Requirements Specification for Local Emergency Area Network (LEAN)

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Contents

1 Introduction

1.1 Document Purpose

This document is a requirements specification for Local Emergency Area Network (LEAN). The specified product is a Local Area Network deployed in emergency scenarios aimed to provide a network infrastructure in areas where communication channels get compromised.

The requirement specification document will outline the product scope, functionality, constraints and requirements for LEAN.

1.2 Product Scope

The overall goal of this project is to construct a Local Emergency Area Network that allows communication between Incident Command System (ICS) staff and their software applications. LEAN includes the following capabilities:

1. LEAN will be a portable ad-hoc network.
2. LEAN will provide Local Area Network communication only for ICS and third party software applications.
3. LEAN will provide an intranet connection.
4. An algorithm will be provided by the developers that upon initial setup will recommend the number of Wi-Fi repeaters needed in a particular incident.
5. An algorithm will be provided by the developers that upon initial setup will recommend the best geographical location for the Wi-Fi repeater pods to be placed, the amount of Wi-Fi repeaters will vary depending upon the size of the incident area..
6. At minimum he product will handle 600 Mbps of bandwidth for data transfer.
7. Centralized server will be purchased by the company and configured by the developers.
8. Wi-Fi repeaters will be purchased by the company and configured by the developers as needed.
9. Wi-Fi repeaters will be hardened using a special casing/shell by the developers.
10. Wi-Fi repeaters will contain a sensor array to be configured by the developers

LEAN will provide an intranet for ICS responders through a wireless network deployed by a centralized server and a hardened Wi-Fi repeaters cluster. LEAN will dynamically fit the range of the incident by determining the best location for each node in the repeater cluster using an algorithm.

LEANs design purpose is to provide a secure and reliable network infrastructure for ICS software applications. Although LEAN will be capable of allowing extra network appliances such as switches, routers, servers and technologies to connect or work over the network, the developers will not be accountable for later additions of network appliances or technologies.

1.3 Intended Audience and Document Overview

This section is aimed to suggest which sections of this document would be more useful for each of the following group of readers:ICS commander, the project sponsor, technical support staff, and ICS responders.

1. Section 1 and 2 will help ICS commander get acquainted with LEANs functionality.
2. Section 1, 2,3, 4 and 5 will help the project sponsor get acquainted with all the aspects involved in this project to make an informed decision whether or not invest in LEAN.
3. Section 1, 2.1, 2.2, 2.3, 2.4, 3, and 4 will help technical support staff in maintaining LEAN.
4. Section 1, 3.1.1, 3.1.3 and 3.1.4 will help ICS responders get acquainted with the interface of LEAN.

1.4 Definitions, Acronyms, and Abbreviations

Name	Definition
LEAN	Local Emergency Area Network
ICS	Incident Command System
Pod	Physical network device that is used in this instance as a Wi-Fi repeater and sensor data collector.
Wi-Fi	Wireless Fidelity technology.
Ad-hoc	A decentralized type of wireless network.In which each node participates in routing by forwarding data for other nodes.
Intranet	A private network accessible only to an organization's staff.
Network appliances	Hardware that can be connected to a network such as Routers, Switches, Servers.
WRP	Wireless routing protocol
HTTP	Hyper Text Transfer Protocol
WPA2	Wi-Fi Protected Access 2
Delta Data	Data indicating a change in value

1.5 References and Acknowledgments

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2 Overall Description

2.1 Product Perspective

LEAN is a system that solves communication issues for ICS events when other systems either fail or are not reliable. LEAN technology already exists in locations where large numbers of people need access to data via their electronic devices. Areas like hospitals and universities have large networks accessible anywhere by a single Wi-Fi network and password. As users move through the network they never lose connectivity because there are Wi-Fi repeater nodes located throughout the area.This technology is the idea behind LEAN.

LEAN will exist as a scalable network to meet the demands of different size ICS events. This is the difference between LEAN and already established network technology, LEAN can cover any size event area by using Wi-Fi extender pods that can be placed as needed to extend coverage to any size as well as inside buildings or in locations not accessible by larger equipment.

2.2 Product Functionality

LEAN will provide stable communication for ICS responders and commanders. ICS personnel will determine the ICS incident area and deploy Wi-Fi extender pods based on a strategic algorithm for placement of the LEAN pods to cover the ICS incident area completely. LEAN will provide data communication for the following:

1. Form submission
2. Email communications
3. Image transfer
4. Environmental information via sensors
5. Third party applications will be able to access LEAN for their communication needs.

