System Architecture and High Level Design

for

AGORA

Version 1.1

A Versatile Environment for the Development of IntelliDrive Applications

(Visual … Extensible … Rule-Based)

Department of Computer Science, Western Michigan University



Table of Contents

Table of Contents ..... **ii**
Revision History ..... **ii**
1. Introduction **1**
1.1 Purpose 1
1.2 Document Conventions 1
1.3 Intended Audience and Reading Suggestions 1
1.4 References 1
2. Overall Description **1**
2.1 Product Perspective 1
3. Building Blocks **1**
3.1 Architecture Building Blocks 1
3.2 Solutions Building Blocks 5
4. Architecture Vision **7**
5. System Architecture **8**
5.1 TMC 9
5.2 VIS 9
5.3 Gov 2.0 9
5.4 A3 10
6. Tools and Utilities **10**
6.1 Road Sign Capture Tool 10
Appendix A: Glossary **10**

Revision History

Name	Date	Reason For Changes	Version
Vinay B Gavirangaswamy	02/13/2010	Intial Draft	1.0
Vinay B Gavirangaswamy	02/16/2010	Changed project name from VII to AGORA, changed paragraph formatting, and reformatted cover page.	1.1

1. Introduction

1.1 Purpose

AGORA refers to a set of application and infrastructure which constitutes intellidrive environment that is being developed at Computer Science Department, Western Michigan University. This infrastructure consists of On-Board Equipment (OBE), Road Side Equipment (RSE), and Traffic Management Centers (TMC), which work together to increase the safety and efficiency of the transportation network. Current system that is deployed across the university consists of initial versions RSE's, OBE's and VIS. And Current scope of work involves enhancement of VIS to include more features and functionality through incorporating different capability/applications. And it will also include development of TMC (Traffic Management Center). However the goal of this program is to facilitate MDOT in enforcing a safe and an efficient transportation system.
This document rationalizes different views of the AGORA system, and also tries to identify components which will be used to architect AGORA.

1.2 Document Conventions

TBD

1.3 Intended Audience and Reading Suggestions

Document is primarily intended for members of MDOT team which consists of graduate students working under the guidance of Dr. Ala Al-Fuqaha and Dr. Dionysios Kountanis.

1.4 References

- Project Proposal Document
- System Specification for AGORA

2. Overall Description

2.1 Product Perspective

AGORA is a futuristic technology that is engineered to increase the safety and efficiency of the transportation network. This is achieved through integration of number of platforms such as OBE, RSE, and TMC.

3. Building Blocks

3.1 Architecture Building Blocks

3.1.1 Centroid

A primary principle upon which AGORA system is defined includes increased safety and efficiency of the transportation network. Based on this aspect one of the basic requirement is to track vehicles that operate on the transportation network. For this purpose we have defined **centroid,** which is location with co-ordinate of an object in the transportation network. Group of centroid allocated to a region or geography are known as centroid set.

3.1.2 Regional Managers

Regional managers are special purpose building blocks which are built in association with centroid sets. A typical regional manager will keep track of other components of typical transportation ecosystem; which includes vehicles, road attributes, and point of interests for a particular centroid set.

3.1.3 Super Nodes

Super node consists of one or more regional managers. It is constructed for multiple reasons, which are primarily because of the sheer number of components that a transportation network will consist

- To introduce fault tolerance
- Act as facilitator among regional managers
- Govern regional managers, etc.

3.1.4 On-Board Equipments

Typical on-board equipment will consist of both hardware and software components used to integrate vehicles with other building blocks in AGORA.

- **Garmin GPS18x (USB GPS device)**

  Connects to the system to allow reading of latitude, longitude and heading of vehicles



Figure 1: USB GPS device



- **OBDLink**

Connects to On Board Diagnostic (OBD) system of 1996 and newer vehicles allowing for collection of vehicle data such as RPMs, speed, etc.

- **VMM6300 Vehicle Mounted Mobile**



Figure 3: VMM6300 Vehicle Mounted Mobile

Compact and ruggedly designed, the Motorola Vehicle Mounted Modem (VMM) turns a vehicle into a mobile office. Mobile Data Terminals (MDT), IP video cameras, and other IP ready devices can access a high-speed, mobile broadband network via a standard RJ45 Ethernet Port. This high performance wireless modem operates using the QDMA air interface and fully supports motion along with client meshing in the 2.4GHz. If the University would like to enable the 4.9 GHz spectrum the VMM is available as a VMM7300 for the 4.9GHz frequency band.

