PANIK **(Partially Automated Network Installation Kit)**

by

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ABSTRACT

As of 2019, it was estimated that over 21 million people in the United States go without reliable Internet connectivity (Winslow, 2019). The Internet is integral to everyday life now more than ever; many relying heavily on it for conducting work, obtaining an education, and maintaining communications. Because of these benefits and reliance, it is essential for anyone to have access to the Internet when it is needed, especially in cases of emergency. However, many people do not have the financial resources or technical know-how to stay connected. Our PANIK Guide hopes to help solve this issue by providing a user-friendly approach to setting up an inexpensive mesh network that can be used to help provide this access in areas and times where Internet connection is needed most. PANIK Kits are an affordable, easy to set up, quickly deployable approach to help connect those who are in most need of these resources.

1 INTRODUCTION

1.1 Introduction

4.13 billion people found themselves using the Internet as of March 2019, more than half of the global population (Meeker, 2019). There's no doubt that the Internet will continue to be an ever-important component to people's daily work, student education, and within social circles, especially in light of the COVID-19 pandemic. While usage is global, access to the Internet globally is not guaranteed or even feasible for some communities, leaving those in the offline world disconnected from vital information, resources, opportunities, and news that could prove life-saving in some situations.

1.2 Problem

Countries, cities, and regions of poverty, including regions within the United States, do not have equal access to the Internet and its abundance of resources. This digital divide has become more prevalent than ever due to our response to the COVID-19 pandemic, with some demographics being more harshly affected than others. Poorer countries who lack this access are cut off from life saving information and updates on the pandemic. Students without sufficient access to the Internet struggle to find ways to continue their education at home, and workers who are not able to make the switch to an online workplace are left unemployed without online resources to facilitate their job search (García & Weiss, 2020). These are only examples from our recent pandemic response, though there are many other contributors to the digital divide we face in the world today that need to be addressed. This leaves some of our most vulnerable even further out of reach from the support that can be provided with an Internet connection.

While this digital divide predates the pandemic, access to the Internet and the freedom to communicate for anyone can also be put at risk in the case of emergencies such as natural disasters, financial recessions, etc. Such occurrences could leave once connected families, homes, even cities or regions of a country without vital communications for unknown periods of time with limited resources.

A lot of individuals also lack the proper technical knowledge to set up a network with internet access on their own, often relying on paid professionals to perform the setup. Access to information today can be considered a human right, and should be available to every individual regardless of location and status. We would like to find a way to make Internet access in such situations more accessible to those who may need it.

1.3 Solution

Our solution to making Internet access more accessible is our Partially Automated Network Installation Kit or PANIK Guide, which is a step-by-step instructional guide to setting up your PANIK Kit - a mesh network kit capable of being rapidly deployed and configured, whether in the wake of disaster or in areas of poverty where Internet access is non-existent. The guide will contain information about the PANIK project, the equipment needed to create a PANIK Kit, affordable hardware sourcing tips, a setup guide to complete the PANIK network setup, and resources for any troubleshooting or maintenance that could be needed on the network. Our kit could be an answer to a variety of needs, so we have ensured that it can be specialized to fit a variety of situations. For our prototype network, we repurposed old routers as a cost effective solution to this problem.

More than 10% of Americans don’t have access to the Internet, and the rates at which some demographics are being affected are much higher than others. Age, ethnicity, employment status,

and residential region are all factors that correlate with an individual's likelihood of having an Internet connection, which should not be the case (US Census Bureau, 2019). Our goal is to provide a semi-automated method of network installation and configuration that can be built by anyone, regardless of their experience with networking setup, that is affordable and secure to help bridge the gap to individuals most affected by the digital divide.

1.4 Project Goals

Our main goal for our PANIK Kit and Guide is to provide an affordable, easy to set up, and secure mesh network setup that can be assembled and deployed rapidly in response to a variety of situations where network connectivity is needed; our main areas of focus being situations of disaster response and impoverished areas and families that need affordable Internet access. These kits will highlight the repurposing of older hardware, keeping the cost of a kit down while also keeping functional hardware out of landfills, but will still provide adequate connection quality to users. Users will not need to have prior or hired knowledge of network setup and configuration to setup and deploy a PANIK network. Automating the routers' configuration will make setup and usability appealing to individuals with varying levels of technical knowledge and experience.

1.5 Overview

The rest of this report will outline the processes and steps taken to complete our project. This report includes the following sections: design objectives, methodology, budget, timeline, problems encountered, and future recommendations.

