Multi-Modal Intelligent Traffic Signal System (MMITSS)

Field Applications User Guide

University of Arizona

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RECORD OF CHANGES

A – Added, M- Modified, D - Deleted

Version Number	Date	Identification of Figure, Table, or Paragraph	Title or Brief Description	Change Request Number
1.0	6/7/2015	N/A	Initial Draft	

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1. Purpose of the Document

This document is a user guide for the Multi-Modal Intelligent Traffic Signal Systems (MMITSS) applications. This document contains the detailed usage instructions for each of the MMITSS applications including a description of each configuration file that is required.

2. MMITSS Introduction

MMITSS is a USDOT Cooperative Transportation Systems Pooled Fund project that focuses on connected vehicle Dynamic Mobility Applications (DMA). The project investigates the next generation of traffic signal system in a connected vehicle environment that serve multi modal including general vehicles, transit, emergency vehicles, fright vehicles, pedestrians and bicyclists. The project mainly consists of four parts: Intelligent Traffic Signal System (ISIG), Signal Priority (SP), Mobile Accessible Pedestrian Signal System (PED-SIG) and real-time performance observer (PERF-OBS). I-SIG provides real-time adaptive signal control to general vehicles which is the major topic of this dissertation. Signal Priority provides priority to different modes of vehicles including transit, trucks and emergency vehicles. PED-SIG includes a smartphone application that can send pedestrian signal request and provide assistance to disabled pedestrians. PERF-OBS monitors all the users on the road and collect real-time performance data by movement by mode such as travel time, delay, and queue length etc. The component diagram of MMITSS is shown in Figure 1. More details of the introduction of the project can be found in (Head et al., 2015) and (University of Arizona, 2015). WAVE message transceiver (MSGTRANS) provides a physical-layer agnostic network interface, mainly used for DSRC communication using the WAVE protocol. The message transceivers are required on both RSE and OBE and are used by ISIG, SP and PERF-OBS. All the applications will be introduced in following sections.
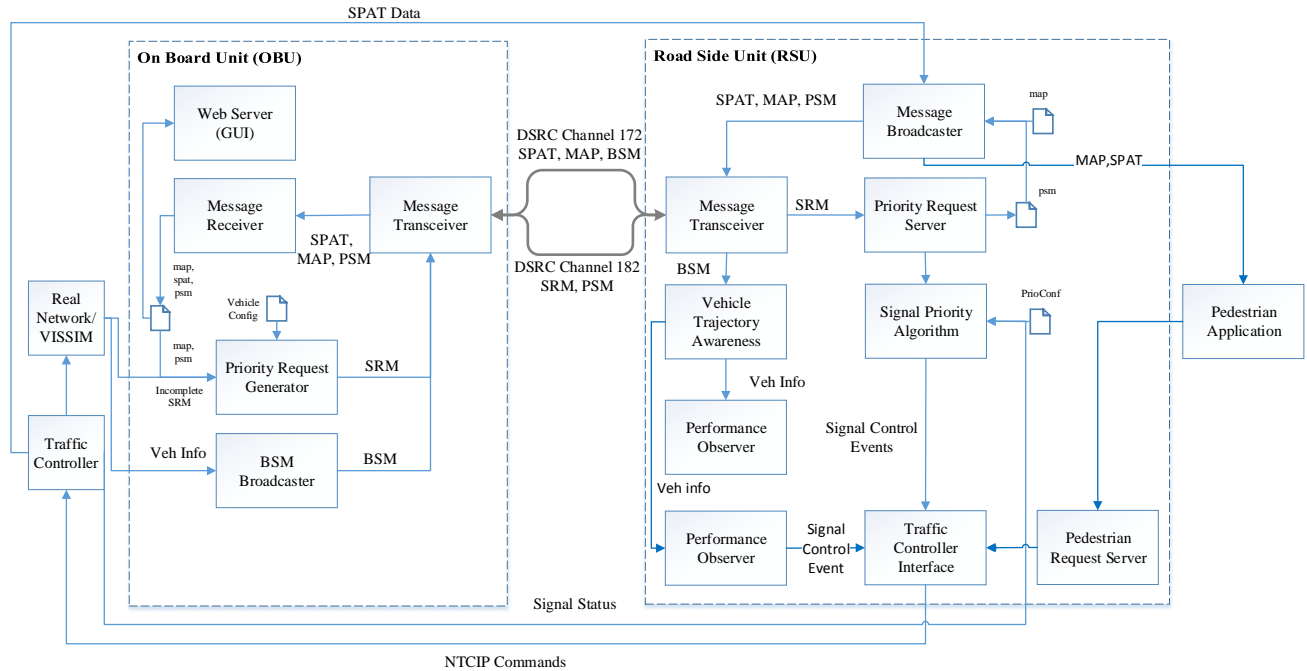
Figure 1 MMITSS Component Diagram

MMITSS is composed of a collection of applications that each performs critical system functions. Table 1 summarizes 16 MMITSS applications with its hardware location (e.g. processor) and the MMITSS functions that it supports.

