

Smart Automotive Diagnosis Adapter

EDGSN 100

Section 004

Seal Team 6

Olivia DeCarlo - oliviadec@gmail.com

Alex Walsh - apw5143@gmail.com

Nathan Davis - nateasteroidd@gmail.com

Bryan Ryder - bryder2016@gmail.com



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Professor Colledge

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Executive Summary

The purpose of this design challenge report is to address a customer need in either the home, car, or with wearable devices that utilizes the Internet of Things. We selected the aspect of the smart automobile. A problem was identified to address this, and we designed a smart adapter for a vehicle's On Board Diagnostics port that will use the internet to alert the owner and the owner's shop when a problem is occurring. Our device uses Bluetooth technology to connect an OBD II reader to a smartphone to tell the owner their problem. Through a smartphone app, our system will connect to the internet through the smartphone to coordinate with mechanics via email and sync with the car owner's calendar to suggest an appointment time for service. Essentially, the product will simplify problem diagnosis and maintenance scheduling for vehicle owners.

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1.0 Introduction

AT&T presented the Engineering Design 100 classes with a challenge. They wanted students to generate an idea that would utilize the “Internet of Things” in either the home, car, or wearable devices. The Internet of Things (IoT) is defined by Techopedia.com as “a computing concept that describes a future where every day physical objects will be connected to the Internet and be able to identify themselves to other devices. The IoT is significant because an object that can represent itself digitally becomes something greater than the object by itself.” The object interacts with many devices gaining added functionality from each interaction, and can function without any user input.

The IoT provides unlimited opportunity for the connection between people and everyday objects around us. From tracking down your lost keys to monitoring empty parking spaces in your city, the IoT and its applications make living much easier. This project has provided us the opportunity to create a product that connects us to the IoT, and ultimately make life easier.

2.0 Project Background

Our team applied the emerging concept of the Internet of Things to address the aspect of automotive care. By first identifying the needs of consumers and stakeholders of the automotive industry nationwide, we conceptualized a product that would ease the life of car owners, mechanics, and dealerships while taking advantage of the Internet of Things. The majority of the U.S.’s car owners are unacquainted with the intricacies of their vehicle and how to properly maintain or diagnose it. To address this, we designed a smart adapter for a vehicle’s On Board Diagnostics port that will use the internet to alert the owner’s shop of when a problem is occurring with the car and auto-schedule an appointment. Not only will it take care of the hassle of dealing with a malfunctioning vehicle, but it will interface with an existing smartphone app that tells the owner exactly what is happening with the car in real time and explain problems in terms easily understood by the average car owner.

3 Relevant Technologies to Know About:

- **OBD (On-Board Diagnostics) Generation II Port:** Allows current code readers to interface with a vehicle’s onboard computer.
- **Bluetooth:** Developed over the past two decades that allows wireless, close range communication between electronic devices.
- **Cellular Data Transmission:** Current technology using towers and satellites to relay cellular data between devices and/or computers.
- **Wi-Fi:** Close range wireless communication that requires an internet connection and a wireless router for operation.

- **RS232 Wired Connection:** Decades-old standard for transmitting data; employs physical wires to conduct electrical data signals that can be processed at either end.



Figure 2: A flowchart of information from start to finish

2.1 On-Board Diagnostics (OBD) II ports

- ❑ Interface between vehicle's engine control unit (ECU) and outside device
- ❑ Installed on all vehicles sold in U.S. beginning in 1996, now worldwide standard
- ❑ Produces diagnostic trouble codes based on data from a host of sensors around the vehicle (engine temp., knock sensors, emission control, etc.)
- ❑ Requires RS232 interface adapter to fit into 16 pin plug (RS232 is capable of communicating directly with a mobile device either wired or wirelessly)

