node's location information, which may be located many hops distant. This method avoids the buildup of errors by employing Kalman filters while refining the location using least-squares estimate. When the network lacks sufficient anchor nodes or the locations of anchor nodes contain error factors, this method's calculations will be inaccurate. We compare these characteristics to our suggested approach in the section on evaluation. To get beyond NLOS's limitations, several scientists have turned to machine learning techniques.

For example, the acoustic location processing system (ALPS) system [14] integrates Bluetooth and ultrasound data and applies machine learning algorithms to the received signals. Similar learning methods were used by Xiao et al. However, the effectiveness of the aforementioned learning-based systems may be highly reliant on learning parameters, which are intrinsic limits of machine learning systems. Additionally, the map-based approach requires pre-processing of the target region, which may not be feasible in some catastrophe situations.

The use of mobile beacons has been suggested as a locator alternative to traditional GNSS-based systems. [6] As the number of anchor nodes grows, the localization error tends to go down. Sichitiu and Ramadurai16 drew this conclusion and developed a localization method that utilises just a single mobile anchor and treats each of its dynamic positions as an anchor. The localization method proposed by Sun and Guo uses probabilistic estimates, but the movable anchor's trajectory is fixed to a helix trajectory. These authors [8] and [9] also proposed a method that chooses anchor points on the RSSI-range circle and then calculates the node's location based on the characteristics of that circle and a chord's perpendicular bisector. These prior studies, on the other hand, assume that the trajectory of the mobile anchor is fixed, and therefore the positions of the mobile anchors are pre-known. These limitations make it difficult to use in our disaster and rescue scenario goal. Our goal scenario is that rescuers would enter catastrophe zones where their trajectories cannot remain static, and as a result, the locations of the rescuers are unknown, much like the locations of unknown victims.

3. Methodology

People are often buried and trapped in the rubble of collapsed structures like bridges and homes after a natural catastrophe such as a tornado or landslide. Rescuers would be sent into the disaster zones to look for the missing people and bring them to safety. However, network infrastructures such as cellular networks and Wi-Fi APs are highly likely to be destroyed beneath the debris of buildings, making traditional communications between victims and rescuers impossible. Furthermore, GPS devices are unlikely to function well in disaster-stricken areas. In light of these findings, we suggest an ad hoc network approach that aims to assist rescuers in identifying survivors without GPS or infrastructure networks in a catastrophe scenario. Figure 1 depicts the ideal situation for which this essay is written. We assume, in particular, that every rescuer beneath catastrophe sites travels about in search of victims. Except for a victim node D in Figure 1, most rescuers and catastrophe victims don't have access to any network infrastructure. In certain cases, the edge node may have a network connection to a location outside of the disaster zone. We're trying to create an ad hoc network of victims who can submit assistance requests to an outside rescue centre by taking use of this edge node.

This article uses an ad hoc network and a catastrophe-specific localisation technique to help people in the event of a disaster. Let's say the dotted lines in Figure 1 show the path of a rescuer. Beacon frames from three distinct places are sent to the rescuer as he travels, allowing the victim A to compute his own position without the help of the rescuer. As a result, the closest victims to the rescuers will be found first. After then, victim A's location information is sent to victims B and C via an ad hoc network, and victim C may use that information to determine its own position. Victim B's whereabouts may have finally been determined.

Challenges

The following difficulties arise from the catastrophe and rescue scenario described above:

No infrastructure available

We anticipate that neither the rescuers nor the victims will have access to any centralised infrastructure for communication in the crisis area (such as cellular net- works and AP-based Wi-Fi network). The only means of communication available to them is an ad hoc network. As a result, these networks are almost certainly isolated and not connected to the outside world. Because of this, we presume there is no central command centre and that each rescuer and victim must make their own choice.

No access to a GPS system

It's possible that GPS won't function effectively for rescuers or victims alike in the given catastrophe scenario.

Nodes are Mobile

In most cases, a rescuer will be on the go rather than secluded in one location. The technique of localisation should take this into account, as well as the distance between static and mobile nodes.

Limitation of electrical power

Victims, in particular, are likely to have limited power resources (such as a battery), thus the suggested technique must be both power-efficient and simple. The suggested localization technique, in particular, should converge quickly in order to locate victims as quickly as feasible and rescue them as quickly as possible.

Proposed Rescue Platform RescueTalk

RescueTalk is an application-layer ad hoc network that was developed as part of this paper. There are three main components to the platform we're proposing: creation of ad hoc platforms (1), identification of survivors (2), and location-based routing (3), We'll go through each of these sections in depth in the paragraphs that follow.

4. Architecture

Ad hoc network architecture

RescueTalk is an open-source application-layer ad hoc network for smart devices that is designed and developed in this article. According to Figure 2, in order to locate victims and communicate with rescuers, we first build an application-layer protocol specifically for this ad hoc network. Using RescueTalk, rescuers and catastrophe victims may communicate and locate one other when Wi-Fi or cellular base stations are accessible on-site.

