THE MESH NETWORK SOLUTION

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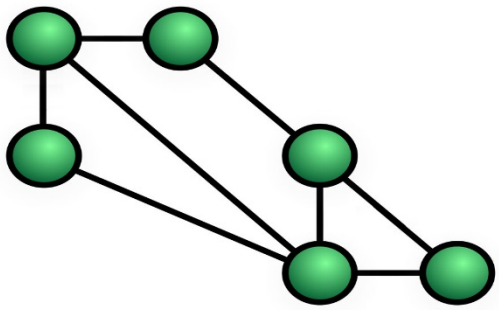
Abstract

All communities and organizations will face large scale emergency, disaster, or special event – the operative question is not "if," but rather "when." Emergency mass communication to residents, visitors, and guests is critical. During these events, communication systems such as cellular and Wi-Fi networks are taxed and tested to their fullest, assuming they remain functional in the first place. Given the shortcomings of the current Public Safety and emergency wireless mobile communications systems and present failures, it is necessary to look at direct device-to-device mesh networking as a redundant safety net.

This paper examines past communication issues and solutions. Also, this article explores a communication system that enables real-time information sharing, constant availability, and inter-agency interoperability called mesh networking. It is a modern mobile communication infrastructure well-suited for public safety and disaster recovery applications.



*A **mesh network** (or simply meshnet) is a local **network** topology in which the infrastructure nodes (i.e. bridges, switches and other infrastructure devices) connect directly, dynamically and non-hierarchically to as many other nodes as possible and cooperate with one another to efficiently route data from/to clients.*

Introduction

Today the level of resiliency offered by the current networking solutions and communications systems needs serious revamping.

After the wildfires that killed 25 people in Sonoma County in October of 2017, the California Governor's Office of Emergency Services commissioned an independent assessment of Sonoma's disaster communications plan. In addition to the loss of life, an estimated 100,000 people were evacuated, and more than 5,000 structures burned. The Tubbs Fire was the second worst wildfire in the state's history as of the writing of this document.

Sonoma County does have a public alert and warning system. They can alert county residents and visitors of impending dangers and other issues. The report states that specific procedures for using those alert and warning capabilities were "uncoordinated and included gaps, overlaps, and redundancies."

The investigation found that county emergency personnel were unprepared for the challenges that they faced with wildfires. In addition to the lack of preparedness, Sonoma County staff members had an outdated understanding of the alert systems and unorganized emergency and alerting protocol.

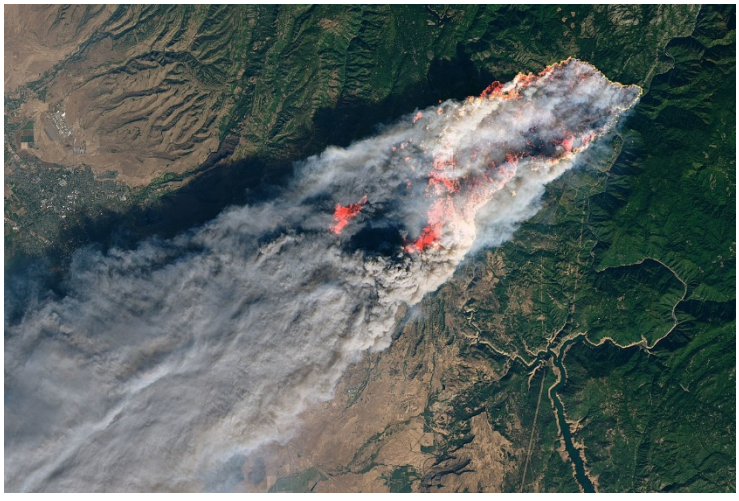


Figure 1 Image: NASA (Joshua Stevens) - NASA Landsat 8 Operational Land Imager

The report foreshadowed events that were to come, Sonoma County's disaster communication plans and training issues are not unique. In November of 2018, the Camp Fire ripped through the town of Paradise in Butte County California, beating out the fire in Sonoma County in size. It burned 240,000 acres, which is 386 square miles, it destroyed 18,804 buildings and, and caused 85 fatalities. The lessons that we learned in Sonoma were not applied in Butte.

Lessons not learned

To better understand how the failures occurred a detailed review of the records show problems with the alerts issued by Butte County and Paradise police.

The fire started on November 8 that 6:30 am, by 7:23 Butte County issues its first warning via Twitter. The tweet from the Butte County Sheriff's office was to evacuate Pulga.

Cal Fire reported that the fire was moving about a football field a second. The light reached Paradise by 8:00 am. The emergency officials sent out an evacuation order to residents closest to the fire. By that time, it was too late.

According to reports only about 25% of the residents in Butte County are signed up for their mass communications system. Survivors of the fire stated that they got information via Facebook, texts from friends, or decided to evacuate on their own.