3.1.5 Road Side Equipment

Road side equipments are used to integrate OBE's with other building blocks. Their primary function is to assist in communication.
Below is the description of equipments that are used in AGORA,

- **IAP7300-01 (VLAN): Intelligent Access Point**

  In a MOTOMESH Quattro broadband network, the Intelligent Access Point is a small, low-cost device that acts as the transition point from the wireless network to the wired world. Each IAP provides dual band operation at 2.4 GHz and 4.9 GHz, with radios that support both 802.11 b/g and MEA/QDMA air interfaces for data communications. The IAP is software upgradeable from a single band to dual band (2.4GHz and 4.9GHz) operation. Additionally, it will be software upgradeable from standards based 802.11 WLAN capabilities to MEA. Standards based 802.11b/g at 2.4 GHz comes enabled as a standard feature with all infrastructure devices. The ability to allow client access is software configurable via network management on a per node basis. The proposed IAP includes the communications for 802.11 WLAN and MEA/QDMA in the 2.4 GHz spectrum. The IAP can be field upgraded to add the communications in the 4.9 GHz band as needed.

  The IAP7300-01 with VLAN models contains a VLAN switching capability that merges the two data streams onto one physical connection that translates to the need for only one Ethernet Port for Data I/O. The single Ethernet port for I/O is necessary, for example, when deploying this equipment with Canopy devices to avoid having to purchase and deploy two Canopy radios per IAP.

- **MWR7300: Wireless Router**



Figure 4:IAP7300-01 (VLAN), Intelligent Access Point



Figure 5: MWR7300, Wireless Router

The Mobile Wireless Router (MWR) provides dual band (2.4 GHz and 4.9 GHz) broadband wireless data coverage for client access and wireless backhaul support for other wireless routers. This device also provides wireless network access to one or more IP devices via its built-in RJ45 Ethernet port. For the proposed MWR the ports are enabled with the included software licenses, which are enabled from the MiSC. Like the IAP, the MWR includes the communications for 802.11 WLAN and MEA/QDMA in the 2.4 GHz spectrum. The MWR can be field upgraded to add the communications in the 4.9 GHz band as needed.

- **MiSC: Mobile internet Switching Controller**

The MiSC system includes hardware and software to provide routing, switching and network management functions. It also supplies the connection to the wired world. The proposed MiSC hardware has been provided to operate on the supplied Motorola supplied ML series laptop, core router and two LAN switches, one for the wireless equipment with its specific configuration and the other to support the connection of other application servers.

The MeshManager software resides on the Motorola supplied ML series laptop and provides all of the network management and gateway element functionality for the MOTOMESH Quattro network. As proposed the MeshManager application has been provided to support up to 50 MOTOMESH devices.

- **Canopy Advantage Access Point and Subscriber Module**

  The Motorola Canopy Advantage equipment has been developed to provide a wireless Ethernet bridge using publicly available frequency spectrum. The product proposed to Western Michigan University will use the 5.7 GHz spectra and is configured as a Point-to-Multipoint. The Canopy Advantage Access Point is to be connected to the MiSC through the provided core Ethernet switch. The Canopy Advantage Subscriber Module is intended to be located with the MOTOMESH Intelligent Access Point. The Canopy Advantage equipment is supplied with two adjustable mounting brackets, two universal Ethernet surge arrestors and two Powers over Ethernet Power supplies.



Figure 6: Canopy Advantage Access Point and Subscriber Module

3.2 Solutions Building Blocks

Architecture building that we defined above will act as bricks and mortar to build solutions that will realize principles of AGORA. Below is the list of such solutions that are defined

3.2.1 TMC-Traffic Management Centers

TMC's are designed to serve number of purposes while integrating with other architecture building block and system building blocks. TMC's silent features and capabilities are as follows

3.2.1.1 Features and Capabilities

- Capture Hazardous Data (HD)
- Store HD (CRUD)
- Web UI
- Integration with vehicle
  - Capture Hazard Data through VIS

    - Display hazards through VIS
    - Advertisements
- Visual Reports - Granularity may vary by radius, route or type of hazard
- Weather reports
- Advertisements (TBD: How to capture and to store?)
- Hazard category maintenance (localization, time of the year etc)
- VOIP
- Visual tracking – Real time, History, Privacy level
- Logging
    - For visual logging
    - Application logging
- Define and maintain data access level
- On-star kind of capability

3.2.2 Gov 2.0

Gov 2.0 is a capability which is being developed to enable real time feedback to VIS regarding hazards. These hazards can be divided into number of categories. And public/vehicles can inform/gather this information either intelligently or it can be conveyed explicitly (manufactured).