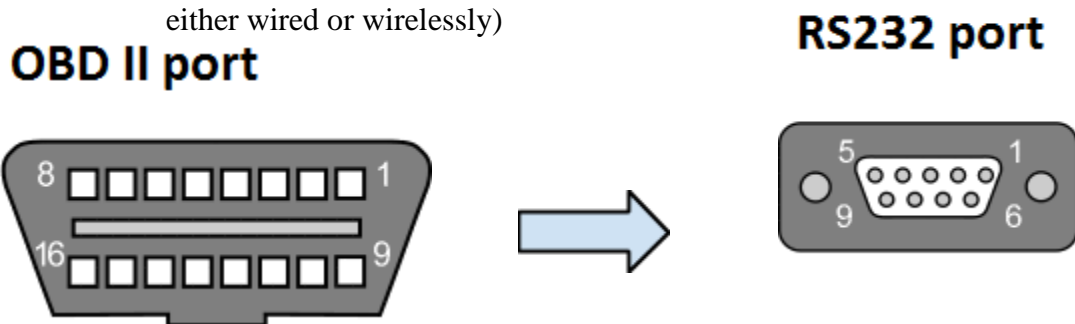


Figure 1: Signal must go from an OBD II port to a mobile ready format.

2.2 Bluetooth

- ❑ Short distance wireless communication technology that connects devices to one another.
- ❑ Uses a radio frequency transceiver centered at 2.4 Gigahertz through use of an ISM (Industrial, Scientific and Medical) band.
- ❑ Uses a hierarchy of devices.
 - ❑ One master device with up to 7 slaves.
- ❑ Master device algorithmically chooses a specific frequency hopping pattern using the 79 frequencies in an ISM band.
 - ❑ Pattern is designed to exclude frequencies being used by neighboring devices (Wi-Fi, other Bluetooth devices, etc.).
- ❑ Divides frequencies into slots, which send packets of data between devices.

- ❑ Synchronous Bluetooth allows for instantaneous transportation of data, which is what we'll be using.
- ❑ Uses an “inquiry” and “inquiry scan” system to connect devices to one another.
- ❑ We will use Bluetooth within our OBD II ports (slave devices) to connect them to smartphones (master devices).

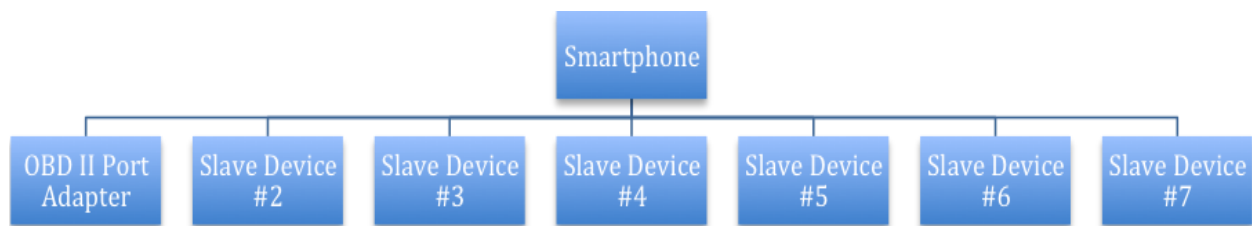


Figure 3: A hierarchy showing the master device and the maximum amount of slave devices.

2.3 Wireless (Cellular data)

- ❑ The type of communication used between cell phones and provider's towers
- ❑ Each cell(tower) has 800 total frequencies
- ❑ Each phone uses 2 unique frequencies
 - ❑ One to send data
 - ❑ One to receive data
- ❑ These frequencies are assigned by the following process:
 - 1) The cell sends a System identification code (SID) with network information
 - 2) If the phone can communicate with the network, the phone sends a response
 - 3) The tower uses this response to create a unique registration number, determine the phones location, and assign the two unique frequency
 - 4) The phone sends any necessary data
 - 5) When your signal strength weakens and your signal strength to another cell strengthens your identification information is sent between cells and you are assigned two new frequencies.
- ❑ Using a 4G network you can send and receive up to 100 megabytes/second
- ❑ Once your phone connects to the cell the provider has control over how the data is transmitted however fiber optic cables are normally used for high speed long distance data transmission.

