Deployment of Emergency Response Networks, a Web Application for Management

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Abstract *— With every passing day, more resources become internet dependent. It's evident that as time passes the share of our daily communications that rely on the internet will only continue to grow. Banking transactions take place online, enterprises rely on Voice over IP to communicate between workplaces, and online social media platforms are the method of choice for most individuals. While these are all welcomed commodities, it does however pose a huge drawback in the event a natural disaster renders the internet unavailable. Response efforts must be well planned and swiftly executed to ensure as little downtime as possible. Emergency Networks must be monitored and managed to ensure proper functionality until normal conditions are re-established. This paper addresses the hurdles that may be encountered during an event that cripples an existing internet infrastructure and proposes alternatives to deploy and monitor a temporary solution that provides the necessary services while intelligently safeguarding the available bandwidth.*

Key Terms *— Disaster, Emergency Communications, Emergency Network, Network Deployment, Network Site Database.*

INTRODUCTION

Puerto Rico was recently devastated at the hands of hurricane Maria. Almost eight months after the event both the power and communication infrastructures are still struggling to get back on their feet. Although the re-establishment of the power grid is of the upmost importance, one can arguably claim that the hardest aspect to deal with was the lack of communication after the event. Without communication both the government and the citizenship were left powerless. Let's face the facts, such an event can present itself at any moment in the shape of a hurricane, an earthquake or however nature chooses. We've now seen what happens when a nation is unprepared for an event of this magnitude. While we could point out the fact that local service providers were unprepared for an event where the power grid would not be at their disposal for the foreseeable future, formulating a plan to re-establish communications as soon as possible should be one of the country's top priorities. To achieve this goal, we must make optimal use of the resources at hand, including both temporary power sources and temporary network equipment. Once a site has their regular sources for power or internet connectivity back online, the emergency equipment can be moved to another site that still needs the services.

MOTIVATION

Having lived through several months without communications after a natural disaster, I wondered what were the main roadblocks that stood in the way of getting things back to normal. Then, I got the opportunity to work with an emergency response network provided by a nonprofit organization. After months of both maintaining the existing sites and deploying new ones, I realized there are still ways to improve. A tool can be developed to aid in the process. Although there are several needs, the main focus of this application is to provide a way to track site information and do so in a centralized location where all team members may have access on a moment's notice. With such a huge task, there will be several teams tasked with installing, maintaining and decommissioning sites on a day to day basis. Thus, an up to date database of current sites and their resource usage is necessary. More importantly, once a resource is decommissioned in the system, all team members will be made aware of its availability.

PROBLEM

The occurrence of a natural disaster quickly changes the landscape when it comes to the demand of certain resources. What was negligible yesterday could be the most sought out item today. When it comes to power related items, such as generators, batteries and fuel, this is especially true. Having the necessary resources ready is of the upmost importance, but if having them locally available is not viable, having a plan to acquire them is a must. The reality of the situation is that this will be a temporary solution. This means that we'll be dealing with limited resources. This is what makes proper use of those resources so important. The efforts will start by deploying those resources to sites with high priority. This category will be comprised of Emergency Operation Centers, 911 call centers, hospitals and government agencies tasked with coordinating relief efforts. It's important to note that while these sites will be our primary targets for deployment, they will also be the primary targets when it comes to re-establishing power and standard communications. This means that once those sites are re-connected to their normal power and internet connections we can use the emergency equipment on other sites. While not grouped with the sites we previously mentioned, this second group of sites will be in dire need of internet connectivity. In this secondary field we have local businesses such as pharmacies that need the internet for medical insurance submissions, schools need internet to access their grading systems, and the general public needs hotspots to go about their important transactions. This scenario with new deployments, decommissions and re-deployments of previously used equipment requires a centralized solution that provides immediate insight on the availability of the IP addressing space, site information such as coordinates, network topology, network components, and site contacts. Any information that makes coordinating relief efforts as easy as possible is crucial. When it comes to our primary targets such as Emergency Operation Centers and 911 call centers, any delay in the process can be life threatening.