3.2.2.1 Features and Capabilities

- Detailed category list
- Category types
    - Natural (e.g. Icy condition, foggy)
    - Artificial (e.g. Potholes, accidents etc)
- Web interface
- In-vehicle interface
- Sync categories with TMC (idea is to keep VIS light weight)
- Methods to detect hazards
    - Intelligent – In vehicle
    - Offline – manufactured (e.g. web, cell phone)

3.2.3 A3

A3 (Advisory alert application) is used in conjunction with Gov 2.0; A3 is the intelligence behind hazard awareness in VIS.

3.2.3.1 Features and Capabilities

- Detailed category list
- Category types
    - Natural (e.g. Icy condition, foggy)
    - Artificial (e.g. Potholes, accidents etc)
- Web interface
- In-vehicle interface
- Sync categories with TMC (idea is to keep VIS light weight)
- Methods to detect hazards
    - Intelligent – In vehicle
    - Offline – manufactured (e.g. web, cell phone)

3.2.4 VIS

Vehicle Integrated System is tailored solution that will be integrated in all the vehicles that operate in the given transportation network. This solution will also be custom tailored for different type of vehicles that operate on the transportation network.

3.2.4.1 Features and Capabilities

- Coarse context visualization and detailed context visualization
- Road side signs
- Traffic light timing information
- Icy road conditions
- Foggy conditions
- School-bus, emergency vehicle, road work, Hazardous road conditions
- Unsafe proximity to vehicles
- Fuel consumption
- Trip time
- Carbon footprint
- VoIP
- Toll application
- Parking application
- Gas prices around current GPS location
- Weather summary

4. Architecture Vision

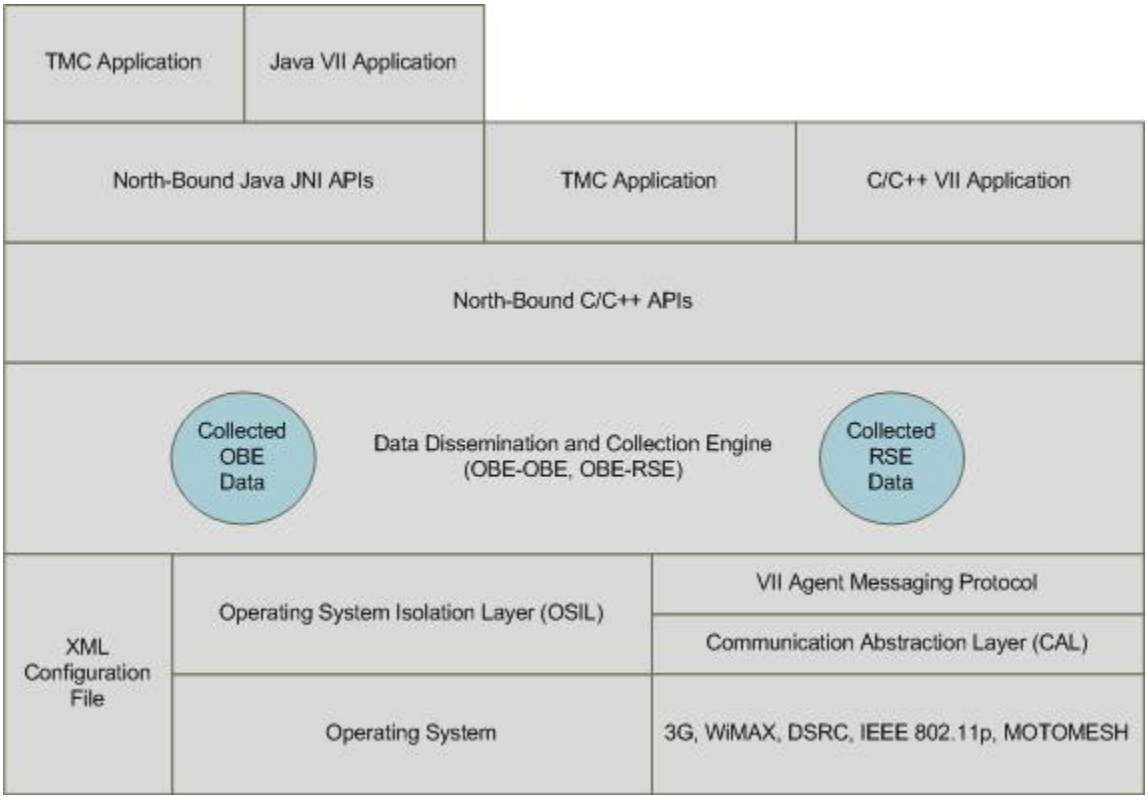


Figure 7: High-Level Architecture of the Proposed VII Framework

The high level architecture of the proposed AGORA framework is as shown below. It should be noticed that the framework hides the complexities associated with the data exchange process (between OBE's and between OBE's and RSE's) from application developers. This enables developers to focus on utilizing the collected data from neighboring vehicles and road-side equipment to build advanced AGORA application.