2 DISCUSSION

2.1 Project Concept

The idea for our PANIK Kit was conceived out of a desire to help the most vulnerable and underprivileged in our society. With connection through technology being one of the most prominent forms of communication in today's world, finding a way to ensure this communication method is available to everyone in any situation is still something that we, as a society, need to address. Mesh networking technologies were also a topic of interest at the time, so some light research on the subject led to some interesting uses of the technology in the cases of emergency response in tackling the digital divide. Due to time and budget restrictions for this project, the project scope was narrowed to focus on the main goals for the project.

2.2 Design Objectives

- ***Cost Affordability***
    - Keeping a low buying price for this kit was a key point we wanted to focus on. Looking into our scenario we identified that many areas without connection may be like that because of cost. A monthly internet service can be very expensive. For this goal we focused on using old routers and repurposing them to act as more modern devices that are usable for our kits.
- ***Usability***
    - Another key point we wanted to focus on was the usability of our kit. The majority of individuals most likely will not have the appropriate

knowledge to set up a mesh network and configure it. By implementing automation of these tasks, we appeal to a wider audience. We want anyone to be able to set up a PANIK Kit up regardless of their technical background.

- ***Security***
    - Mesh Networks are susceptible to security issues. We provide a security assessment within the PANIK Guide outlining the limitations we faced in our design use cases, along with some safe Internet practices for end users.

2.3 Abandoned Goals/Focus

- During the course of our project we switched focus. At first we wanted our mesh network kit to be made for deployment in the event of a natural disaster or emergency where networks may be down in large areas. Upon further research we concluded that this idea was a bit too broad and that we needed to narrow our focus. Our PANIK Kits are the result of this narrowed focus. We have not completely dismissed the option of usage in disasters or emergencies as it is very applicable to those situations, it is just not the primary focus of our project.

2.4 Methodology and Technical Approach

Our methodology for the PANIK Kits align with our goals for this project, to aid in the accessibility of the Internet. We've chosen to choose budget-friendly hardware and software for the technical components of the PANIK network. We also want to ensure that these connections are secure for end users, so we utilize features and protocols that provide the safety needed.

Design Requirements

- Repurpose old routers
    - Using older routers that could be repurposed using modern meshing techniques ensured that we met our goal for creating a cost effective solution.
- Network Security
    - One of our biggest goals was to create a secure environment and this needs good network security. Having good network security practices and knowledge of options available will help end users in this regard.
- “Partially” Automated
    - Having some automation as a requirement in our PANIK Kit. By automating a part the router configurations we meet our goal of usability and appealing to a wide range of people with different technical backgrounds/skills.
- User Friendly
    - Having a user friendly product is ideal to ensure we meet our usability goal. If users are not able to understand and use our kit easily and efficiently then our goal is not met.

2.5 Ethical Dilemma

- Security/Privacy concerns
    - Any major network security will be a major concern especially in a Mesh Network where multiple users may be connected at once. If security on the network fails and there is malicious activity where would the fault fall?

- Who pays for what?
    - In the scenario of a PANIK Kit installed in an apartment building where multiple tenants would share the connection there comes the issue of payment between tenants. What would be appropriate payment for each? Would that vary on data usage? This would be up to the landlord or individual that is responsible for the network but still raises some dilemmas.

2.6 User Profile: PANIK

User Profiles: Networking/Security Engineer, Initializer, End User

There will be three types of users interacting with our PANIK network. The first users described are our Networking Engineers who will be maintaining the network after its creation, and fixing bugs and/or errors that may occur on the network. The second user group is made up of the initializer who is responsible for obtaining network hardware and setting up the network. The third user group is the end users whom the network is created for.

Figure 1: Network Security Engineer User Profile

Networking **Security Engineer**
Application: PANIK Networks
Potential Users: Networking Security Engineers (Developers)

Software and Interface Experience: The user should be familiar with the DDWRT, and understand the configuration capabilities. They have experience setting up the network automatically and manually. They should also have experience troubleshooting devices and Internet connection. They are responsible for the automation of the network setup, along with being able to troubleshoot any errors thrown during an automated setup.
Experience with Similar Applications: Networking Engineers group have a lot of experience with wireless networks and Mesh networks, they have studied this in school. Not only have they studied this area of technology, but they also use networks on a daily basis.
Task Experience: Using the WRT page in the configuration and maintenance of the PANIK Network.
Frequency of Use: Once the network is set up and configured, the user will only interact with the application as needed. The user will interact with the PANIK network after its creation to stay compliant with security requirements, to correct application bugs discovered after launch, and to update features based on end user comments.
Key Interface Design Requirements that the Profile Suggests: This user will be publishing the information needed to create a PANIK network after having completed configuration and automation of the network setup, considering initial use cases and scenarios as well.