IMPORTANT CONSIDERATIONS

A country which relies heavily on aerial infrastructure for both power and communications, has high exposure to any type of event. Under such circumstances, it's unacceptable that the bulk of the communications grid be dependent on the power authority [1]. Also, given the fact that the demand for fuel will surely rise due to the use of personal generators, it's imperative that the emergency solution provides power based on some form of renewable energy. Gas and diesel generators may seem to be an appealing option, but acquiring and distributing the necessary fuel while the demand is high may be an uphill battle. Another aspect to take into consideration is the fact that topography such as the one found in Puerto Rico requires cell sites at very remote locations due to the mountainy terrain. Some of these sites are very hard to reach for normal vehicles, making it a nightmare for fuel delivery trucks. Due to these limitations, the most widely used form of renewable energy employed at single sites is by far the photovoltaic system. There are however very different requirements depending on the site when it comes to cell sites.

The loss of connectivity at a given site may be caused by loss of power at the site or at some point along the way to the site where the provider's equipment is stored. It can also be caused by the interruption of the cable medium that provides the service. Depending on the damage the infrastructure has suffered, alternate means to connect the site will be required. In the following sections we'll look at the options for connectivity, the sites that may be encountered, and the limitations of the equipment.

POWERING THE SYSTEM

Having technologies that allow us to disseminate internet service to wherever we need it is only one part of the equation. We must also come up with a way to power the cell sites and the sites on the client's side. Since the systems deployed on the user's premises will be very similar to one another, a system to provide power for the necessary equipment may be standardized. An average system with a router, a point to point radio and three access points has an approximate power demand of 100 watts after factoring in the inverter efficiency.

Table 1
Standard Site Equipment

Quant	Description	Power Usage
1	MX64W Router	18 Watts
3	MR72 Access Point	42 Watts
1	Ubiquiti P2P Antenna	24 Watts
	Total Approximate Watts:	74 Watts

There are numerous photovoltaic kits at affordable prices that can easily comply with this requirement. It is however a different story when it comes to the cell sites, these should be designed by the provider and should be a standard element when designing a cell site. The capacity of such a system can vary tremendously depending on its purpose and the area it serves.

CELL SITES

A cell site is also known as a cell tower. These sites are placed in strategical locations depending on the topography of the area being served. These sites may be owned by a service provider or they may have a private owner that rents the tower out to one or several providers.

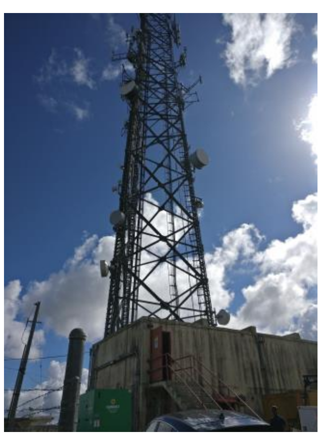

Figure 1
Typical Cell Site

When establishing a plan to deploy an emergency network, the first step is to draft a map with the location of all available cell sites in the area. Once the event itself subsides this map will serve as the starting point when determining cell site availability. The team must identify which towers are functional and which ones are offline due to the event.

Figure 2
Available Cell Site Map

This map will play a vital role once the client sites are determined. Although proximity is an important factor, other factors such as line of sight will determine the viability of the temporary link.

TOPOLOGY ALTERNATIVES

There are basically three alternatives to provide a temporary internet connection. When there are no landlines functioning and cell towers are unavailable, a Very Small Aperture Terminal (VSAT) is the best option. This type of connection uses a dish similar to those used for satellite television applications, a specialized Low-noise Block Downconverter (LNB), and a Block Upconverter (BUC) to achieve satellite connectivity [2].

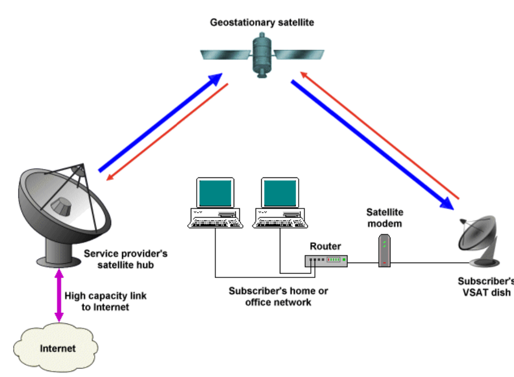

Figure 3
VSAT Technology

In areas where a cell tower is functional, sites within the service area may be connected using the wireless signal available whether it be 4g LTE or 3g, commonly used for mobile phone technologies.

