ILR 02 – Progress Review 1

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1. Individual Progress

I undertook the following tasks:

1. Conduct a literature survey on possible network architectures for communication.
2. Conduct lab inventory/ market survey for communication equipment.
3. Decide on a suitable test platform-
    a. For early prototyping purposes
    b. For further development purposes

1. Conduct A Literature Survey On Possible Network Architectures.

This task involved addressing the following requirements of the project-

Mandatory Functional Requirements

1. Share Data with other vehicles- Vehicles will send and receive basic information regarding location, available and occupied spots, and obstacles by joining the network.

Mandatory Non-Functional Requirements

1. Communicate reliably between local vehicles- If the vehicle loses network connection, it will re-join quickly without losing information. Vehicles would be allowed to join and leave the network as required.
2. Make minimal changes to infrastructure- No changes shall be made to the parking lot, nor will a central server be installed for the system to operate.

Desirable Functional Requirements-

1. Maintain scalable network of vehicles- The network will operate for more than two mobile platforms.

A literature survey was conducted and its findings are as follows-

- **Mobile Ad-Hoc Networks (MANETs)**

A Mobile Ad hoc Network (MANET) is an instance of an opportunistic network. It is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires.

It is the implementation of ad-hoc networks i.e. networks that are temporary in nature. The key feature of this type of network is that each device in this network is free to join or leave the network and change the path it takes to communicate with other devices at will. Devices can communicate with each other even if a route connecting them may not exist or may break frequently. This aligns with our requirement of having mobile platforms that share data in a reliable manner.

MANETs can be implemented in several ways- Vehicular Ad Hoc Networks (VANETs), Smart Phone Ad hoc Networks (SPANs) and Internet based mobile ad hoc networks (iMANETs). The VANET network type is the closest match to what we wish to implement in our project and hence I decided to pursue it further.

- **Vehicular Ad-Hoc Networks (VANETs)**

The typical communication links in a VANET include-

- Vehicle to Vehicle (V2V) Communication
  Through V2V communication, vehicles in the vicinity can communicate data such as current location, speed, heading and pose to other cars.

- Vehicle to Infrastructure (V2I) Communication
  The Vehicle can communicate to Road Side Units (RSU) to gain information about traffic management, detours and other broadcast messages. The infrastructure units can also be used to provide infotainment services to vehicles.