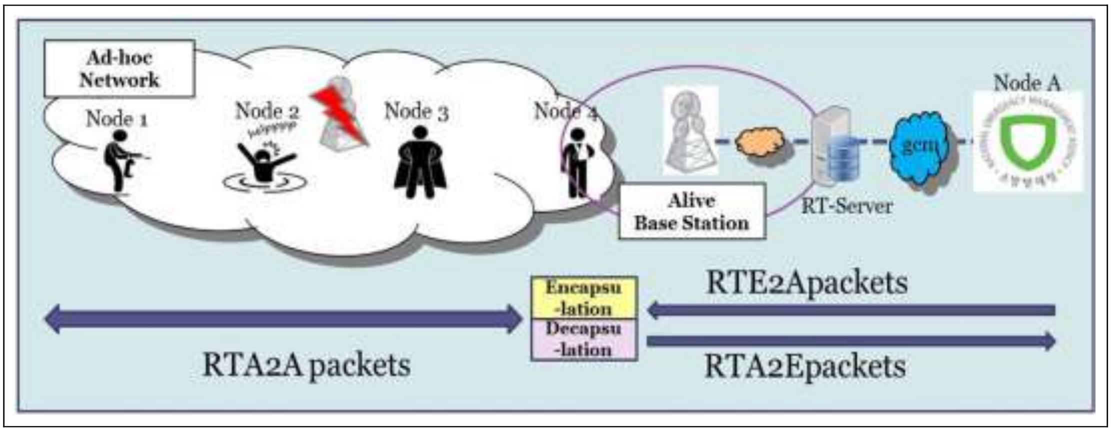

Fig 2: System Overview

Additionally, if an edge node is still linked to the disaster site (such as rescuer node 2 in Figure 2) and receives RescueTalk messages from a victim, the messages may be sent to the disaster site's outside rescue centre for additional assistance. To be more specific, the edge node encapsulates or decapsulates RescueTalk packets to send them to the outside or to send the outside packets into an ad hoc network. RescueTalk communication formats and protocols are designed in this article as illustrated in Figure 3 to make this situation feasible. Each node beneath the catastrophe site may interact with each other using this application-layer protocol and can also send this message to an edge node outside the rescue centre via an edge node to further forward. Because the proposed platform is an application-layer ad hoc network, network infrastructure such as base stations and Wi-Fi APs need not be modified. It's simply a matter of installing apps on each mobile device to get the platform up and running.

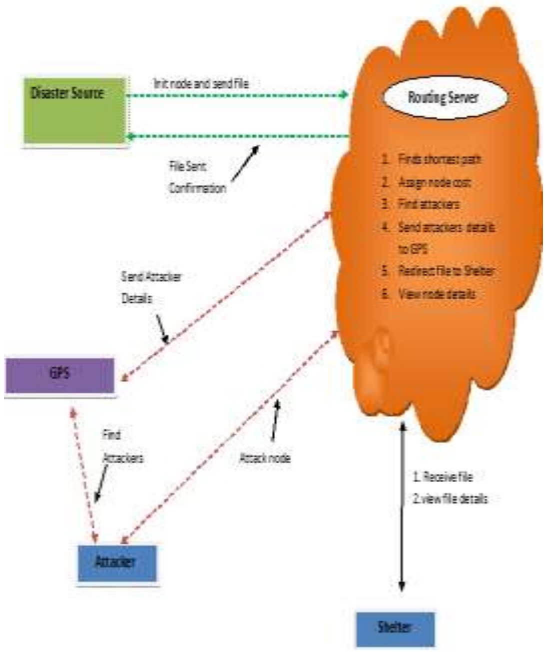

Fig 3: System Architecture

5. Implementation

Disaster Source

In this module, the data Disaster Source will explore the disaster-related data file and initialise the nodes, then pick a node & transmit to a specific shelter such a hospital, apartment, or cottage. Routing servers receive the data files from Data Sources and route them to end users who are located closer to them. The router will respond to the data provider if the transfer is successful.

Router/Server

The Routing server in this module has n nodes (A, B, C, D, E, and F) to offer a data service. The Routing Server receives the data file from the Source and chooses a node that is closer to the destination and sends it there. If an attacker is discovered in a router, the Routing Server will choose a different, closer node to send to the intended end user. We can set the distance between nodes, look at node information, and see who's attacking who in a routing server. If we wish to assign a distance, we should choose the node name, input a new distance, and then submit the change. This information will be saved on a routing server.

GPS

We may do several operations, such as viewing the route trajectory and seeing the assault destination, in this module. If we choose View Route Trajectory, we will be presented with all of the relevant information about the path, including the city name, metadata, and the date and time. We can see an attacker's information in GPS, such as their name, city, Mac address, and the date and time.

Shelter (Hospital, Cottage, Apartment)

There are n number of end consumers present in this module (A, B, C and D). The data file may be sent to the end user through Routing Server from the source. The file will be sent to the intended recipient as-is, with no changes made to it. Only users connected to the router will get certain types of data.

Attacker

The attacker is rerouting the trajectory node in an attempt to get an advantage. The attacker will choose a node and use a bogus key to get access to it. This information will be stored in GPS and Routing Server after a successful attack, along with tags like the attacker's name and city and IP address.

6. Conclusion

To rapidly and correctly search for and rescue catastrophe survivors, RescueTalk has been designed as a mobile ad hoc network platform. D2D for 5G and Wi-Fi Direct are used to build RescueTalk's application layer. There are many advantages to this approach over others being investigated in the field. First and foremost, it provides and executes a real-world platform for rescue operations by using smart device direct connections efficiently. As an example, it does not depend on GPS, cellular networks, or Wi-Fi access points. Furthermore, the suggested platform is based on smart handheld devices and is developed at the application layer. This indicates that the proposed protocol only needs minor changes to the underlying protocols. They can also send assistance signals to an outside rescue centre so that rescuers may quickly find the survivors and save them using this platform.

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