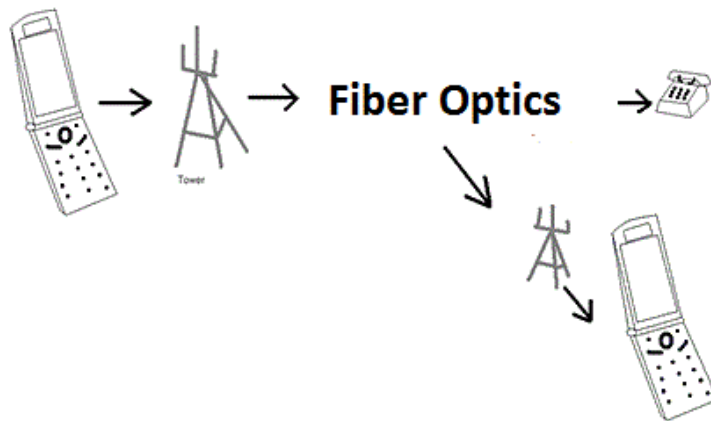


Figure 4: Overview of a cellular network

2.4 RS232 Wired Connection

This connects the OBD II reader to any other computer. After the OBD II reader converts the signal format, a 9 pin RS232 a male cable is attached to the female end of the OBD II reader. From here the cord can connect to any other RS232 port.

3.0 Project Objectives

Before we could successfully implement a design concept, we needed to identify exactly what specific qualities our product would need in order to be marketable to the stakeholders. We identified our stakeholders as vehicle owners and drivers, mechanics, and telecommunications / technology companies. An important part of the list of stakeholders in this project is that we (the designers) are all stakeholders, because we all drive and own vehicles. This gave us a more personal perspective on the project.

After identifying stakeholders, our team brainstormed a list of preliminary specifications that our conceptual designs would have to meet. Our list included:

- Straightforward installation
- Operation across many platforms
- Target price of less than \$100 (to be competitive with similar products),
- Able to be integrated into existing cellular plans
- Overall “user friendly”

The average car owner doesn’t have the skills or knowledge to identify problems with their car and how to address them. Maintenance usually takes a great deal of time and money, and in our busy culture, this inconvenience causes proper vehicle maintenance to be put on the back burner (leading to more time/money spent down the road). We needed to create an interface that gives the consumer the ability to run diagnostics on their own car without spending the time or money to go to a mechanic. For example: if a check engine light comes on, the problems

could range from a faulty transmission to a loose gas cap - one of which requires professional maintenance and one that requires walking around to the side of the car and tightening the cap.

Our smart diagnostics device will simplify the world of automotive care by automating service visits (after owner and mechanic confirmation) and informing the owner of their problem in comprehensible terms.

4.0 Conceptual Designs & Details

- **Built-In Dash Program-** translates OBD II codes into user-friendly language. Installed by manual modification to the vehicle's computer using specialized software.
- **Handheld Database-** generates the OBD II code from the reader, but also gives the user the actual problem and information regarding the vehicle by searching the database in the device.
- **On Board Adapter-** will alert the driver if something is troublesome in the vehicle. Driver will get an alert sent to their smartphone via Wi-Fi or Bluetooth telling them the problems and specifications associated with it. The user will then have the option to schedule an appointment with a mechanic right from their phone.
- **Wireless OBD II Adapter-** will communicate with the mechanic directly to inform them of parts/ inventory that would be helpful to their business so they can keep their stock updated. The device would be sold by mechanics and no app would be required for the user except Bluetooth to connect the adapter to the internet and the mechanic.