2.3 Users and Characteristics

ICS emergency responders and commanders will be the primary user of this system. This will include: police, fire, medical, Hazmat responders, as well as search and rescue, logistics, ICS command center personnel and anyone else who may need to communicate for a specific ICS event. LEAN should be accessible to them at all times during the ICS event.

An ICS logistics team will be required to deploy and maintain all Wi-Fi extender pods. The pods will broadcast statistics to the central server at ICS command so logistics can monitor any issues that arise. Logistics then can diagnose and determine the best course of action to either repair or update the pods as needed. The logistics team will require more in depth training with LEAN than a typical LEAN user. This training will include coverage for pod placement training, network monitoring and maintenance.

Emergency responders will need minimal skill level to use LEAN. Most users will already be familiar with how to connect a device to a wireless network, if training is needed this will be handled by ICS command.

2.4 Operating Environment

LEAN will operate in most environments. Extreme weather conditions will not affect the stability of LEAN within normal weather extremes. These extremes are assumed to be:

1. Temperature will not exceed 149 degrees fahrenheit, preliminary testing on the raspberry pi has shown the ethernet controller can handle 149 degrees fahrenheit, but the CPU/GPU can not exceed 138.2 degrees fahrenheit according to GeekStaff [1]. This test will be verified during the design and verification process of LEAN production.

2. Water resistant pod casing will be used to protect the Wi-Fi repeaters from moisture and dirt. The casings will not impede the signal strength of the Wi-Fi signal being produced.

3. LEAN pod casing will provide shock absorbency for the entire pod, so the hardware does not get damaged in case of being physically hit or dropped. Considerations have been taken as far as the design to have the pod casing absorb seismic activity that may occur during an ICS event. Further testing will need to be done to determine exact seismic activity the casing will resist.

LEAN will operate on the Linux-Debian based operating system. Both the central server and Wi-Fi repeater pods will operate on the same operating system.

A sensor array will be included with the pods and interface with the Raspberry Pi processor,these sensors will provide ICS logistics with vital information about the pods and their status and condition in the field. The sensor array will include:

1. Temperature Sensor- monitor the pods processor temperature

2. Power monitor- monitor the battery life of the pod

3. GPS sensor- monitor the location of each pod

4. Accelerometer- monitor pod movement

5. Luminosity sensor- detect light

6. Barometric sensor- atmospheric pressure

2.5 Design and Implementation Constraints

1. Battery weight will need to be less than 100 pounds which will help determine portability.

2. Battery cannot be tilted more than 22 degrees from vertical as defined by Trojan Battery Company [2].

3. Processing speed - The default clock speed for a Raspberry Pi is 700 MHz.

4. Bandwidth of LEAN network will operate at 2.4 GHz.

5. LEAN will also contain a Wi-Fi radio that meets IEEE standard 802.11n with a data rate of 600 Mbps [3].

2.6 User Documentation

The following documentation will be provided with LEAN:

1. Manual for installation and setup
2. Manual for pod maintenance/update procedures
3. Manual for monitoring and analyzing pod vitals received from the sensor arrays

2.7 Assumptions and Dependencies

1. The code and algorithms used in LEAN will be completely written by the LEAN development team, no code will be reused from other projects.
2. LEAN will use the Raspberry Pi processor which is already existing technology.
3. Pods will be durable against damage and resistant to weather and atmospheric extremes.
4. Operating temperature will not exceed 138 degrees Fahrenheit as tested by Geekstaff, further testing will be done to verify [1].
5. Most users will already be familiar with how to connect a device to a wireless network, if training is needed this will be handled by ICS command.
6. LEAN will not provide storage space on it's centralized server, the applications using LEAN's network must provide their own means of data storage.
7. ICS logistics will be responsible for setup and maintenance of LEAN.

3 Specific Requirements

3.1 External Interfaces

3.1.1 User Interfaces

1. A terminal interface connection through USB
   (a) Bash library commands to manipulate network settings.
   (b) Password protected to prevent any unauthorized software manipulation.
   (c) Ability to run software for setup and pod placement.
   (d) All installed software will report to the terminal without user interrogation
   (e) Refresh output data at a minimum of 15 seconds.
2. Pod status tracking software that reports pod status to a monitor at the central server
   (a) All pods are visualized on a map with specific GPS location.

