Improving Internet Connectivity
in Rural West Virginia

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Introduction

In this digital age, high speed internet access is necessary for economic development, research purposes, and much more. As part of a larger endeavor to enhance the infrastructure and quality of life in West Virginia, our group has been asked to address broadband internet connectivity in particular.

Many parts of rural West Virginia lack access to a high speed internet connection. Students, job applicants, business owners, and many others in West Virginia will incur economic losses due to their inability to capitalize on the advantages that the internet offers. Providing broadband internet access could improve school quality, provide many economic opportunities to citizens and business owners, and improve the general quality of life for the citizens of West Virginia. Not only will it benefit the citizens, it will also become a new market for the service providers.

Background Information

The project is focused on the three southernmost counties in West Virginia: McDowell, Wyoming, and Mercer. These three counties are mountainous, relatively poor, and not densely populated; their internet infrastructure is sparse.

Existing Services and Coverage

While land-line telephone service is ubiquitous in the project area, broadband, primarily via the telecom company Shentel, is only available in the larger towns, and along the routes connecting them, through a mixture of fiber-optic and coaxial copper cable.

Wireless connectivity is more widespread, but even there, coverage can be spotty; terrain can mask significant areas, and the cell tower network is not very dense in that part of the state (see figure 1). Both Verizon and AT&T (figures 2 and 3), among several other networks, claim to cover all or part of the area, but their claimed coverage area is often overly optimistic.
Figure 1 - Cell Tower locations from www.deadcellzones.com

Figure 2 - Verizon Cell Tower Data* Coverage
*meaning any form of Data(2G,3G,4G+)
Assumptions

For purposes of this project, we assume that each household in the project area has, at a minimum, a telephone line. Whether this phone line can practically be used for DSL is a separate question, of course; we will assume that the wires themselves are adequate, if the necessary network infrastructure is in place.

Some broadband internet service is already present in parts of the project area. We assume that the internet service providers have an acceptable level of cyber security built into their service. We also assume that the existing ISPs’ service uptime is on the order of 99.5%. 
Problem Statement

The goal of this project is to understand the options, and the tradeoffs between the options, for providing broadband internet access to a key area in southern West Virginia.

The desired result of this project is a well-characterized and analyzed trade-off space, covering capital investment, internet connection speed, expected availability, return on investment, security, and other related factors.

Scope of Project

In West Virginia, there are several counties that are ideally representative of the internet connection issues that this project is aiming to address. Those counties are Mercer, McDowell, and Wyoming counties, which are all adjacent to each other at the southern border of West Virginia. While McDowell and Wyoming has significantly more wired infrastructure than Mercer counties, they all share the common issue of rural areas being disconnected from the world wide web.

The primary scope of this project is to analyze the existing conditions and available services in the target region, and generate alternative solutions for providing internet access to the underserved rural areas of the target counties. With this data, the citizens of the region can view the short-term or long-term internet service options to help them decide if they would like to pursue one. From the Internet Service Provider side, they can use the data to determine if they can economically expand their services into the underserved areas. This project will consider the upper time limit as 10 years from the start of this project.

To provide a comprehensive analysis and solution to the problem, this project will be comprised of several components that accurately define the various aspects that project aims to address. The overall project will consist of the Stakeholder analysis (SA), Alternatives Solutions Analysis (ASA), and the Economic Analysis. The Stakeholder Analysis (SA) will provide an initial look of the region as a whole in regards to its population, average income, population density, terrain, and locational issues. It will also feature a survey of users to obtain the current condition of their access and its quality if applicable, along with information from the Internet Service Provider(s). The ASA will contain data for each technology/service provider available for the three counties which will include bandwidth, upload/download speeds, and monthly cost. The EA will address the financial and economic issues with the solutions defined in the ASA.

Subsequent effects of providing high speed internet to those who have been deprived of the access are numerous. At the very least, it provides internet applications and services that were previously not available on slow or non existent internet service. This allows students and teachers to access a plethora of material online. For those seeking employment, this provides access to online applications and educational materials for training. For businesses, this may open a new world of opportunity as brick and mortar stores can move to conduct business online as well.
## Preliminary Requirements

<table>
<thead>
<tr>
<th>UID</th>
<th>Functional Requirement Description</th>
<th>Implemented In</th>
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<tbody>
<tr>
<td>1</td>
<td>General System Requirements</td>
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<tr>
<td>1.1</td>
<td>System shall address the internet conditions for Mercer, Wyoming, and McDowell Counties of West Virginia. The named counties will be referred to as the &quot;target regions&quot; for this project.</td>
<td>GIS Model</td>
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<tr>
<td>1.2</td>
<td>System shall list the existing Internet Service Providers in the target regions.</td>
<td>Alternatives Solutions Analysis</td>
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<tr>
<td>1.3</td>
<td>System shall provide the limitations of bandwidth, upload speed, and download speed of each Internet Service Provider available.</td>
<td>Alternatives Solutions Analysis</td>
</tr>
<tr>
<td>1.4</td>
<td>System shall provide at least one internet service solution for all households in the target region.</td>
<td>Alternatives Solutions Analysis</td>
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<td></td>
<td>Analytics Requirements</td>
<td></td>
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<tr>
<td>2.1</td>
<td>System shall create a matrix correlating the available services against monthly cost and download speeds.</td>
<td>Economics Analysis</td>
</tr>
<tr>
<td>2.2</td>
<td>System shall use a quantitative metric to compare different internet service alternatives.</td>
<td>Economics Analysis</td>
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<td></td>
<td>Technical Requirements</td>
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<tr>
<td>3.1</td>
<td>System shall provide a Geographic Information System (GIS) model displaying the target regions with current existing wired infrastructure.</td>
<td>GIS Model</td>
</tr>
<tr>
<td>3.2</td>
<td>System shall provide a Geographic Information System (GIS) model displaying the target regions with a proposed expansion.</td>
<td>GIS Model</td>
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<td></td>
<td>System Security Requirements</td>
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<tr>
<td>4.1</td>
<td>System shall provide Broadband options that provides a direct connection to the service provider.</td>
<td>Alternatives Solutions Analysis</td>
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Technical Approach