5. System Architecture

Typical system architecture of deployed AGORA will include all the components that are shown below.

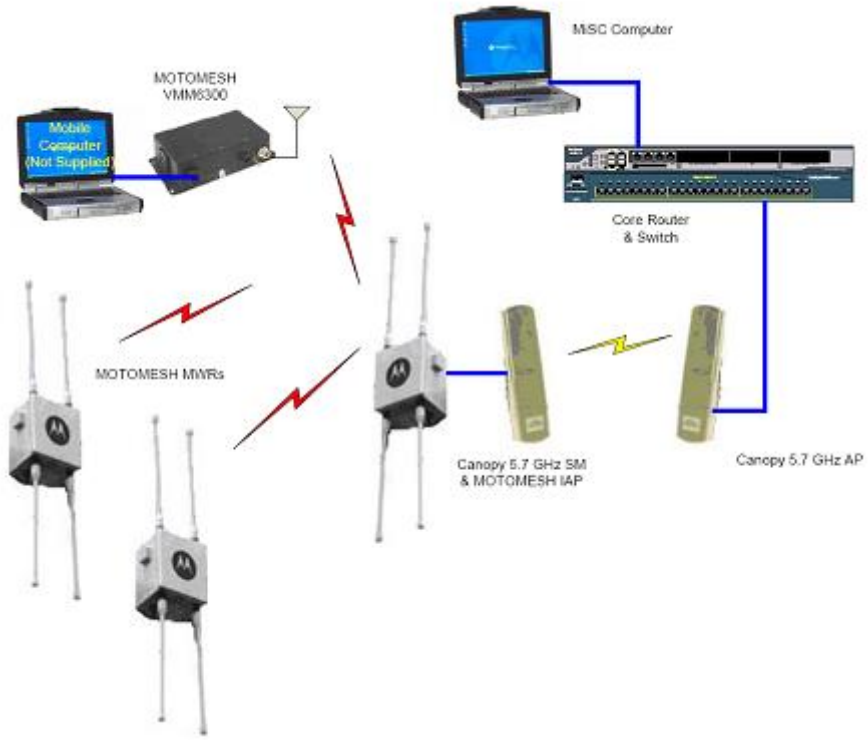


Figure 8: Typical System

This system architecture at Western Michigan University provides a MOTOMESH Quattro system that is similar to the equipment that has been deployed around the Rack Financial Center in Novi, Michigan. This includes equipment for one Mobile Internet Switching Controller (MiSC), one MOTOMESH Quattro Intelligent Access Point (IAP), two MOTOMESH Quattro Mobile Wireless Routers (MWR) and three MOTOMESH 6300 Vehicle Mounted Modems (VMM). Also included with the MOTOMESH equipment is one Canopy Advantage Access Point and Subscriber Module to be used to extend the Ethernet link between the Mobile Internet Switching Controller and the MOTOMESH Intelligent Access Point.
Locations 1, 2, and 3 shown in the image below denote the future placement of the IAP and (2) MWR. The device at location 1 will be powered by a wind turbine.



5.1 TMC

5.1.1 Software requirement

- Java 1.6
- Glassfish application server 2.1.1
- MySQL server 5
- Metro web service stack

5.2 VIS

5.2.1 Software requirement

- Java 1.6
- Java FX
- Java Media Framework (JMF) -Software the process audio data from VOIP communication.
- Sphinx4 - Speech recognizer that will be integrated to allows hands free access to the system.
- MjSip - Java based implementation of a SIP stack. Used to establish connection between users for VOIP communication.

5.3 Gov 2.0

5.3.1 Software requirement

- Java 1.6
- Java FX
- JAX-WS
- VIS

5.4 A3

5.4.1 Software requirement

- Java 1.6
- Java FX
- JAX-WS
- VIS

6. Tools and Utilities

As part of the system design and construction number of tools and utilities will be developed to facilitate in the design. Some of these have been mentioned below

6.1 Road Sign Capture Tool

This tool is used to capture road signs such as speed limits, pedestrian crossing, stop sign etc. For each of the signs corresponding metadata is generated and stored in configuration store, which is later communicated in the VIS and other systems.

Appendix A: Glossary

MDOT – Michigan Department of Transportation
OBE – On-Board Equipment
RSE – Road-Side Equipment
TMC – Traffic Management Centers
A3– Advisory Alert Application
LSA – Life Safety Application
VIS – Vehicle Integrated Software