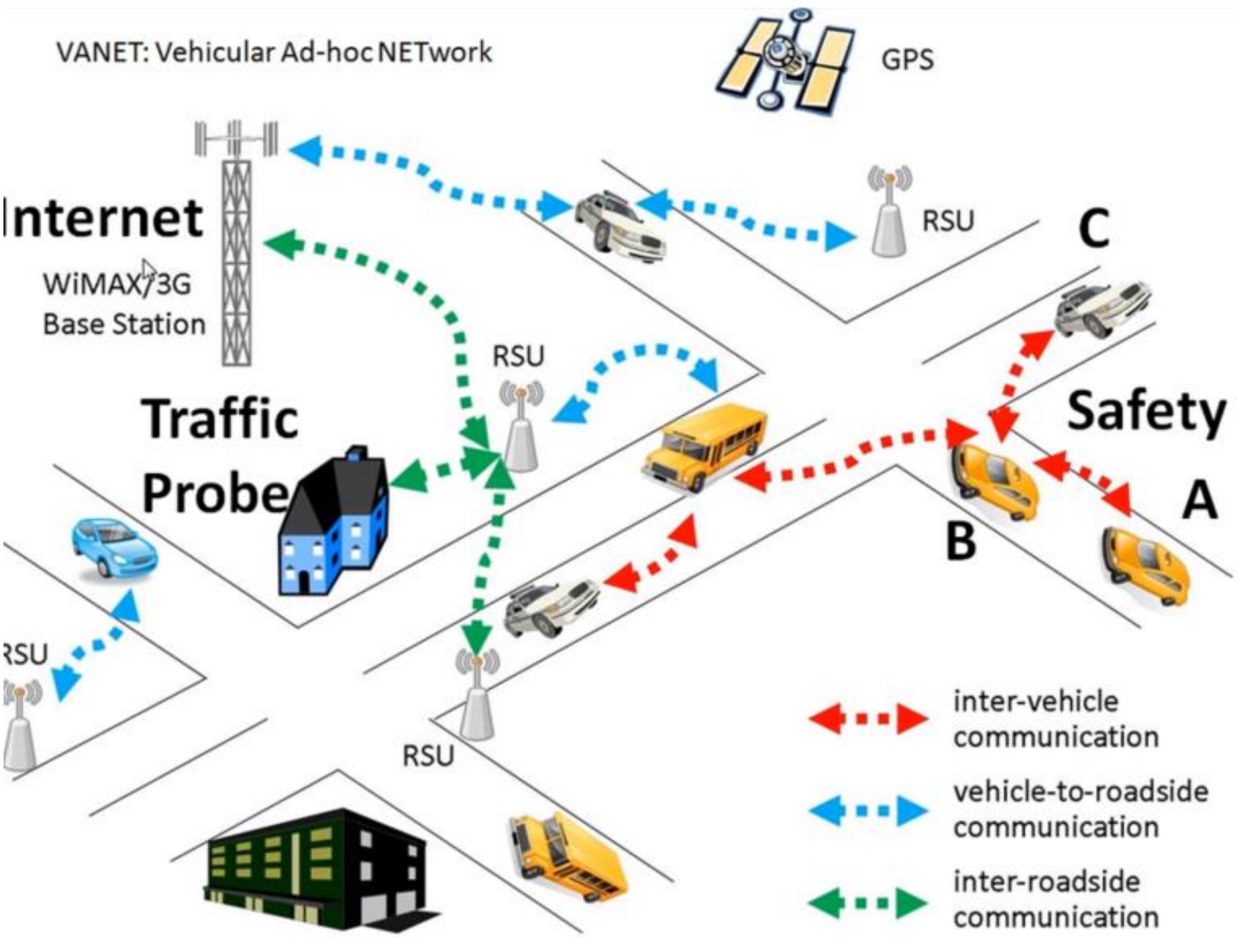

Figure 1- A typical VANET based network

(Source: George Corser- Introduction to VANETs)

The project requires that the vehicles be able to share information much like in a V2V scenario. The project, however, is aimed at the elimination of a central server. Therefore, the V2I communication aspect of VANETs is not to be aimed at.

Another key feature is that a message can be stored in a node and forwarded over a wireless link as soon as a connection opportunity arises with a neighbor node. This is exactly what we intend to do while sharing the parking-lot map information with other vehicles. This would enable the cars to receive the current status of the parking lot and compute the best available spot and the route to this spot. (The best available spot is defined as the one closest to the exit as it would minimize the time for a platform to return to the user.)

The typical applications of the VANET are depicted in figure 1. They include-

a. Safety- Cars can communicate data with each other to estimate each other's intended manouvers based upon shared data. This serves as a basis for the development of anti-collision devices that are being widely used for commercial vehicles.
b. Traffic Management
   VANETs find use by authorities in re-rotuing traffic, traffic light management and congestion management.
   To optimize flows of vehicles: *e.g.,* enhanced route guidance/navigation, traffic light optimal scheduling, lane merging assistance
c. Infotainment Applications
   These networks can be used to deliver high speed internet connectivity to mobile vehicles.

The VANET network conforms to all the requirements set out for the communication system apart from not modifying the current infrastructure. Thus, it is established that the project should implement a VANET based network which would allow mobile platforms to communicate with each other.

A key challenge in implementing VANETs is the requirement of not changing the current infrastructure in parking lots. To meet this requirement, it seemed plausible to network devices in as part of a mesh topology in which any node could act as a central server. In a mesh network, the range is extended by allowing data to hop from node to node and the reliability is increased by "self healing"- the ability to create alternate paths when one node fails or a connection is lost.

Such implementation often requires the presence of dedicated coordinator nodes which connect segments of the network to each other. This, however, is in direct contradiction to the requirement of eliminating the central server.

This problem was eventually solved by the existence of the DigiMesh family of RF modules. The solution is described in detail in the next section.

2. Conduct a lab inventory/ market survey for communication purposes

To implement the above VANET network, I conducted a survey of existing communication equipment present in the lab inventory.

The equipment in the lab that could be used were-

1. Bullet M5 Routers

   The Bullet routers are a good solution for point to point communication. My prior experience with them aided the decision making process as I knew that these routers were complicated to interface with each other and might not be suitable for integration with our mobile platform. The reliability of the routers was an issue which is one of our main concerns.

2. XBee Series 1 Radios

   The XBee Series 1 radios are based on the Zigbee protocol and is great for low-bandwidth point to point communication. The major drawback of the XBee is that it cannot be configured to be used for multiple devices. They were found not suitable for use with our system.

The next option was to look at possible communication radios existing in the market. Other variants of the Ubiquiti routers existed and were looked into. However, the most suitable product was by Digi which was based on the DigiMesh protocol. It is starkly different to the Zigbee protocol, as is depicted in figures 2 and 3.