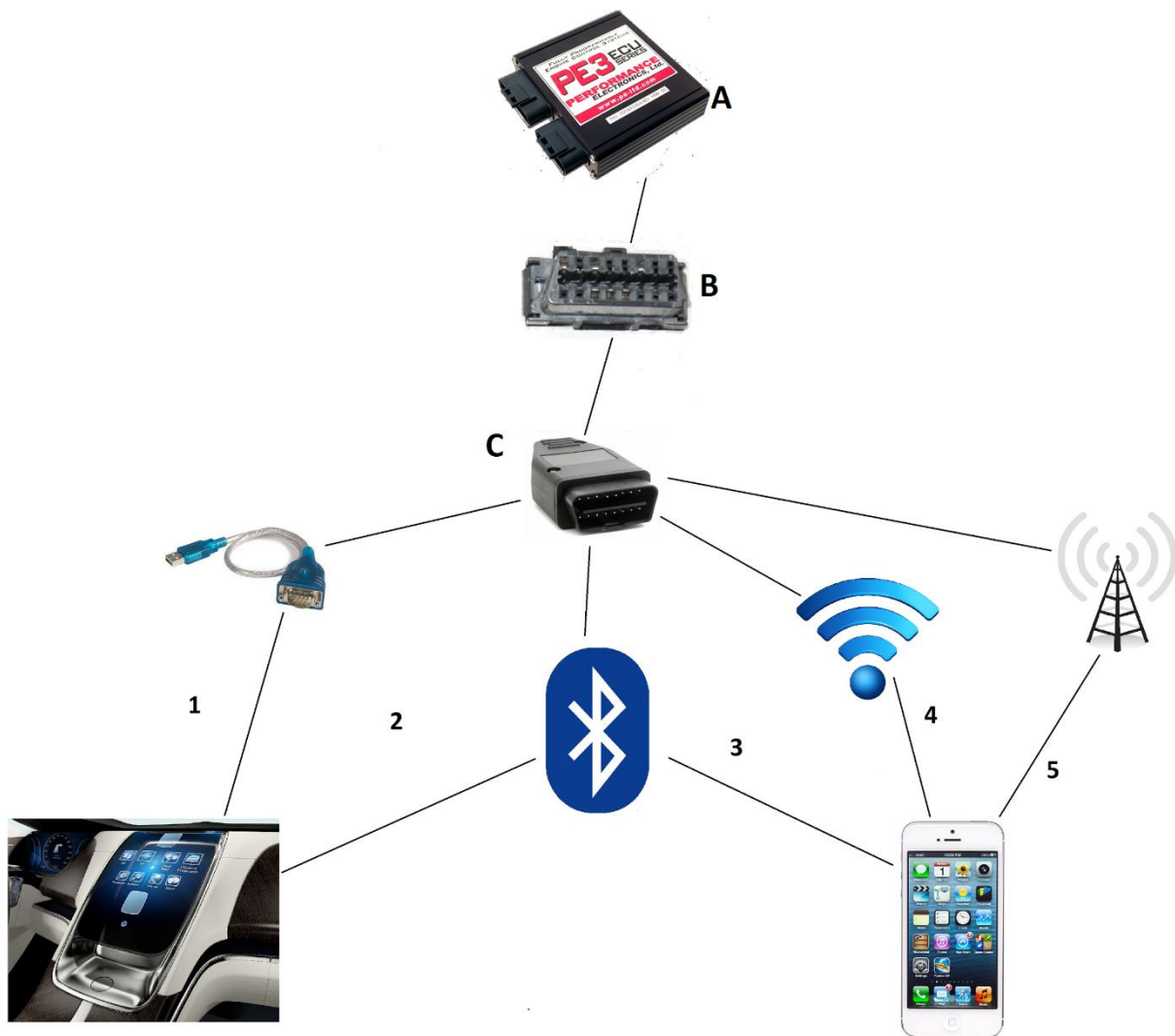


Figure 6: Possible ways to structure an OBD II adapter

A) An Engine Control Unit (ECU)

B) An OBD II port

C) An OBD II reader

1) A wired connection from the OBD II reader to a car's center console.*

2) A Bluetooth connection from the OBD II reader to the car's center console.*

3) A Bluetooth connection from the OBD II reader to the user's mobile phone.**

4) A Wi-Fi connection from the OBD II reader to the user's phone.**

5) A cellular data connection from the OBD II port to the user's phone.**

*This would require a new program to be installed on ECU.

