SOFTWARE REQUIREMENTS REPORT

Group Name: Babylon

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1. PURPOSE

1.1 Introduction

This requirements analysis report provides description of functions and specifications of Babylon Vehicular Ad Hoc Network project which will be performed by Babylon Design Group in METU Computer Engineering department senior design course.

1.2 Scope

Babylon vehicular ad hoc network is designed to be used in motorized vehicles in traffic. The main purpose of the proposed system is to assist drivers by providing them detailed information about the vehicle and surrounding entities in traffic. The system contains a GPS system which will provide geographical coordinates, speed and heading as well as a wireless transceiver which will enable vehicles to exchange information. Interaction with the system is achieved through a graphical user interface.

1.3 Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>Geographical Positioning System</td>
</tr>
<tr>
<td>UIM</td>
<td>User Interface( Map)</td>
</tr>
<tr>
<td>UIR</td>
<td>User Interface( Radar)</td>
</tr>
<tr>
<td>NMEA</td>
<td>NMEA 0183 specification for communication with GPS (National Marine Electronics Association)</td>
</tr>
<tr>
<td>MANET</td>
<td>Mobile Ad Hoc Network</td>
</tr>
</tbody>
</table>

1.4 References


1.5 Overview

Document starts with an overview of the system and the product. Then the requirements are listed. After the market research, use cases, class and state diagrams are presented.

2. SYSTEM DESCRIPTION

2.1 Product Perspective

Transportation systems get more and more complex everyday due to their continuous growth and unpredictability because of human factor involved in the system. In order to have safe and efficiently working system, aerial and naval vehicles are equipped with devices which provide extensive information about environment to the operators.

It is apparent that with advancing technology and increasing need for navigational assistants, automobiles are getting equipped with sophisticated devices today. However, nearly all of the devices integrated with modern automobiles transfer information about only the vehicle itself. With this motivation, the main goal of the project is to develop a wireless vehicular ad hoc network which will promote exchange of valuable information between vehicles in traffic. With such a system drivers will not only observe own vehicle’s data but also will be able to access information received from other vehicles in traffic.

The product consists of a software system which collects information from connected hardware, processes it and displays on its user interface in response to the requests made by the operator. Collected information includes geographical position data from GPS device, information about surrounding entities via wireless communication hardware and information collected by sensors of the vehicle.
2.2 Uses, User Characteristics and Constraints

The system described above may have uses at the following areas:

- **Self and Environmental Awareness**: Drivers can be noticed of status of themselves and other vehicles in proximity (e.g. speed, position, and heading) including types of vehicles (e.g. ambulance, fire truck, police car). This gives drivers a chance to get information as early as possible and act accordingly. For instance, drivers may be noticed of an ambulance approaching to them and leave emergency lane for a safe passage of the ambulance.

- **Accidents**: Modern automobiles are equipped with sensors which detect collision and trigger safety systems such as airbags. Our proposed system may be integrated with these systems so when an accident occurs it may be reported to a central server via GSM network with coordinates of accident site. This may improve the response time of police, fire station and hospitals.

- **Road Information**: Road signs are the most fundamental informing tools used in traffic. However they have limitations. First, they pass on information to the drivers only when they are in sight range. Second, they do not adapt to the changing conditions of the road. E.g. it may be necessary to adjust the limit of the traffic according to weather conditions, traffic density and lighting conditions. By equipping road signs with wireless transmitters, drivers can keep track of current traffic regulations which apply to them. Moreover, there can be other...
uses for roadside transmitters. Due to an accident, or a natural disaster roads can be closed; partly or to full extent. In this case, officials will put a transmitter to the site and it will inform the incoming traffic to reduce their speeds or even to change their course.

- **Commercial Uses**: The information broadcasted by roadside equipment is not necessarily only about status of the road. There can be other uses as well:
  
  o **Looking for a product**: supermarkets may place a transceiver to join the ad hoc network and wait for product queries which are broadcasted by consumers who are looking for a certain product. When query is received by the supermarket, transceiver sends response to the driver indicating its coordinates. As a result, driver can see the coordinates of nearest supermarkets which supply the product.
  
  o **Nearest pharmacy on duty**: It has been very problematic to find the nearest pharmacy on duty during nighttime at an emergency. Pharmacists may use a transmitter which will broadcast that they are open with information of their coordinates.
  
  o **Nearest car park**: Many shopping centers provide number of available parking lots on screens placed at the entrance of car parks. In addition to these screens, wireless transmitters may be placed which will send information about number of available parking lots. This information may travel from car to car, notifying drivers in other vehicles as well. This system may be applied to car parks in city centers or university campuses as well at the beginning. As a result, drivers will spot the nearest car park available to them. Other information that can be shared in a similar manner may be coordinates of the nearest gas station or the nearest hospital etc.