The second issue with the mass communications system was even those who signed up found that success deepened on the geographical zone of the resident. The success of the call was generally deteriorating as the fire spread, and the infrastructure was damaged or overwhelmed. Even in the best-performing zones, 25% of messages failed to connect to a resident's phone. In some areas, the call failure rate was 94%.

Failure of The Infrastructure

The California Public Utility Commission (CPUC) reported that on the first day of the fire seventeen cell towers burned by the end of the first two weeks, 66 cell phone towers were damaged or out of service. The damage causing phones to go silent or dropped calls as surviving towers became overloaded by traffic.

Kelly McKinney, the author of *The Moment of Truth* and former emergency manager in New York City, called for the creation of a statewide system to provide a mass notification template at the minimum and argues that the state should backup local emergency management agencies.

Alerts and evacuations have fallen short in other California disasters as well. In January of 2018 the mudslides that divested Montecito alert messages were sent, however, hillsides already were collapsing, killing more than 20 people.

In 2017, the Bay Area Urban Areas Security Initiative, a federally-funded project to improve the Bay Area's capacity to respond to catastrophic events released a report on mass communications and public warning systems. The report stated that public warning systems controlled by individual Operational Areas (OA) and that each OA has its technologies, vendors, and policies, and training. In some cases, there are both duplication and gaps in their coverage and no protocol for coordinating messages between the OAs. As a result, depending on the area a person is in the messages they receive are often different and may have conflicting information.

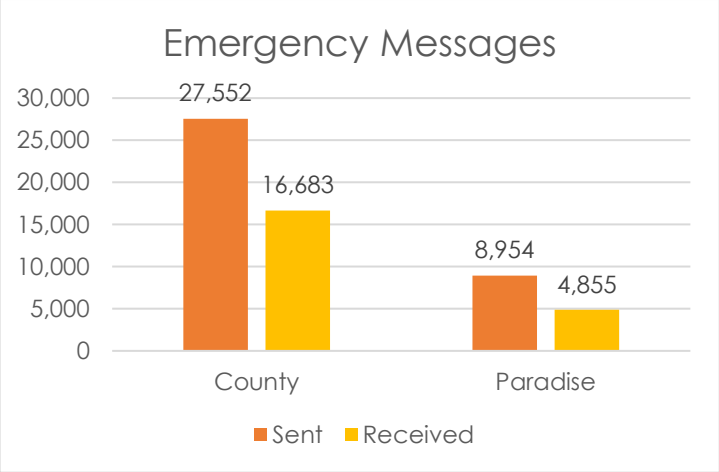
McKinney stated "California's alert system is, in reality 58 county alert systems duct-taped together, with 58 different processes and capabilities.

What Do the Numbers Say?

California's alert system creates otherwise avoidable delay, additional workload, and opportunities for error, according to the CalOES report.

A California law aims to improve notification in the future by creating an opt-out process for emergency notifications instead of the current opt-in process. This still does not address the visitors in the jurisdiction and short-term residents.

In Butte County, only residents who had registered for the alert system could receive notifications during the Camp Fire. Thirty-eight thousand seven hundred two people reside in the towns of Paradise, Magalia, and Concow, with others scattered in more rural parts of the county.



The county logs from November 8th confirm that 27,552 messages were sent. Only 16,683 messages were received by phones. Paradise officials reported that they sent 8,954 messages and only reached a total of 4,855. According to reports and additional 6,000 texts and 6,700 emails were sent by emergency management officials the first day. It is unknown the number of people that viewed those messages.

How do we improve?

One of the significant weaknesses of the emergency alert system is the dependency on electricity and that backhaul serving mobile networks remains uninterrupted. One solution is the use of landlines because of the heat-resistant copper wires. However, 52% of American households are on wireless phone systems, and an estimated 9 million homes are using VoIP.

Figure 2 Image: electrical-engineering-portal.com

The pressing issue with cell phone use in an emergency is that coverage is less reliable. The average person does not know that cell towers need electricity to operate. In areas of the country where flooding is an issue, cell towers fail due to flood damage as well. Currently there is no requirement to have backup electrical power at cell towers. Some of the carriers are putting LP or natural gas generators in limited locations. Also, cell service at some point terminates at a central office and relies on fragile glass fiber optic networks to route calls from the base stations to switching stations, then to customers. Moreover, because the systems are designed in a straight line when one tower goes down, incoming calls reverse direction and bounce back.

The limited networks in rural areas leave them especially vulnerable to loss of service. Also, cell providers are not communicating with emergency management officials about what towers are down or the number of them.

The mass communications company that services Butte County reported that 56% of the 4,272 calls that failed was due to "operator intercept" or the call being "timed out." That is the phone is no longer in service, the phone was disconnected, or the network did not have enough signal strength or bandwidth due to cell tower failure.