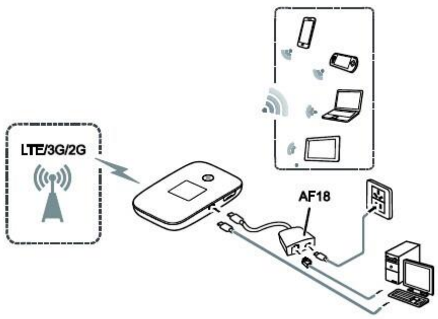

Figure 4
3G/4G/LTE Technology

In instances where there is a nearby cell tower, but the coverage does not reach the site, a point to point (P2P) connection may be achieved using antennas in the 2.4Ghz and 5Ghz WI-FI spectrums or by using TV White Space technology which take advantage of unused frequencies in the TV channel spectrum.

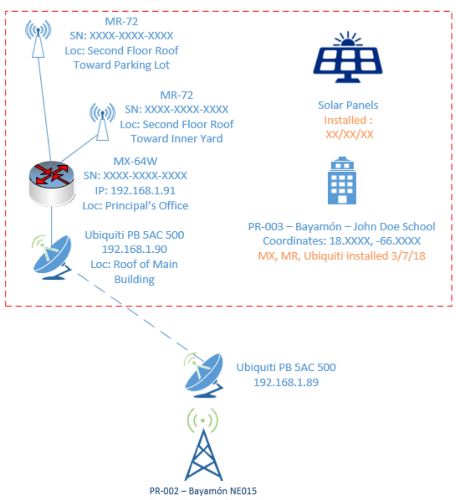

Figure 5
Point to Point (P2P) Technology

At the end of the day, there is no "one size fits all" solution that can be deployed at any site. It all depends on cell positioning, the surrounding geography, site size and site peculiarities. That's why we need a tool that can keep track of all the relevant information at each site and present it in an organized manner no matter where, or who the user is.

Developing the Web Based Application

Now that we've had a better outlook at the equipment that comprises a provisional network. Let's dive into the focus of our project. To develop the Web Application we're interested in, we must first look at the needs we need to fulfill.

Table 2
Functional Requirements

Requirement	Description
Ability to register new sites while requiring that crucial data be included	Allows the creation of sites including a unique site ID, site coordinates and install date.
Ability to register system components	Inventory must be easily registered in the database. It must include the site number where it has been deployed or if it's at a warehouse.
Ability to keep track of decommissioned sites and proposed sites	Decommissioned sites and proposed sites must have their separate unique ID's and a separate view.
Ability to register generators and PV systems	This equipment must be registered in the database and it must provide the current location whether it's been deployed, or it's stored at a warehouse.
Ability to register site contacts	Contact individuals for each site must be registered in the system.
Ability to register Service Providers and their contact information	There will be different backhaul providers depending on the area being worked on. The system must keep track of this information.

Platform Specifics

The following table contains the specifics for the system and the development tools used for this project.

Table 3
Platform Specifics

Component	Description
Database Software	MySQL Version 5.7.17
Development Environment	PHP Version 5.6.30
Web Server	Apache 2.4.25
Web Browser	Compatibility with the latest versions of Microsoft Edge, Mozilla Firefox, Google Chrome and most browsers
Usability	Simple and friendly user interface.

Designing and Creating the Database

With our requirements outlined, we can now start designing our schema [3].

- **SITES** (site_id, location, site_name, latitude, longitude, inst_date, status, con_type, backhaul, prov_id).
- **PROVIDERS** (prov_id, prov_name, prov_phone).
- **ACCESS_POINTS** (ap_num, serial_num, manufacturer).
- **ANTENNAS** (ant_num, serial_num, manufacturer, model, cur_site, ip_address).
- **CONTACTS** (site_id, contact_name, phone_no).
- **GENERATORS** (gen_num, serial_num, manufacturer, model, cur_site, ip_address).
- **ROUTERS** (router_num, serial_num, manufacturer, model, cur_site, ip_address).
- **TOWERS** (tower_id, location, site_name, latitude, longitude, inst_date, status).