- **Optimization of traffic lights**: If the proposed system is installed in every vehicle, traffic lights will have information about incoming traffic. Thus, instead of the fixed-time lights, the duration of the traffic lights will be adaptive. As an example, in a two sided traffic light system, if there is a heavy traffic flow in one direction and the other side has relatively less dense traffic, the lights will be adjusted to overcome this situation. One side will receive more red lights and similarly duration of the green light will be more at the other side.

  Typical users of the system will be automobile drivers and passengers who are capable of using devices at least as complicated as navigation assistants provided in cars.
The system is constrained in some aspects regarding traffic environment. It is known that VANETs have the following unique properties\(^1\), putting constraints or relaxations on the system with respect to other ad hoc networks:

- Rapid changes on network topology because of relative fast movement of vehicles in traffic
- Frequent network disconnections, especially in low traffic density
- Data compression/aggregation required to accommodate for the limited bandwidth of wireless transceiver
- Feasibility of predicting vehicle locations where pre-built road locations are known
- Energy not being an important issue since power source of the vehicle is used

There may be other conditions in the traffic such as high number of events occurring at the same time, changing weather and geographical conditions, radio interferences, traffic regulations, different standards used in different vehicle brands which pose constraints on the system.

The next section lists the functional requirements which are compiled according to the uses listed above.

### 2.3 Functional Requirements

#### 2.3.1 User Interface (Radar)

**2.3.1.1 Introduction**

First user interface equipment is the radar. Basically radar will show information about the world around the vehicle. It will show the details of vehicles or the road side equipment having the system.

**2.3.1.2 Requirements**

1. UIR **shall** display own vehicle’s coordinate, heading and speed with user centered.
2. UIR **shall** display surrounding vehicles’ coordinates, headings and speeds.
3. UIR **shall** display each vehicle type (ambulance, fire truck, police or individual) with different shapes.
4. UIR **shall** display information received from roadside equipment.
5. UIR **shall** support zooming to some extent.

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6. Functionalities 1 and 2 could be turned on and off.
7. General information messages received from vehicles and road side equipment shall be displayed on UIR.
8. User will be able to switch to UIM on UIR.
9. UIR shall be able to change the range of objects that it recognizes as the environment surrounding the vehicle.

2.3.2 User Interface (Map)

2.3.2.1 Introduction
This interface is a conventionally used GPS system. It will show the current map, and will allow users to create path between two locations.

2.3.2.2 Requirements
1. UIM shall contain three text boxes. First text box shall be used for navigation to a desired location. Remaining boxes shall be used for path finding.
2. UIM as default shall display map of current location.
3. UIM shall navigate to another location when name or coordinate of a geographical location is entered to first box.
4. UIM shall find the shortest path between the coordinates written at the two text boxes. These locations may also be inputted by clicking on the screen.
5. When user gives an input, the screen shall be centered to that specific path or location.
6. Until a user input, the screen shall refresh the screen every second to catch with the vehicle.
7. User will be able to switch to UIR on UIM.

2.3.3 System

2.3.3.1 Introduction
The following requirements will describe the core of the system, like how vehicles should communicate and how position data will be found and used.

2.3.3.2 Requirements
1. System shall send and receive vehicle coordinate, speed and heading information.
2. System shall replicate information received from other sources and send it to other vehicles.
3. User shall be able to limit the range of information received.
4. System shall be able to operate in high density traffic where information density is also high.
5. System shall tolerate lags and faults in data transmission.
6. System shall prioritize data to be transferred if the amount of data is larger than the bandwidth provided by hardware.
7. The wireless communication device in each individual vehicle shall have a minimum range which permits effective communication between vehicles moving in traffic.

8. System shall have a dynamic network structure which adapts changes in links to other entities.

9. Official vehicles (such as ambulances and fire trucks) shall supersede the following requirements: UAR: 6 and S.R.:3.

10. Accidents shall be detected from the signals from the emergency system of the vehicle. Ad hoc system shall be used to warn the vehicles to contact officials.

**2.3.4 Road Side Equipment**

**2.3.4.1 Introduction**

System model also contains non vehicular components. These components, road side equipment, will inform drivers about the world conditions.

**2.3.4.1.1 Requirements**

1. Examples to road side equipment may be; road signs, hospital or other official buildings, gas stations etc.

2. Road side equipments may be portable. As an example, when a problem occurs at some part of a road, officials may deploy road side equipments transmitting caution signals.

3. These equipments shall be simple devices capable of only transmitting messages through the ad hoc network without containing an operating system.

4. Since messages from road side equipment is user controlled, vehicles shall receive only limited information from stations due to safety constraints.