The IIC project will proceed along two tracks in parallel: one track will be a quantitative analysis using geographic information system (GIS) software; the other will be more qualitative research on the systems that are available, or are expected to be available soon, and their capabilities.

For the GIS track, we first will collect data on current broadband availability, both wired and wireless, in the area of interest. For wired, this will largely consist of current fiber and coaxial lines; for wireless, this will largely consist of existing cell towers and their viewsheds. Additionally, if time permits, we may attempt a viewshed/orbit analysis for satellite internet availability.

Next, we will collect GIS data on population distribution in these three counties. Using that data, along with the current availability maps, we should be able to identify areas of significant population where broadband is not available. Within the set of these areas, we can then identify which areas can be covered with DSL lines, which can be covered with new fiber/coaxial lines, which can be covered with new cellular towers, and so on, taking into account the results of the Non-GIS track research.

In the Non-GIS track, we will research the various projects currently being worked on to provide global wireless broadband coverage — “sky-fi”, as it’s sometimes called; how likely they are to succeed, and when they might be available. Related to this, we will also try to predict medium-term changes in the meaning of “broadband”, and identify which approaches might become obsolete soon, or might become more available.

Additionally, we will try to predict demographic changes (such as urbanization or depopulation) which may change the areas that need service.

Finally, we will analyze the trade-off space between capital investment, internet connection speed, expected availability, return on investment, security, and so on. To understand this trade-off space is the main goal of the project.
Expected Results

The expected results from this project will be in two parts. The first part will provide a current status of the existing broadband conditions and available services in the three target counties. Based on the analysis of the current broadband condition in the target area, we will generate alternative solutions for improving connectivity in the target area. The recommended solution will consist of short-term and long-term service options. The user will obtain additional broadband options, and the internet provider will have a tradeoff analysis for whether to expand their services and what are the costs or ROI.

To provide accurate technical comparisons and analyses of the technology available, there will be an Alternative Solutions Analysis (ASA). As mentioned earlier, the ASA will contain technical data for each technology/service provider available. Along with the current technical data, it will include data for infrastructure expansion if applicable, which includes the service provider’s costs to expand (per mile/consumer), as well as any costs that will be paid by the end user.

The second part of the project will provide future predictions, either in demographic changes such increase or decrease in population size which might impact the area needed for services. Also another future prediction will be technology changes that might include new ways of providing broadband such “sky-fi” internet.

The alternative solutions will be analyzed to generate matrices that display the short/long term costs and benefits. These matrices will be a part of the Economic Analysis (EA). This will provide an economic comparison for the consumer and service providers to see what the best course of action will be for the respective parties. The matrices will contain the service types, upload/download speeds, bandwidth, monthly costs, availability timeline, expansion costs, and expansion customer population. By providing the solutions in this format, the stakeholder should be able to obtain a more comprehensive view of their options available in the present time as well as any in the near future.
Project Plan

Work Breakdown Structure

Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Task Description</th>
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<tbody>
<tr>
<td>30-Jan</td>
<td>Meet with sponsor</td>
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<tr>
<td>9-Feb</td>
<td>Problem definition</td>
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<tr>
<td>19-Feb</td>
<td>Problem approach</td>
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<tr>
<td>1-Mar</td>
<td>Literature research</td>
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<tr>
<td>11-Mar</td>
<td>Background</td>
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<tr>
<td>21-Mar</td>
<td>Resource allocation</td>
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<tr>
<td>31-Mar</td>
<td>Schedule</td>
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<tr>
<td>10-Apr</td>
<td>Gather requirement</td>
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<tr>
<td>20-Apr</td>
<td>Gather data</td>
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<td>30-Apr</td>
<td>Analyze model input</td>
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<td>10-May</td>
<td>Develop model and incorporate data</td>
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<td>model verification and validation</td>
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<td></td>
<td>Execute what if analysis</td>
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<td>Analyze simulation results</td>
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<td>Meet with professor</td>
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<td></td>
<td>Prepare report</td>
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<td>Presentation draft</td>
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<td>Deliverable</td>
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<td>Meet with professor</td>
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<td>Sponsor Review</td>
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<td>Prepare final presentation</td>
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<td>Review/Correction</td>
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