**This would require a new application to be installed on the user's phone.

4.2 Research, Analysis, and Concept Selection

To compare each conceptualized design, we developed both weighted and un-weighted selection matrices to compare our preliminary specifications to our conceptual designs.

Possible Solutions	ECU installation monitoring system	OBD II with vernacular	OBD II Port to users phone	OBD II port for mechanics inventory
Specifications				
Expands/ Improves what is already on the market	+	-	+	+
Easy to install	-	+	0	+
Works across platforms	-	+	0	0
Target of <\$100	-	+	+	+
Integratable into cell phone data plan	0	-	+	0
User friendly	0	0	+	+
positive	1	3	4	4
negative	3	2	0	0
sum	-2	1	4	4

Possible Solutions		OBD II Port to users phone		OBD II port for mechanics inventory	
	Weight		Weighted Score		Weighted Score
Specifications					
Expands/ Improves what is already on the market	0.15	5	0.75	4	0.6
Easy to install	0.15	5	0.75	5	0.75
Works across platforms	0.25	5	1.25	5	1.25
Target of <\$100	0.1	3	0.3	5	0.5
Able to be integrated into cell phone data plan	0.15	5	0.75	1	0.15
User friendly	0.2	4	0.8	5	1
Sum	1		4.6		4.25

5.0 Detailed Design

After the selection matrices were completed, it was clear that the **Bluetooth capable On-Board Diagnostics plug-in adapter** was the most appropriate design solution.

Met all Design Requirements:

Easy Installation - Plugs in with a small 16 pin connector located conveniently under the dash

Utilizes Existing Technology on Market -

Smartphones that are already in users' hands including the Apple iPhone or any Android-equipped device contain a wireless receiver that will use Bluetooth to capture and translate real time vehicle information into a user-readable form that will be displayed via an app.