Table 1 MMITSS Applications

Application Name	Location	MMITSS Components
MMITSS_MRP_EquippedVehicleTrajectoryAware	RSE	ISIG, PERF-OBS
MMITSS_MRP_MAP_SPAT_Broadcast	RSE	SP
MMITSS_MRP_Priority_Solver	RSE	SP
MMITSS_MRP_PriorityRequestServer	RSE	SP
MMITSS_MRP_Signal_control	RSE	I-SIG
MMITSS_MRP_TrafficControllerInterface	RSE	I-SIG, SP
MMITSS_Ped_MAP_Broadcast	RSE	PED-SIG

MMITSS_MRP_PerformanceObserver	RSE	PERF-OBS
MMITSS_MRP_Priority_Webserver	RSE	PERF-OBS, SP
MMITSS_MRP_PedRequestServer	RSE	PED-SIG
MMITSS_RSE_Message_Transceiver	RSE	ISIG, SP, PERF-OBS
MMITSS_OBE_BSMData_Transmitter	OBE	ISIG, PERF-OBS
MMITSS_OBE_MAP_SPAT_Receiver	OBE	SP
MMITSS_OBE_PriorityRequestGenerator	OBE	SP
MMITSS_OBE_Webserver	OBE	SP
MMITSS_OBE_Message_Transceiver	OBE	ISIG, SP, PERF-OBS

The current implementation of MMITSS requires that all the field applications need to be run on Savari StreetWAVE RSE and Savari MobiWAVE OBE. To compile the source code, the Savari SDK is needed. There is no need to install the applications. After compiling, the binary file of each application should be copied to /usr/local/bin folder of RSE or OBE.

3. WAVE Message Transceiver

The WAVE Message transceiver works in the same way on both OBE and the RSE. The application is invoked as below:

OBE: MMITSS_OBE_Message_Tranceiver –f CONF [-d]

RSE: MMITSS_RSE_Message_Tranceiver –f CONF [-d]

Argument: -f specifies which file to use to read configuration information. (e.g. /etc/config/wmefwd/bsm_wme.conf)

Extra Argument: -d debug mode to print logs to screen rather than writing to a file.

Sample Configuration file is as follows. Inline comments explain the role of each option:

```
############################################
###    Sample config file for WME app    ###
############################################

### Configuration enabled: 0 -> Disabled; 1-> Enabled; Default -> 1
Enabled = 1

### Name of the Message: Default -> WME_MSG
MsgName = BSM

### Direction: 0 -> Outgoing; 1 -> Incoming; Default -> 1
Direction = 1

### Channel number to use for WME: Default -> 172
ChannelNumber = 172

### Interface to use for WME: Default -> ath0
InterfaceName = ath1

### PSID of the message which uses this config file: Default -> 0x10
PSID = 0x20

### Channel Mode: 0 -> Alternating; 1 -> Continuous; Default -> 1
ChannelMode = 1

### Remote IP to which socket is opened: Default -> 127.0.0.1
RemoteIP = 127.0.0.1

### Remote port to which socket is opened: Default -> 9999
RemotePort = 3333

### Protocol to use for socket: Default -> UDP
RemoteProtocol = UDP

### Provider Service Context: Default -> "PSC"
PSC = MMITSS

### Message Length: Default -> 128 bytes
MsgLength = 75
```

This configuration file shows an example of BSM transceiver in RSE. For different message types on different devices, users need to modify: Name, Direction, Channel, Interface, PSID, Remote Port, and Message Length as well as the configuration file name (e.g. srm_wme.conf). All the WAVE message transceiver configuration files should be copied to /etc/config/wmefwd

4. Intelligent Signal Control

The Intelligent Signal Control applications requires the following applications in RSE and OBE need to be run:

RSE:

MMITSS_MRP_EquippedVehicleTrajectoryAware PORT SPEED_CO LOG

Argument PORT: port that receives BSM, should be 3333

Argument SPEED_CO: speed coefficient, should be 1.0

Argument LOG: 1- log incoming BSM data; 0- don't log incoming BSM data

MMITSS_MRP_Signal_control PORT PR OBJ

Argument PORT: Port that request vehicle trajectory from VehicleTrajectoryAware, should be 3333