Figure 2: Initializer User Profile

Initializer
Application: PANIK Network
Potential Users: Initializer
Software and Interface Experience: The user should be comfortable using computers at a basic level and be able to open and run files at will. This will be necessary in order to perform the simple automated configuration. Be able to read instructions clearly in order to understand what hardware to obtain as well as optimal locations to set up the hardware (Routers, Access Points, Powersources ,etc).
Experience with Similar Applications: The Initializer is expected to have basic experience connecting to a network with their device.

Task Experience: Running the configuration script during the setup phase of the PANIK network. Provide Permission to End Users to use the PANIK Network.
Frequency of Use: The Initializer should only need to reference the guide during the setup stages of the network. This guide would include which hardware to purchase, and how to set up the PANIK network. The Initializer would only be responsible for setting up the network once. This is as simple as setting up and powering on your devices, and running configuration script to take care of the details automatically.
Key Interface Design Requirements that the Profile Suggests: This user will be initializing the network for the end users by utilizing the published guide by the PANIK Network Security Engineers. They will need to follow instructions provided in the guide thoroughly to ensure proper connections are made, configurations are created, and connections are secured.

Figure 3: End User Profile

End Users
Application: PANIK Network
Potential Users: End Users
Software and Interface Experience: Users should have experience connecting to a network on their devices.
Experience with Similar Applications: Using wifi on their phones, tablets, computers, and other devices.
Task Experience: End Users should only be interacting with the network by connecting with it and using the connection as they see fit. They should first acquire permission to use the PANIK network from the Initializer.
Frequency of Use: Whenever the end users need to access the Internet, which could be constantly, daily, monthly, or yearly.
Key Interface Design Requirements that the Profile Suggests: The network needs to be secure, easily accessible to the user.

2.7 Use Case Diagram

Figure 2&3: Use Case Diagram *The following diagrams, Figure 2 and Figure 3, demonstrates the use case for PANIK. The diagram shows all possible users with corresponding tasks.*

Figure 2: Use Case Diagram

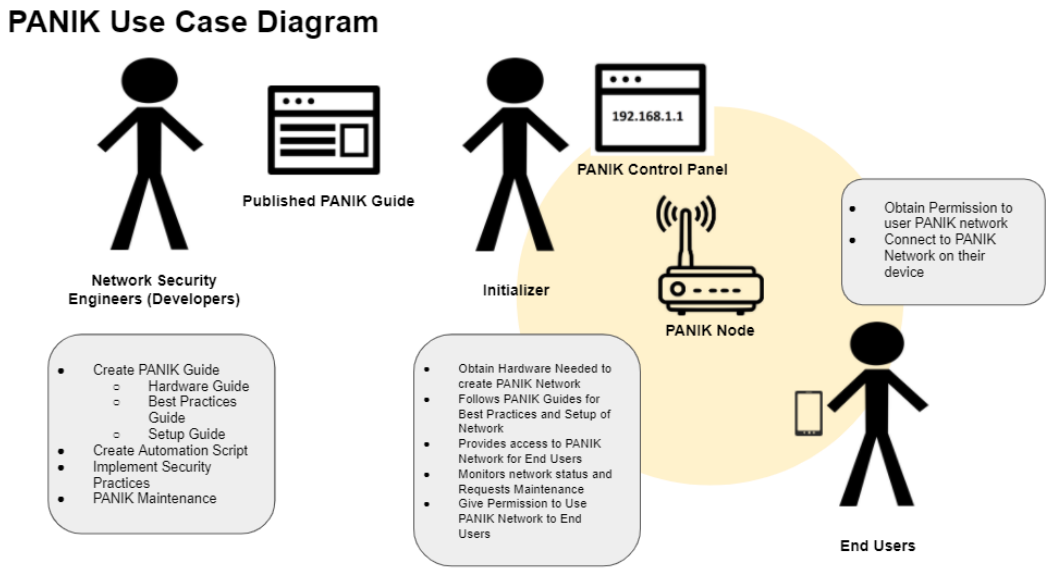
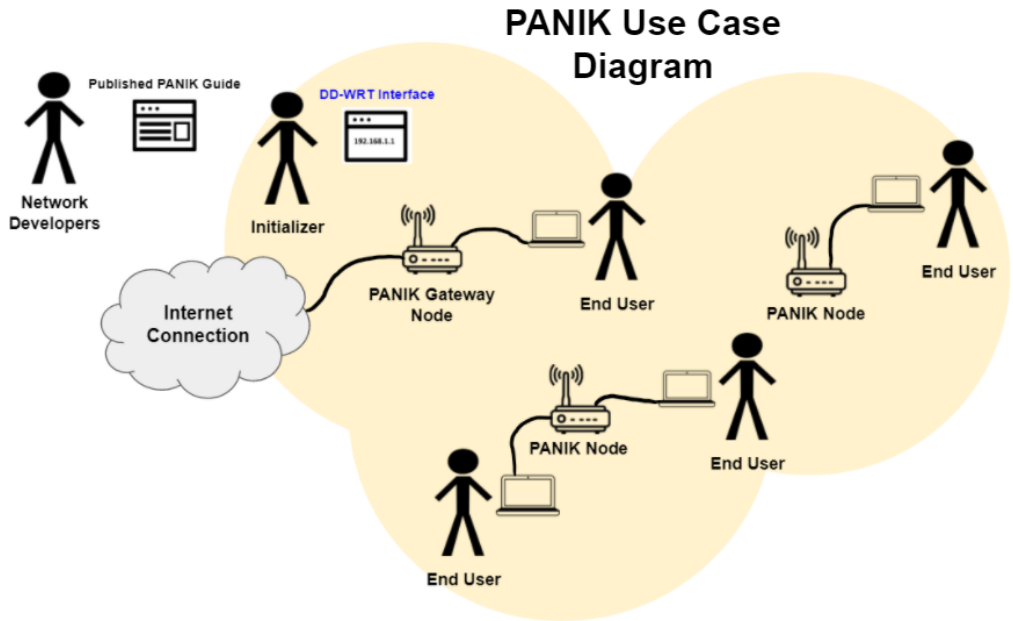