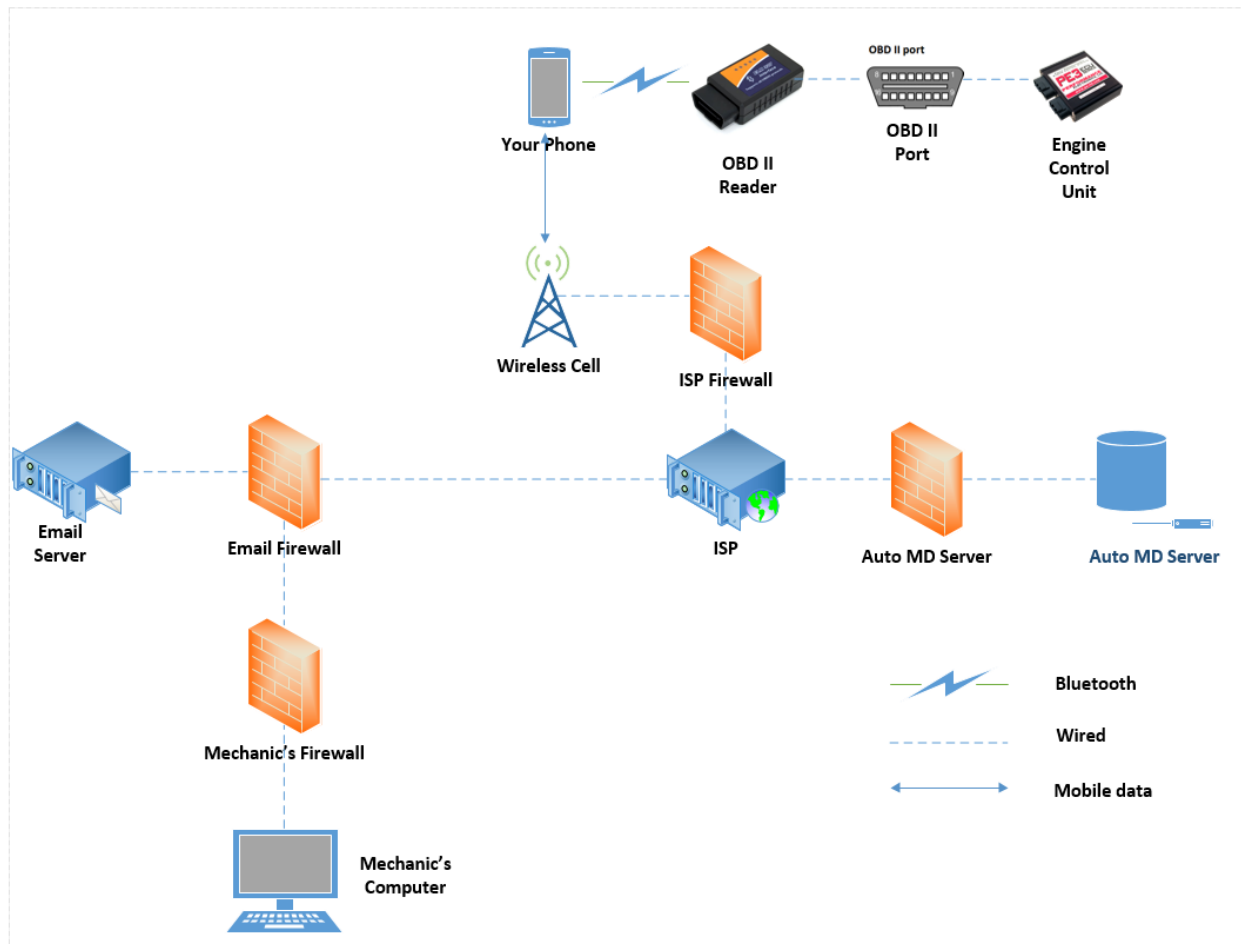
User Friendly - The straightforward user interface of existing smartphones makes operating the professionally designed app extremely easy.

Works Across Platforms - Industry-standard 16 pin connector that is on all vehicles manufactured after 1996 will be the physical link between the car's computer and the plug-in adapter.



Our product will be interfaced directly with the computer of the car through the On-Board Diagnostics II port, and it will accordingly allow real-time data to be transmitted wirelessly to a user's smartphone. Metrics ranging from engine speed to fault codes will be available through the OBD II port. . The adapter will feature a Bluetooth transmitter that utilizes a wireless frequency to transmit data through radio waves at 2.4 GHz. Smartphones, including the Apple iPhone or any Android-equipped device, contain a wireless receiver that will be able to translate this data into a user-readable form that will be displayed via our app. In turn, this app has the capability to sync (as is very common with smartphone apps) with other apps such as Email,

Calendar, Phone, etc. to accomplish the task of notifying your mechanic of the problem through email and suggesting possible appointment times that are in accordance with both the user's and mechanic's calendar. However, if no time is available with the preselected mechanic, the user will have the option to choose from a list of nearby shops to schedule an appointment at if the repair is pressing. Plug-in devices that sync with smartphones do already exist on a closed loop - that is, they can only tell you what your trouble code is and basic vehicle parameters. The On-Board Diagnostics plug-in adapter takes this concept one step further by connecting it to the Internet of Things.



5.1 Security Concerns

The issue of security is important when any part of a car is connected to the internet. The OBD II port connects directly to a CAN bus. Malicious software can be installed on the CAN bus. The CAN bus contains all of the engine control units so any function of the car can be controlled. By association the OBD II port and any device connected to the OBD II port can control the car. This product will control what accesses the OBD II port in these ways:

1. The following setting is optional but highly recommended
2. The OBD II port will require authentication to initiate Bluetooth communication.