Argument PR: Market penetration rate (change when needed)

Arguemnt OBJ: 0 - objective is to minimize total vehicle delay; 1- objective is to minimize total queue length

MMITSS_MRP_TrafficControllerInterface

There is no argument for this application

MMITSS_RSE_Message_Tranceiver -f /etc/config/wmefwd/bsm_wme.conf

Argument 1: location of the configuration file (e.g. /etc/config/wmefwd/bsm_wme.conf)

OBE:

MMITSS_OBE_BSMData_Transmitter

There are no arguments with this application

MMITSS_OBE_Message_Tranceiver -f /etc/config/wmefwd/bsm_wme.conf

Argument 1: location of the configuration file

Several configuration files need to be constructed before running the applications.

RSE: All the RSE configuration files are located under /nojournal/bin

1. Configinfo.txt

The content of the file should be: /nojournal/bin/ConfigInof_XXXXX.txt where XXXXX is the name of the intersection.

2. Configinfo_XXXXX.txt (XXXXX is the name of the intersection)

   The content of the file will be read from the controller when the applications started.

3. Signal_Config_COP.txt

   The content of the file is the signal parameters of the signal controller including number of phases in use, phase sequence, minimum green time, maximum green time, yellow time, red clearance time, pedestrian walking time and pedestrian clearance time.

4. XXXXX.nmap (XXXXX is the name of the intersection)

   The content of the file is the intersection map description file. Details of how to construct the map and an example map file can be found in (University of Arizona, 2015).

5. DSRC_Range.txt

   The content of the file is the geo-fencing area of the intersection which specifies the length of the extension of map nodes from the reference point for each leg of the intersection.

6. IPInfo.txt

   The content of the file is the IP address and port information for the (virtual) signal controller

7. ntcipIP.txt

   The content of the file is the IP address and port information for the (virtual) signal controller

8. Lane_Phase_Mapping.txt

   The content of the file is the phase mapping to lane in order to calculate requested phase. The value is the phase number. The sequence of the number in line 2 is phase of approach 1 through, approach 1 left, approach 3 through, approach 3 left, approach 5 through, approach 5 left, approach 7 through, approach 7 left. The approach number should match your map. If a phase doesn't exist, put zero, if left turn and through share the same phase, put the same value.

9. nmap_name.txt

   The content of the file is the name of the map description file: /nojournal/bin/XXXXX.nmap

5. Signal Priority

In the field version, the following applications in RSE and OBE need to be run:

RSE:

MMITSS_MRP_MAP_SPAT_Broadcast MAP_IP SPAT_IP LOG

      Arguments MAP_IP: Local host IP for sending MAP to

      Argument SPAT_IP: Local host IP for sending SPaT to

      Argument LOG: 1: log incoming SPaT data; 0: don't log SPaT data

MMITSS_MRP_Priority_Solver –s NETWORK –c INTEGRATION

      Argument NETWORK: -s 1: for congested network; –s 0: for regular network

      Argument INTEGRATION: -c 1: for using signal priority control with actuated control; -c 2: for using signal priority control with I-SIG

MMITSS_MRP_TrafficControllerInterface

MMITSS_MRP_PriorityRequestServer_field –o COOR –c INTEGRATION

      Argument COOR: -o 1: for considering coordination as a form of priority; –o 0: without considering coordination

      Argument INTEGRATION: -c 1: for using signal priority control with actuated control; -c 2: for using signal priority control with I-SIG

MMITSS_RSE_Message_Tranceiver -f /etc/config/wmefwd/spat_wme.conf

      Argument 1: location of the configuration file

MMITSS_RSE_Message_Tranceiver -f /etc/config/wmefwd/art_wme.conf

      Argument 1: location of the configuration file

MMITSS_RSE_Message_Tranceiver -f /etc/config/wmefwd/srm_wme.conf

      Argument 1: location of the configuration file

OBE:

MMITSS_OBE_MAP_SPAT_Receiver

MMITSS_OBE_PriorityRequestGenerator_field

MMITSS_OBE_Message_Tranceiver -f /etc/config/wmefwd/spat_wme.conf

 Argument 1: location of the configuration file

MMITSS_OBE_Message_Tranceiver -f /etc/config/wmefwd/art_wme.conf

 Argument 1: location of the configuration file

MMITSS_OBE_Message_Tranceiver -f /etc/config/wmefwd/srm_wme.conf

 Argument 1: location of the configuration file

Several configuration files need to be constructed before running the applications.