**2.4 Nonfunctional Requirements**

Nonfunctional requirements listed in this section are necessary features regarding security and usability which are observable at runtime as well as non-observable features such as maintainability and testability.

- The system should be designed to be applicable in cities or other populated city-like regions.
- It is to be used only with vehicles (cars, trucks, buses, vans etc.) on roads. Aeroplanes or trains are not to be considered in the application domain.
- Different types of vehicles should be managed differently.
2.5 Hardware Requirements

Each vehicle will contain the following systems:

- For geographical data: A GPS receiver.
- For communication through ad hoc network: A ZigBee module.

2.6 Software Requirements

- A Linux based operating system will be used.
- For the UIM “Google Map Catcher” API will be used.
- UIM will be a browser based system.

Developer Tools: Eclipse and NetBeans will be used in order to develop our code in JAVA.

2.7 Requirements Traceability

<table>
<thead>
<tr>
<th>ID</th>
<th>USER REQUIREMENTS</th>
<th>FORWARD TRACEABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>User shall see his/her vehicle in UIR.</td>
<td>SRS 2.3.1.2. 1</td>
</tr>
<tr>
<td>U2</td>
<td>User shall see his/her vehicle's speed, heading and coordinates via UIR.</td>
<td>SRS 2.3.1.2. 1</td>
</tr>
<tr>
<td>U3</td>
<td>User shall see surrounding vehicle types on UIR.</td>
<td>SRS 2.3.1.2. 3</td>
</tr>
<tr>
<td>U4</td>
<td>User shall see surrounding vehicles' speed, heading and coordinates on UIR</td>
<td>SRS 2.3.1.2. 2</td>
</tr>
<tr>
<td>U5</td>
<td>User shall see general information messages via UIR.</td>
<td>SRS 2.3.1.2.7</td>
</tr>
<tr>
<td>U6</td>
<td>User shall be able to choose not to see any information of his/her vehicle on UIR.</td>
<td>SRS 2.3.1.2. 6</td>
</tr>
<tr>
<td>U7</td>
<td>User shall be able to choose not to see any information about surrounding vehicles on UIR.</td>
<td>SRS 2.3.1.2. 6</td>
</tr>
<tr>
<td>U8</td>
<td>User shall be able to zoom in/out at specified intervals on UIR.</td>
<td>SRS 2.3.1.2. 5</td>
</tr>
<tr>
<td>U9</td>
<td>User shall be able to limit the range of information received on UIR.</td>
<td>SRS 2.3.1.2.9</td>
</tr>
<tr>
<td>U10</td>
<td>User shall see positions and types of roadside equipments on UIR.</td>
<td>SRS 2.3.1.2. 4</td>
</tr>
<tr>
<td>U11</td>
<td>User shall be able to switch from UIR to UIM via a specific button on UIR.</td>
<td>SRS 2.3.1.2.8</td>
</tr>
<tr>
<td>U12</td>
<td>User shall be able to switch from UIM to UIR via a specific button on UIM.</td>
<td>2.3.2.2.7</td>
</tr>
<tr>
<td>U13</td>
<td>User shall be able to see his/her location on UIM.</td>
<td>SRS 2.3.2.2. 2</td>
</tr>
<tr>
<td>U14</td>
<td>User shall be able to zoom in/out at specified intervals on</td>
<td></td>
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</tbody>
</table>
**3. MARKET RESEARCH AND LITERATURE SURVEY**

GPS-based systems are widely used in many countries, responding solutions to many problems in different areas. Apart from the USA’s Global Positioning System (GPS); European Union’s Galileo Positioning System, Russia’s GLONASS and China’s Compass Navigation System are in use as alternatives and complementary to each other. Currently existing GPS-based systems to solve daily life problems make use of one of these global satellite systems. Investigating the traffic control and information systems with GPS in USA, one can come across many patents regarding the issue. An example[2] is a traffic control unit is included to collect data from plural vehicles (primarily the speed and the heading of the vehicle) and to analyze traffic patterns to control metering lights and speed limits.

The invention also has functions like trip planning. News from Australia states that all GPS vendors united under the umbrella of SUNA to manage traffic mainly in Sydney and Brisbane. Making use of GPS devices on vehicles, which are broadly used in the country, traffic information is broadcasted to drivers using the Radio Data Service protocol which silently encodes the SUNA Traffic Channel information on an existing FM broadcast service, it is then received by a navigation system and used to identify and, if possible, avoid the traffic. The system also includes translation of information messages about incidents and road works so that drivers could avoid congested roads by collecting raw traffic flow data from a loop sensor network embedded in the road pavement near intersections[3].