Figure 3: Use Case Diagram



2.8 Technical Architecture

PANIK uses scripting to automate configuration processes. We have two types of scripts:

- Setup Script: This script installs all the prerequisite needed for configuration of the router by using powershell. It installs Python, Firefox, and Selenium (Firefox webdriver).
- Selenium Scripts (including Properties Files): These scripts use the Selenium webdriver to logon to the DDWRT web portal and automatically configures the router to the necessary settings. These settings are specific to the corresponding properties file associated. Users will be able to adjust their router configuration by editing the values of the properties files accordingly.

2.9 Testing

We constantly troubleshooted and fixed our scripts and configuration settings to get what we wanted. There is a lot of trial and error sometimes when writing code. Outside of this we also conducted user testing of our PANIK Kit. Through this test the user was tasked with properly setting up their routers and running the necessary scripts to configure their routers. These user tests brought light to some things about our directions that we missed such as:

- Steps that are not as simple as they seem. We had to keep in mind that this should be usable by someone with little to no technical experience.
- Using less technical words and phrases
- Certain steps that should be in our directions that are not there. There were a few times that something was not clear and one or two steps would have cleared up all confusion.

Getting feedback from actual users is crucial as they will be the end user and will ultimately end up using this in the long run. From this feedback we could edit our directions to be more user friendly and address the issues we found.

2.10 Budget

Table 1: Project Budget The table below displays the budget for our project. Because of the flexibility of PANIK networks, there is no exact price for all users. Below are price ranges for hardware, internet plans, and tech support. Users are not required to purchase everything listed below and as long as they have compatible routers, a reliable powersource, and an internet plan, they will find success using PANIK networks.

Table 1: Project Budget

PANIK Budget			
NO.	ITEM	UNIT	UNIT PRICE
FIXED COSTS			
1	Routers	1	$20.00-60.00
2	SUAOKI Portable Power Station 150Wh	1	$125.99
3	CyberPower CP1500AVRLCD Intelligent LCD UPS System	1	$154.99
4	PAXCESS 60W 18V Portable Solar Panel	1	$139.99
5	Custom 3D printed Case	1	$150-$200**
6	Pelican Protector Case	1	$30-$100

MONTHLY COSTS			
7	Satellite Internet Plan	Monthly	$30.00-$150.00/mo
8	ISP Internet Plan	Monthly	$25.00-$300.99/mo
9	DSL Internet Plan	Monthly	$50.00-$100.00/mo
10	Mobile Hotspot Internet Plan	Monthly	$25.00-$85.00/mo
11	Modem Rental	Monthly	$10.00-$25.00/mo
TECH SUPPORT / MISCELLANEOUS COSTS			
12	Geek Squad Tech Support	Per Incident	$99.99
13	Computer360 Tech Support	Per Incident	$129.99

2.11 Project Timeline

Table 2: Project Timeline The table below displays the timeline for our project.