(b) Each pod can be selected to display sensor array information and any anomaly detection.

(c) Anomalies will be reported by flashing the pod icon on the map.

(d) Anomaly detection will begin an emergency mode that greatly increases sensor interrogation.

3. LEAN will provide a WPA2 encrypted wireless connection that responders will connect to as if they were connecting to their business Wi-Fi.

   (a) LEAN will provide no user interaction through wireless connection. This will only be provided by third party applications.

3.1.2 Hardware Interfaces

1. Each pod will be equipped with a GPS sensor

   (a) Data will be interrogated at a maximum of once every thirty minutes to preserve pod battery life.

2. Each pod will be equipped with an accelerometer

   (a) Data will be interrogated at a minimum of once every ten seconds.

3. Each pod will be equipped with a weather chip

   (a) Contains a minimum of one luminosity, temperature, and barometric sensor.

   (b) Luminosity sensor will be interrogated at a minimum of once every five minutes.

   (c) Temperature sensor will be interrogated at a minimum of once every five minutes.

   (d) Barometric sensor will be interrogated at a minimum of once every twenty minutes.

4. Each pod will be equipped with a power level sensor

   (a) The power level sensor will be interrogated once every five minutes.

5. Each pod will be equipped with a Wi-Fi radio

   (a) The radio will meet at a minimum IEEE standard 802.11n[4].

   (b) The radio configuration will have at a minimum a maximum data rate of 600 Mbps like what is provided by the IEEE standard 802.11n [3].

6. Each pod will be equipped with a flooded lead acid battery

   (a) Must have a minimum charge capacity of 30 Ahrs.

   (b) Terminal connections will be sealed and weather proofed.

   (c) The battery will be easily detachable from the rest of the hardware.

(d) The battery will be insulated with an acid-resistant material. The following is a consideration for the insulating material:

i. A layered design consisting of an inner layer of polyvinyl chloride (PVC) for acid and environmental protection, a middle layer of semi-rigid PVC (SR-PVC) to add abrasion resistance, and an outer layer of neoprene (polychloroprene) for excellent flame retardation[5].

(e) The ventilation system will limit hydrogen accumulation to less than 2% of the total volume[6].

7. The central server intranet connection will meet at a minimum IEEE standard 802.11n[4].

8. The central server will be able to handle all ICS wireless traffic load.

(a) Additional servers will be added when traffic load has exceeded 85% of the servers processing power.

3.1.3 Software Interface

1. Server Database

(a) Will only run MYSQL databases for uniformity.

(b) Each endpoint on the sensor array will have it's own database.

i. Joined tables through a foreign key defined as the pod ID [7].

ii. No null data will be stored for time stamps that don't contain data for every sensor.

(c) Every data write will be done in one single query.

2. Will use JSON to encode sensor data packets

(a) Each pod to server transmission will use one JSON hash with two keys; one for identification and one for sensor values[8].

i. The identification key will have one value containing an unique ID describing the pod.

ii. The sensor values key will contain one value for each endpoint in the sensor array.

(b) Each server to pod transmission will use one JSON hash with the same keys received and flags.

i. Flags pertaining to HTTP status codes[9].

ii. Flags pertaining to pod normal/emergency mode.

3. Server Directory Structure

(a) All intranet processing will be contained in the `www` directory.

(b) All `.config` files will be outside of the `www` directory.

4. Sensor Data Interrogation
    (a) There will be a separate python program for each of the sensor array endpoints to interrogate.
    (b) Each timer that tracks the sampling rate of a sensor endpoint will run on a separate thread.
    (c) When a sensor array endpoint has been sampled, the value will be immediately sent with JSON encoding described in section 3.1.3 p2.
5. Routing Protocol
    (a) The node cluster will run the table driven routing protocol, wireless routing protocol (WRP) [10].
    (b) The WRP provides extra information compared to other table driven protocols that will be useful for node integrity.
6. Placement Software
    (a) Pod placement will be estimated by software that examines the surrounding geographical location.