RSE: All the RSE configuration files are located under /nojournal/bin

1. Configinfo.txt

   The content of the file should be: /nojournal/bin/ConfigInof_XXXXX.txt where XXXXX is the name of the intersection.

2. Configinfo_XXXXX.txt (XXXXX is the name of the intersection)
   The content of the file will be read from the controller when the applications started.

3. Configinfo_EV.txt
   The is generated by MMITSS_MRP_Priority_Solver. The file is used whenever there is an EV in the active request table.

4. XXXXX.nmap (XXXXX is the name of the intersection)

   The content of the file is the intersection map description file. Details of how to construct the map and an example map file can be found in (University of Arizona, 2015).

5. IPInfo.txt
   The content of the file is the IP address and port information for the (virtual) signal controller

6. ntcipIP.txt

The content of the file is the IP address and port information for the (virtual) signal controller

7. rsuid.txt

   This file contains the intersection name.

8. InLane_OutLane_Phase_Mapping.txt

   The content of the file is the inlane / outlane mapping to phases in order to calculate requested phase. This file is generated by MMITSS_MRP_MAP_SPAT_Broadcast

9. nmap_name.txt

   The content of the file is the name of the map description file: /nojournal/bin/XXXXX.nmap

10. requests.txt

    The content of the file is the active requests table.

11. requests_combined.txt

    The content of the file is the active requests table.

12. Results.txt

    The content includes the solution of the optimizer whenever the optimizer is called.

13. signal_status.txt

    The content includes 8 numbers that show the status of each phase.

14. NewModel.mod

    The file includes the mathematical model that will be used by optimizer (GLPK).

15. NewModel_EV.mod

    The file includes the mathematical model that will be used by optimizer (GLPK) whenever there is an EV at the intersection.

16. NewModelData.dat

    The file contains the input for the mathematical model.

OBE: All the OBE configuration files are located under /nojournal/bin

1. vehicleid.txt

   The content of the file shows the vehicle ID, vehicle type and vehicle name

2. signal_status.txt

The content includes 8 numbers that show the status of each phase.

3. Intersection_maps.txt

   The content of the file is the list of received maps

4. Intersection_MAP_XXX.txt (XXX is the MAP ID)

   The content of the file is the map description file with MAP ID XXX.

5. psm.txt

   The content of the file indicates all of the active priority requests at the intersection. The first line shows the number of requests. The rest lines are the information of each request such as vehicle id, type, ETA, inlane, outlane, start time of service, end time of service, and vehicle status.

6. ActiveMAP.txt

   The content of the file indicated which intersection the vehicle is approaching and which one it is leaving.

7. busStopsRange.txt

   This file is used only for transit vehicles. It indicated the distance between each bus stop in the route of the bus to the next intersection. The bus stop distance to intersection is important only when it is less than 300 meters.

6. Performance Measurement

In the field version, the following applications in RSE and OBE need to be run:

RSE:

MMITSS_MRP_EquippedVehicleTrajectoryAware PORT SPEED_CO LOG

   Arguments PORT: port that receives BSM, should be 3333

   Argument SPEED_CO: speed coefficient, should be 1.0

   Argument LOG: 1: log incoming BSM data; 0: don't log incoming BSM data

MMITSS_MRP_PerformanceObserver_Field PORT PR SERVER_IP

   Argument PORT: Port that request vehicle trajectory from VehicleTrajectoryAware

Argument PR: Market penetration rate (change when needed)

Arguemnt SERVER_IP: IP Address of the Database Server Machin (change when needed)

MMITSS_RSE_Message_Tranceiver -f /etc/config/wmefwd/bsm_wme.conf

Argument 1: location of the configuration file (e.g. /etc/config/wmefwd/bsm_wme.conf)

OBE:

MMITSS_OBE_BSMData_Transmitter

MMITSS_OBE_Message_Tranceiver -f /etc/config/wmefwd/bsm_wme.conf

Argument 1: location of the configuration file

Several configuration files need to be constructed before running the applications.

RSE: All the RSE configuration files are located under /nojournal/bin

1. Configinfo.txt

   The content of the file should be: /nojournal/bin/ConfigInof_XXXXX.txt where XXXXX is the name of the intersection.

2. Configinfo_XXXXX.txt (XXXXX is the name of the intersection)
   The content of the file will be read from the controller when the applications started.

3. XXXXX.nmap (XXXXX is the name of the intersection)

   The content of the file is the intersection map description file. Details of how to construct the map and an example map file can be found in (University of Arizona, 2015).