We've now defined the entities and the attributes that will be part of our database. A simple Entity Relation Diagram (ERD) will serve to establish the relationships between the entities. In figure 6 we can see the ERD diagram for our schema.

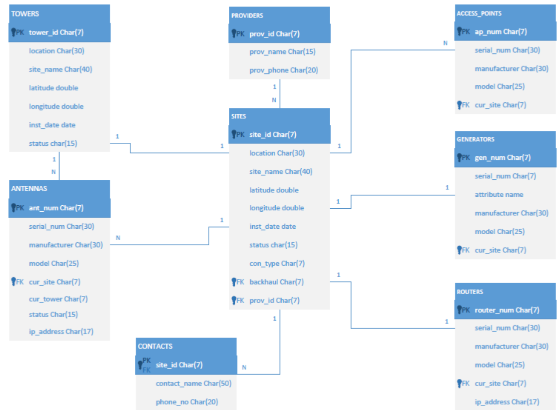

Figure 6
ERD Diagram

Once our database has been designed and our relations have been determined, we may commence with the implementation. For this project we will use mySQL to implement the database. Figure 7 shows an example of one of our relations once it has been created and data has been recorded. The table being displayed shows the "sites", which is the main relation in our schema. It contains information about every site that is active, decommissioned or planned for assessment. Other information such as location data is documented along with an assigned site number. It's crucial that this information be available at all times due to the fact that the team that installs the equipment may not necessarily be the one performing the maintenance and the decommissions.

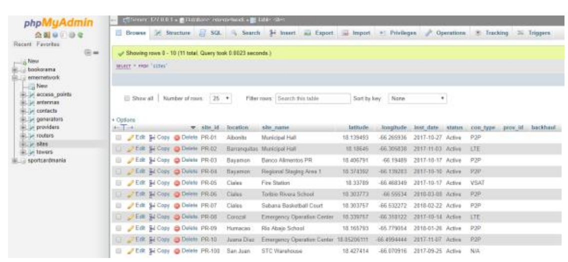

Figure 7
Database Relation

The database will now need a web-based user interface to access and edit the data. Our code will be written using PHP and the application will be hosted using Apache. In figure 8 we see an example of our main webpage and the user interface.

Figure 8
Web Interface

The user may select different filters, so the search criteria may be adapted to his needs. In figure 9 we can see a site search that uses the location filter. The user may select other filters such as the site ID or the site name to conduct the search. It all depends on the information that he has at hand.

Figure 9
Search Results

The application presents a user-friendly interface that allows the user to view or alter the existing data in the database. New entries may also be added to the warehouse.

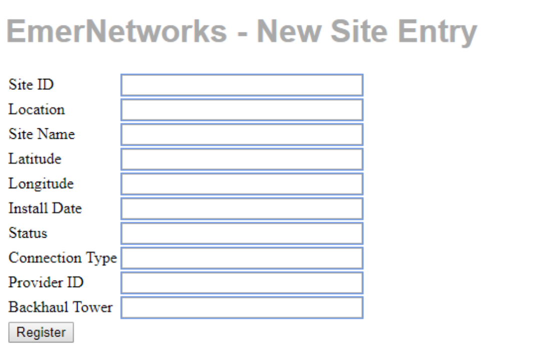

Figure 10
Data Logging

CONCLUSION

When preparing for a natural disaster, there is no “one size fits all” solution. The conditions will vary depending on the event, and the solutions implemented in the field must adapt to any given scenario. The resources available will be shuffling between sites through the project lifecycle. This application will provide a centralized and robust tool that will keep track of the current inventory whether it’s currently deployed, or it’s ready for deployment at a storage site. It will also provide a live summary of the IP number space for the assigned network ID. This will avoid having issues with duplicate IP’s that would otherwise cause conflicts within the network. The plans and methods discussed in this paper aim to be as flexible as possible.

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