3.1.4 Communications Interfaces

1. Protocol
    (a) LEAN will operate on the HTTP-Intranet to achieve the fastest speeds possible.

3.2 Functional Requirements

1. Wi-Fi Access Point
    (a) Wireless access will be WPA2 secure
        i. ICS Unit specific passwords will be used to connect.
    (b) Will provide basic connectivity to a user
        i. Share their information with a central server.
        ii. 3rd party applications that need a network.
2. Collect Sensor Data
    (a) Anomaly Detection
        i. Detect abnormal data that does not characterize with the normal operating data of the sensors.
        ii. Detect threshold data that exceeds conditions resulting in pod damage.
        iii. Detect a large change in data (delta data) that would indicate abnormality.
    (b) GPS Data

i. Geographical location will be collected for placing the pods on an interactive map.
ii. When geographical location can not be updated, it will be marked as an anomaly.
iii. When delta data indicates a large change in geographical position it will be marked as an anomaly.

(c) Temperature Data

i. Collect thermal data to determine operating conditions for the pods.
ii. When maximum threshold temperature is passed, it will be marked as an anomaly.
iii. When delta data indicates a fast change in temperature it will be marked as anomaly.
iv. When temperature can not be collected, it will be marked as an anomaly.

(d) Luminosity Data

i. Collect light intensity data.
ii. When minimum light intensity threshold has been exceeded, it will be marked as an anomaly.
iii. When maximum light intensity threshold has been passed, it will be indicated as an anomaly.
iv. When delta data indicates a loss of light or a great increase in light intensity, it will be marked as an anomaly.
v. When light intensity can not be collected, it will be marked as an anomaly.

(e) Barometric Data

i. Collect elevation data to add another element to location services.
ii. When delta data indicates pressure change threshold has been exceeded, it will be marked as an anomaly.

(f) Power Level

i. Detect battery charge capacity.
ii. When battery charge capacity has reached a minimum threshold, it will be marked as an anomaly.

(g) Accelerometer Data

i. Collect movement and seismic data.
ii. When data indicates that the pod has moved beyond the maximum threshold, it will be marked as an anomaly.
iii. When seismic activity has passed the maximum threshold, it will be marked as an anomaly.

3. Emergency/Normal Modes

(a) Emergency Mode

i. When an anomaly has been detected, this mode will be entered.
ii. Will increase sampling rate of all sensors by 90% to gather enough data to directly monitor the reason for an anomaly.

4 Other Non-Functional Requirements

4.1 Performance Requirements

ICS personnel will be able to transfer data with rates of up to 600 Mbps anywhere within the Wi-Fi repeater pods established area. LEAN central server will handle all traffic in and out without loss of data. LEAN will be scalable so multiple servers can be used if needed.

Central server hardware will be powerful enough not to lag when network is loaded with users. CPU utilization will not exceed 85% when network is loaded. The remaining 15% will be free for internal computations as LEAN requires.

4.2 Safety Requirements

Wi-Fi pods will contain a flooded lead acid battery to power all peripherals within the pods including the raspberry pi processor. The battery will be connected to the pod externally, should damage occur to the pod, or any visible malfunction can be seen, the following safety procedures should be taken. As defined by U.S. Battery Manufacturing Company [10] and IEEE Std 484-2002 [6]:

1. Always wear protective eye wear, gloves and protective aprons and overshoes.
2. Use caution when removing a lead acid battery.
3. Eliminate sources of sparks or flames.
4. Keep metal tools and jewelry away from batteries.
5. Portable or stationary water facilities for rinsing eyes and skin in case of contact with acid electrolyte
6. Keep a neutralizing solution close by, Bicarbonate of soda mixed approximately 0.1 kg/L of water to neutralize acid spillage.
7. Class C fire extinguisher.
8. Adequately insulated tools.
9. Spill containment kit when moving cells.
10. Use the correct type of charger.
11. Store batteries in a cool, dry and ventilated area.
12. Make sure battery vent caps are fully seated in place.

13. Dedicate an area for battery maintenance.

14. Maintain electrolyte at proper levels.

4.3 Software Quality Requirements

Software being implemented on LEAN will have documentation provided for basic usage by ICS logistics personnel. The logistics team will require some training for those who will be maintaining and monitoring network traffic.

LEAN will be accessible by all operating systems that can utilize a data network.LEAN will also be very portable, very little setup and hardware is needed in moving or resizing the network as needed by ICS command.

4.4 Hardware Quality Requirements

Developers will be responsible for building and configuring all hardware. The stakeholder should be aware that the Wi-Fi repeater pods will be hardened and should not be concerned with logistics of how the hardware works, only with the information the hardware is obtaining and reporting to LEAN central server.