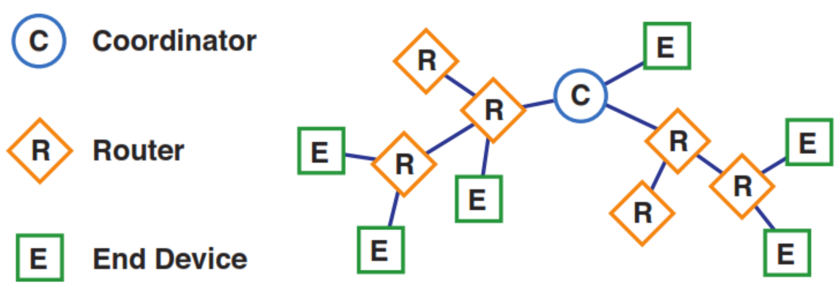

Figure 2- The Zigbee protocol network

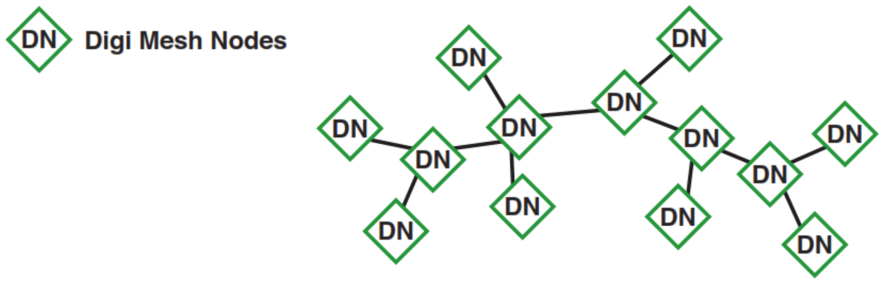

Figure 3 The DigiMesh protocol network

The DigiMesh protocol eliminates the need for dedicated Coordinator/Router nodes as the network is homogenous- all nodes can route data and are interchangeable. The protocol conforms to all the requirements set out in the beginning and is therefore the best fit for our application currently.

XBee Digimesh Multipoint Adapters (Figure 4) was the device selected which uses the DigiMesh protocol for communication.

Figure 4- XBee DigiMesh Multipoint Adapter

The module is available in both the 2.4GHz and the 900 MHz variant. The indoor range of the 2.4 GHz module is around 300 ft. which is sufficient for indoor testing. The USB variant of the adaptor is plug and play and would allow us to connect it with our single board computer. The product has generally favorable reviews and costs around $100, which conforms to our budget.

3. Decide a suitable test platform-

The team needed a platform to begin initial testing of the developed system. We are currently in talks with our sponsor for a platform but decided to order a relatively in-expensive test platform for initial testing.

a. For early prototyping purposes

While deciding on a test platform for prototyping purpose, I considered the following factors-

- Should be able to structurally and spatially support an SBC and a Kinect.
- Shipping time should be minimum
- Minimum cost

I eventually decided that the DFRobot 4WD platform (Figure 5) on Robotshop.com was the one that conformed to our requirements the most. With the help of Richa, we were able to find a bigger variant of the platform on another website and ordered the same.

Figure 5- DFRobot 4WD Mobile Platform

b. For further development purposes

I am currently looking at ROS compatible platforms (http://wiki.ros.org/Robots) and coordinating with the sponsor on this matter along with Mohak. This is needed as we want to minimize our involvement in the development of mobile platforms and focus on the other key areas of the project.

For the progress review demonstration, I wrote a basic code for locomotion of the assembled platform. The platform could move in all directions based upon serial commands by the user.

2. Challenges

One of the challenges I faced was the implementation of the functionality of a VANET without having a central server. The earlier proposed solution of having a network with a central switch eliminate the need for computing at a central node but do not eliminate the physical presence of a central server. This challenge was overcome by exploring the DigiMesh protocol.

Another key challenge was selecting a mobile platform and coordinating with the sponsor regarding the mobile platform. Most of the platforms that we find suitable do not conform to our budget (eg. The integrated Occulus Prime platform costs $1200 per unit).

3. Teamwork

The division of work in the team required me to work with Mohak on the selection of mobile platforms and with Richa for integrating the Arduino Mega with the platform. Pranav and Mohak worked together on finding out possible methods for obstacle detection. The team has decided to move ahead with the Kinect for obstacle detection due to the expansive support and documentation. Richa assembled the mobile platform and worked on integrating it with the Arduino Mega. Dorothy and Mohak created the app and they were successful in establishing a serial link between a phone and a computer.

4. Plans

The team has the following goals to complete by Progress Review 2:

1. Acquire/ place order for the necessary hardware to test mesh grid setup (Shivam)
2. Acquire Kinect and setup interface using ROS (Pranav and Mohak)
3. Create communication channel between ROS and microcontroller (Shivam and Pranav)
4. Demonstrate mobile application's back-end capability of establishing serial communication over Bluetooth (Mohak and Dorothy)
5. Setting up the mobile platform by rigging up with necessary sensors (Richa)

References

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