As more people transition to using cell phones, VoIP and other systems that are reliant on fiber, the more vulnerable they are to having communication issues when infrastructure damage occurs.

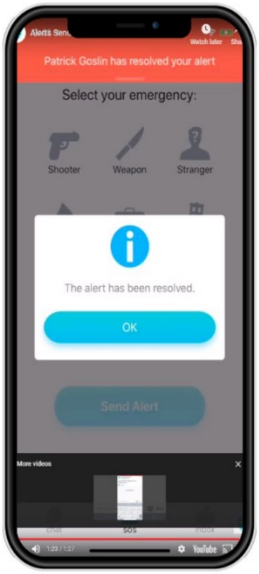
In the past, we used passive alerting systems such as pole-mounted sirens, and door to door evacuations. However, there is an expectation today which allows officials to

send emergency notifications over the cell and other electronic communication devices.

Next generation of mass communications is here.

Titan HST has implemented the use of Dual-Channel Mess Networking in its app. The mesh network is a peer-to-peer network that allows smartphones to talk to each other without the need for cell towers or WI-FI coverage.

The Titan app is designed to spread warnings of the impending critical issues and save lives.



This new form of networking technology can provide billions of people with potentially life-saving alerts and warnings, even if they don't have internet connectivity.

The best part of this technology is that innovative companies can use custom pre-installed software to leverage already commercially deployed hardware such as Bluetooth and Wi-Fi radios. Vic Merjanian, the CEO of Titan HST, stated that mesh networking can communicate between devices up to several hundred feet from one another. In theory, it can enable a message to go around the world.

Sean Griffin from Disaster Intelligence explains how the tech revolution is spreading to every corner of the earth. The Internet of Things, AI, ML, and Deep learning is enabling data analytics and automation in ways never imagined in emergency alerting.

Artificial Intelligence, Machine Learning, and Deep Learning enable the Mesh Network messages to transfer across multiple devices and spread alerts much further than the initial few hundred feet. Mesh Networking eventually alerts people across whole cities, regions, or even countries.

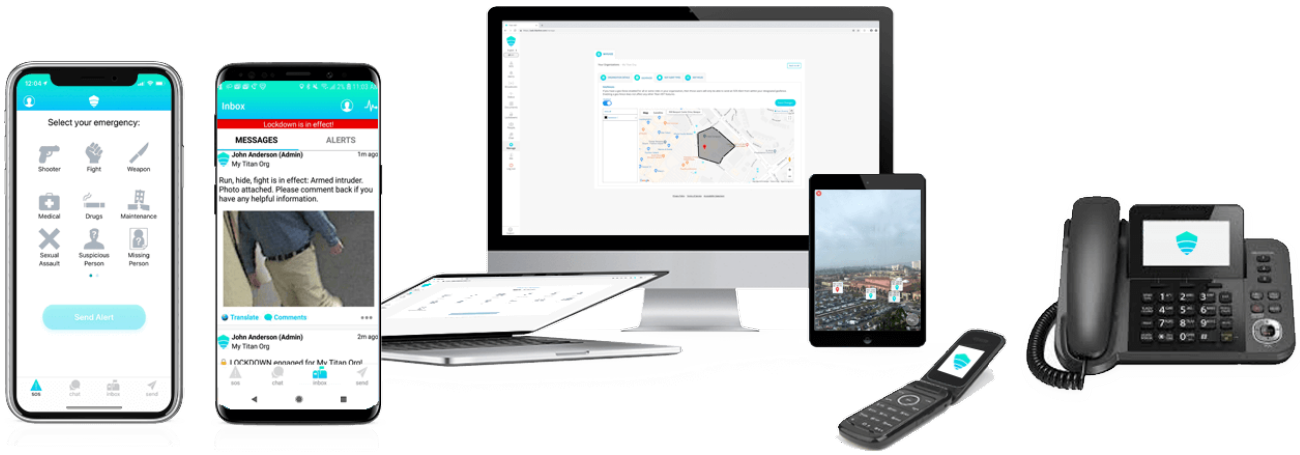
The mesh network can provide alerts to other devices, even if one who receives an alert isn't currently being used. This connectivity is the most critical part of the system.

With the issues that were discussed earlier, mesh networking is essential when receiving an alert. Each device forwards the signal to a neighbouring device. The transfer of information ensures that everyone gets the message in time.

"In this way, mesh networking exemplifies the power of communities," says Dr. Nirmit Desai, one of the IBM researchers behind the project.

Titan HST employs a state-of-the-art cryptography technique to ensure that users are only shown alerts that come from approved users while other users can invisibly pass along the data without being able to view the information, so as to extend range.

In addition to the spread of alerts and information, the mesh network allows for the dissemination of the warnings even with an impacted system with high use. While cellular connectivity struggles in areas like this, mesh networks thrive in these high-density use environments.



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