- a. This occurs during the “inquiry” stage of the connection.
 - b. This will use RSA 256 bit encryption with a public and private key on both ends of the Bluetooth connection.
 - c. If the user enters their password correctly they become a slave.
 - d. Any mobile device which attempts to connect to the Bluetooth but cannot authenticate will not become a slave
3. Additionally all data packets will be encrypted using RSA 256 bit keys.
 - a. This prevents phishing
 - b. This also prevents someone creating a relay in the middle of the network where they could alter commands going to the OBD II reader
4. A physical attack on the cars CAN bus will not be protected.
 - a. Cars are already vulnerable to this type of attack
 - b. The OBD II reader mitigates this risk by requiring an attack to use another access point than the OBD II port for their physical attack.

6.0 Conclusion

Our On-Board Diagnostics Plug-in Adapter successfully meets the requirements outlined by AT&T’s Design Challenge. In the spirit of the Internet of Things, the Diagnostics Adapter embodies this ideal by connecting the average driver’s world into a simpler troubleshooting system. Instead of taking their car into a mechanic which uses extra time and money, a driver with not much knowledge or experience with cars can see what is going on with their vehicle with only their smartphone. The OBD II adapter is successful in diagnosing the problem of the vehicle and translating it into language that the everyday consumer will be able to understand. By linking the user’s smartphone to the mechanic’s scheduling system, this effectively reduces the timetable normally needed when trying to find a time to bring their car into the shop. Mechanics and dealerships will also benefit from this because if they are the default mechanic for a user in the app they will most likely get the business if the user decides to bring the car in for maintenance. Our design concept for AT&T’s Internet of Things challenge combines existing technology with the fairly recent notion of the Internet of Things. This innovative opportunity could potentially simplify the lives of millions.

7.0 References

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8.0 Appendix

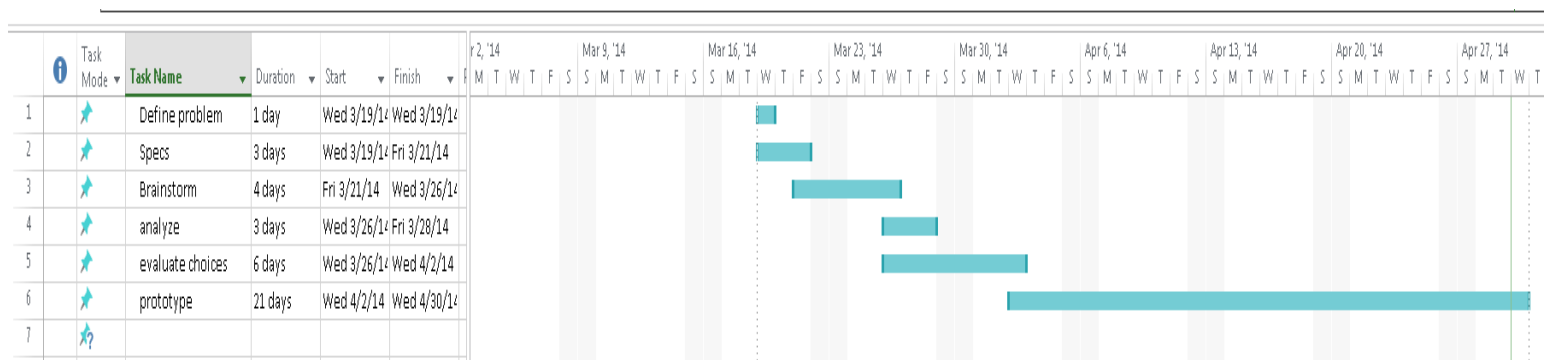


Figure 7: Gantt Chart