Table 2: Project Timeline

Task #	Task Name	Duration	Start Date	End Date
1	Feature Research	4 weeks	Aug 24	Sep 20
2	Hardware Acquisition	2 weeks	Sep 14	Sep 27
3	Router Configuration	2 weeks	Sep 21	Oct 4
4	Plan Reassessment	1 week	Oct 5	Oct 11
5	Network Configuration	3 weeks	Oct 12	Nov 12
6	Research Personal Responsibilities	3 weeks	Nov 2	Nov 22

7	Security Testing	3 weeks	Nov 23	Jan 10
8	Improved QoL Updates / Debugging	5 weeks	Jan 11	Feb 14
9	Plan Reassessment	1 week	Feb 15	Feb 21
10	Project Testing and Polishing	6 weeks	Feb 22	April 5
Final	IT Expo	1 day	April 13	April 13

2.12 Problems Encountered and Analysis of Problems Solved

- ***Hardware***
    - Since we were using repurposed older routers we eventually ran into some problems with different models not having features/services that the other may have. This made progress a bit slow at times since we had to replace some of our hardware. We also found that certain devices did not support the firmware we were using so this also prompted acquisition of new, compatible hardware
- ***SSH***
    - We learned pretty early on that not all routers are compatible with SSH and use the deprecated Telnet instead. While it was initially our plan to use SSH for configuration, due to some routers not being able to use SSH we ended up using Selenium instead.
- ***COVID***
    - This year was unlike any we have ever dealt with. Since we are in the midst of a pandemic everything was moved to a virtual setting. With our

project having a strong hardware focus, it required us to have face to face interaction. Luckily all group members live within reasonable driving distance and could meet every week.

- ***Complexity***
    - We found some guides detailing how to set up a mesh network using DDWRT, but most of these guides were outdated or over-complicated and glossed over some common problems that occurred. While DDWRT is OSLR compatible, it is described on their forums and publications as an “advanced routing configuration” and can be finicky during setup. We hope that with the semi-automation we are able to navigate around this obstacle.
- ***Encryption***
    - When setting up our mesh network we found that with the specific model of router we were using we could not implement any security other than WEP. WEP is not a strong encryption method and is very easy to exploit. We suspect that newer models of this router or other DDWRT compatible routers support better encryption methods like WPA or WPA2.

2.13 Recommendations for Improvement

Throughout the production of PANIK we ran into some limitations such as the security we could implement and our hardware. We could only implement WEP security while still being able to have the necessary protocols needed for our network to properly mesh. We were also limited based on our hardware. We obtained used hardware so availability and usability were not always where we would've liked.

If we were to do this again we would focus on:

- Using a model of router that supports better encryption.
- Having more hardware to use for more potential in our network. We were only able to use one gateway and two peripheral nodes.
- Being able to implement SSH

3. CONCLUSION

3.1 Lessons Learned

- Mistakes are inevitable in any project, by starting off strong, you are able to catch many of the large mistakes early on allowing for enough time to amend them. This is a lot less stressful when compared to running into issues or making mistakes late into the project cycle because there is often a lack of time for proper assessment of each mistake due to deadlines.
- Communication is always an important role when you're working in a group. To be more specific team members must mutually understand the desired outcome of the project and understand the personal goals set by themselves and their team members.
- Online guides can prove to be quite helpful especially if someone else has run into a similar problem, but it's important to keep in mind that online guides are not always reliable and can become outdated very quickly.

3.2 Abilities and Skills Developed Throughout Project

- Further knowledge of DDWRT firmware
- Reconfiguring old routers
- Soft skill development with document creation, presentation / group interaction
- Insight to Mesh Networks and their uses/benefits
- Scripting with Powershell and Selenium
- Troubleshooting with Scripts and Programs
- Basic/intermediate Networking skills

3.3 Plans for the Future

- This project is very adaptable. We only built a prototype using one specific model router. There are a lot of other DDWRT compatible routers that this could be modified and applied to. Any future use of this project could focus on other routers to get more functionality.
- With more time, we would have liked to be able to put a greater focus on an improvement on security. While WEP is suitable for our use cases, we would have liked to find a way to implement greater security such as WPA/WPA2.
- The PANIK mesh network does mesh wirelessly, however the end-users computer systems must connect physically to the nodes for internet access. While this still allows PANIK to extend coverage of the network, with more time, we would have liked to find additional methods to integrate a fully wireless experience for our users.

4. REFERENCES AND APPENDIX

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4.2 Appendix

Below is the link to view our official PANIK Guide. For the sake of length we will not post the whole thing in the appendix as it will make this report excessively long.

PANIK Guide Link
https://docs.google.com/document/d/1m17SGG92r21hVQhhr7GI-IKsJxdKRLMYBgE4y-nrDY0/edit?usp=sharing