SATEL[4], which is an international company having distributors also in Turkey, provides GPS-based applications such as radio modem solutions that enable traffic control, interactive traffic signs and vehicle tracking and positioning; transfer of up-to-date information between/to cars about free parking lots in an area and real-time weather updates and warnings etc; public transportation solutions...
by informing passengers waiting at bus-stops, metro stations etc about the expected arrival time etc of the vehicle; and lifesaving applications that will make it easy to rescue lives in case of accidents.

Tests for speed control systems including automated tolls/charges are being conducted in London, yet discussions continue[5].

Istanbul Metropolitan Municipality announced that they are going to implement GPS tracking systems to control traffic in Istanbul, following the currently used Electronic Supervision System which is based on digital camera recordings.

4. Libraries, API’s And Tools

4.1 Gmap Catcher

http://code.google.com/p/gmapcatcher/

4.2 Java 2D API

http://java.sun.com/products/java-media/2D/index.jsp

5. Use-Case And State Diagram

- Use-Case For Map
• **Use-Case For Radar**

- Zoom in/out
- See his/her vehicle
- Be informed about his/her vehicle's speed, coordinates and heading
- See surrounding vehicle types
- See surrounding vehicles' speed, heading, coordinates
- Choose not to see any information of surrounding vehicles
- Choose not to see any information of his/her vehicle
- Limit the range of information
- See general information messages
- See positions and types of roadside equipments

• **Use-Case For Radar-Map Switch**

- Uses SwitchToUIM button to switch to UIM from UIR
- Uses SwitchToUIR button to switch to UIR from UIM
Description of the Class Diagram

Class diagram aims to reflect the object-oriented nature of the software components by depicting basic class structures and interrelations among them. The diagram does not intend to describe the whole project design, yet indicates the basic software object relations to clarify the scope of the project. Below are the explanations related to the units included in the diagram.

Actors of the system include transmitters and receivers to communicate with each other. *Transmitter* and *Receiver* classes represent these units and they are attached to vehicles and road side equipments. This case is indicated on the diagram by aggregation relationships between *Vehicle* and *Transmitter*, *Vehicle* and *Receiver*, *Road Side Equipment* and *Transmitter*, *Road Side Equipment* and *Receiver* classes. Since actors of the system may have one or more transmitter and receiver units, this case is indicated by putting 1..* on the arrows.

*Vehicle* class represents the main actors of the system with four derived classes *Fire Fighter*, *Ambulance*, *Automobile*, and *Police*. Each derived class symbolizes the distinct vehicle types found on roads. They all have distinct draw functions to make it possible for the users to recognize them via the interface.

*Road Side Equipment* class represents the road signs, hospital or other official buildings, gas station, etc. They inform vehicles on roads about their existence and/or broadcasts warning messages about the general situation of traffic and the user realizes these messages and takes necessary actions according to them via the interface.

*Location* class represents the geographical position information of a specific point in space. It is included in *Vehicle* and *Road Side Equipment* classes to be used as position information by these actors. This case is depicted in the diagram by employing one-way dependency relationships between *Vehicle* and *Location*, *Road Side Equipment* and *Location* classes.

*Radar* class represents the object which is a collection of the actors of the system. In other words, *Radar* class includes zero or more *Vehicle* and zero or more *Road Side Equipment* classes depicted as aggregation relationships between the specified objects with cardinality 0..*. It is connected to and is the basic building block for the *UIR interface* which includes most of the functionality that the system will provide to the end user.

The *UIM interface* is going to be implemented by making use of a suitable map API and it uses the position info depicted by the *Location* class.
Description of the State Diagram

State diagram intends to depict general execution sequences in the system. User can receive information from two interfaces, the UIR and the UIM. The system execution begins with turning-on of the UIR. User can decide to see the information of his/her vehicle on the interface at any time. Similarly, the user can make decisions of seeing other vehicles' information and receiving warning messages from road side equipments, timelessly. In case of emergencies involving the user's vehicle, broadcasting the emergency signal dominates the program execution. Unless emergencies occur, the system continues its normal execution mentioned above.

User can switch to the UIM whenever he/she wants to. User can navigate to another location and find the shortest route between two destinations at any time by using the interface. Finally user can switch to the UIR and the system execution continues from this point.

Hence the system execution mainly comprises of the execution of the UIR and the UIM interchangeably. User can terminate the system by turning off the UIR.
6. TASKS OF THE PROJECT

- **Research on technologies and tools**: Nov. 16, 09 - Dec. 7, 09
  - Zigbee specifications, simulators
  - APIs and development tools

- **Detailed architectural design, UI design**: 14/12/2009 - 21/12/2009
- **Detailed Design**: 14/12/2009 - 04/01/2010
- **Detailed implementation plan, implementation of key components for prototype**: 21/12/2009 - 04/01/2010

- **Prototype Demos**: 11/01/2010 - 23/01/2010

- **Today**: Nov. 16, 09