4. GeoFence_Range.txt
   The content of the file is the geo-fencing area of the intersection which specifies the length of the extension of map nodes from the reference point for each leg of the intersection.

5. IPInfo.txt
   The content of the file is the IP address and port information for the (virtual) signal controller

6. ntcipIP.txt

The content of the file is the IP address and port information for the (virtual) signal controller

7. Lane_Phase_Mapping.txt

The content of the file is the phase mapping to lane in order to calculate requested phase. The value is the phase number. The sequence of the number in line 2 is phase of approach 1 through, approach 1 left, approach 3 through, approach 3 left, approach 5 through, approach 5 left, approach 7 through, approach 7 left. The approach number should match your map. If a phase doesn't exist, put zero, if left turn and through share the same phase, put the same value.

8. Lane_Movement_Mapping.txt

The content of the file is the movement mapping to lane in order to do the performance observation by movement. The value is the lane number. The sequence of the number in line 2 is lane number of approach 1 right, approach 1 left, approach 3 right, approach 3 left, approach 5 right, approach 5 left, approach 7 right, approach 7 left. The approach number should match your map. If a designated left-turn or right-turn lane doesn't exist, put zero. The sequence of the numbers on line 4 is the arbitrary numbers assigned to each travel time section at intersection. This could be used for comparison and data validation in simulation to be matched with VISSIM travel time sections.

9. nmap_name.txt

The content of the file is the name of the map description file: /nojournal/bin/XXXXX.nmap

7. Pedestrian Application

In the field version, the following applications in RSE need to be run:

MMITSS_MRP_MAP_SPAT_Broadcast MAP_IP SPAT_IP LOG

Arguments MAP_IP: Local host IP for sending MAP to

Argument SPAT_IP: Local host IP for sending SPaT to

Argument LOG: 1: log incoming SPaT data; 0: don't log SPaT data

MMITSS_Ped_Map_Broadcast PHONE_IP

Argument PHONE_IP: IP address of the smartphone

MMITSS_MRP_PedRequestServer PHONE_IP

Argument PHONE_IP: IP address of the smartphone

The following applications in smartphone need to be run:

MMITSS Ped Application

The communication between RSE and the smartphone is through WIFI. A router should be configured and connected to the RSE in the same subnetwork as shown in Figure 2.

10.254.56.197   10.254.56.100   10.254.56.26

| Smartphone | ← – – – – – WIFI – – – – → | Router | ← ETHERNET → | RSE |
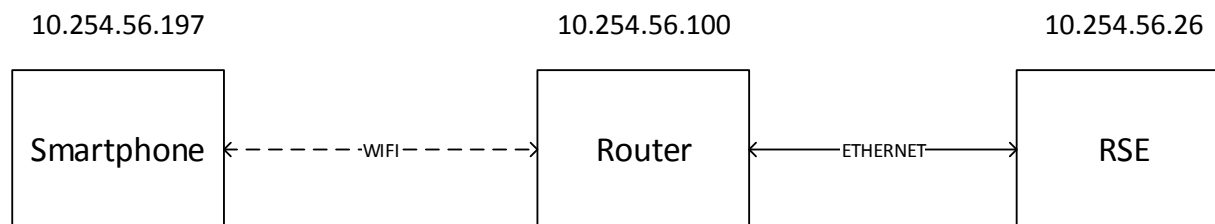
Figure 2 Communication Diagram of MMITSS Pedestrian Application

8. Central System

MMITSS Central System is intended to run on a server in the same network as the roadside equipment. It consists of different file formats including: .sql, .php, .html, .css, and .txt.

The login page is the first page that gets the username and password from the system operator. Currently the credentials are not verified. By clicking the submit button, the operator will be directed to a page with the map of the network on right and list of active intersections on left. For each intersection there is an option for selecting either the configuration page for the signal priority application (N Level Priority Policy) or the performance report page.

The performance Report button directs the operator to a page where they can specify the measurement reports for infrastructure and/or connected vehicles. Some of the fields are not fully functional in this version, for example the split monitoring measures under infrastructure report is not currently implemented since this is typically a traffic signal management system capability. The "Show Metrics" button leads to the next page that shows the visualizations of the selected measures.

9. References

Head, L., Feng, Y., Zamanipour, M., Khoshmagham, S., Khosravi, S., Mucheli, S., 2015. A Multi-Modal Intelligent Traffic Signal System: Architecture, Components, and Implementations. Work. Paper.

University of Arizona, 2015. Multi-Modal Intelligent Traffic Signal System - Detailed System Design. University of Arizona.