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Study and Simulation of Vehicular Ad Hoc Network Modules Using MATLAB

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Abstract— Mobile Ad-Hoc network research has been gaining steam in last few years. Lot of work has been put into devising routing protocols. With the development 802.11p standard dedicated to DSRC, realizing VANETs is very close. As is the case with any system associated with Vehicular design, VANETs also must be tested thoroughly before they are put in real world as the consequences of failing systems are very high in VANETs. There exist a few simulators like GrooveSim which can be used for VANETs but given the popularity and well spread knowledge of MATLAB tool, a simulation environment in MATLAB could be very useful to many researchers. Such environment can be used while designing better MAC protocols, broadcasting schemes, security features in VANETs. Goal of this project is to create a simulation of Vehicular Ad-Hoc network for urban scenario which can be used for testing purposes.

Keywords— MATLAB, Mobility models, Routing, Vehicular Ad-Hoc Networks

I. INTRODUCTION

VANETS are upcoming and promising applications of Mobile Ad-Hoc Networks. They promise vehicle to vehicle interactions for safer transportation, emergency update services during unexpected calamities, efficient traffic routing in urban areas and on freeways for faster transport, routing of packets for infotainment services and much more. A lot of study has been undertaken in this area for last few years. Also the years of research gone into Mobile Ad-Hoc Network will also come to fruition in the form commercial and large scale applications of MANETs when they will be deployed in vehicular systems [3]. VANETs are unique subset of Mobile Ad-Hoc Networks in the sense that the nodes in VANETs strictly follow fixed and regular patterns. The speed and direction of nodes involved is bound by the traffic laws, geometrical and geographical constraints. VANETs also are unique in that the nodes are significantly larger compared to their cellular counterparts. They do not have harsh limitations of the battery size and battery life as vehicular nodes need and consume significant amount of energy for their locomotive operation itself. Hence the energy required for the nodal communication aspect is comparatively very negligible. This presents developers of the VANET systems a unique opportunity to develop an entirely new system that could rival or supplement the already existing cellular system by offering unique and competitive services. With the development of 802.11p version of popular Wi-Fi standard, altered specifically to accommodate the needs of vehicular communication and commercial players like CISCO, NXP AUDI and COHDA systems planning to launch vehicular units from as early as 2014, VANETs are closer to commercial wide scale realization than ever before.

However, VANET research poses peculiar challenges as well, which are totally different from some other existing systems. For example, unlike cellular systems where failure in communication (a blocked call or terminated connection) would reflect at most in user unhappiness, failure of communication between two VANET enabled vehicular nodes sharing critical 'call' about each other's likely near future locomotion, could result in catastrophic results. The vehicular application require impeccable amount of guarantee of service for wide spread use. The main and initial appeal of VANET systems is in notion that replacing warning-response systems currently based mostly on human senses (eyes, ears, muscle reflexes). There is a reason why road-ways vehicle are not allowed to run at speeds of their dedicated-path counterparts. When reliable wireless communication becomes available across machine interfaces in vehicular nodes, the speed of nodes can be increased without loss of safety. The whole set of applications that will be needed to be built around the new eco-system that VANETs will provide. Despite the huge potential of VANET systems, the reach of the field outside enthusiastic research community needs expanding. One major reason for this could be cited as the non-standard multiple tools and resources for development and study. Most of the tools required for VANET study are custom, application specific and have quantized limited reach and awareness. This project aims at demonstrating the utility of popular academic tool-MATLAB. This paper explores the use of MATLAB in exploring few of the interesting modules of VANET study.

II. PROPOSED MODELS

The main goal of this paper was to build simulative models of various VANET system test-cases that are generally built using network simulators without proper GUI support [2]. MATLAB offers rich set of functionalities which reduces the development time for the framework necessary for carrying out tests.

A. VANET Nodes at Intersection of Roads

This model plots intersection of a road with nodes on both the stretches. The nodes on each segment can interact with each other. This model can be used to calculate the Doppler effects due to relative motion between the nodes. This can also be used to estimate the window margins for communication between two nodes on separate roads. This model assumes random points of origin for both the nodes and the nodes can assume independent velocities. In the code built for this model, one inherent problem with MATLAB sequential nature was encountered. As the MATLB allows only 8 parallel threads to be run simultaneously, it was difficult to develop a near accurate depiction of two independent nodes on two separate courses of locomotion. The code was developed exploiting the fact that the computational speed of the each nodal location calculation will be much lower compared to the distance traveled by each node during the encounter. The typical differences was in the order of 10s (nodal encounter window size) to 0.1ms (computational window for each nodal location calculation and update). Thus the sequential nature of the MATLAB code does not affect the accuracy of the model. The simulators used for calculation of nodal locations in mobile networks (VANETs and MANETs) generally use C++ threads in parallel. Though these threads provide accurate location update, the plotting on GUI with given simulators is not as easy as with MATLAB. This marks the interaction of Vehicle-to-Vehicle type. The goal was to demonstrate the utility of sequential MATLAB operation to recreate near real time coordinates despite the lack of parallel computing. The interaction between the two vehicles on a pair of intersecting roads is plotted. The distance between them can be maintained according to the 802.11p. This model plots intersection of a road with nodes on both the stretches. The nodes on each segment can interact with each other. This model assumes random points of origin for both the nodes with independent velocities. Fig.1, Fig.2, and Fig.3 shows the movement of nodes and the interaction between them at different distances on the roads.

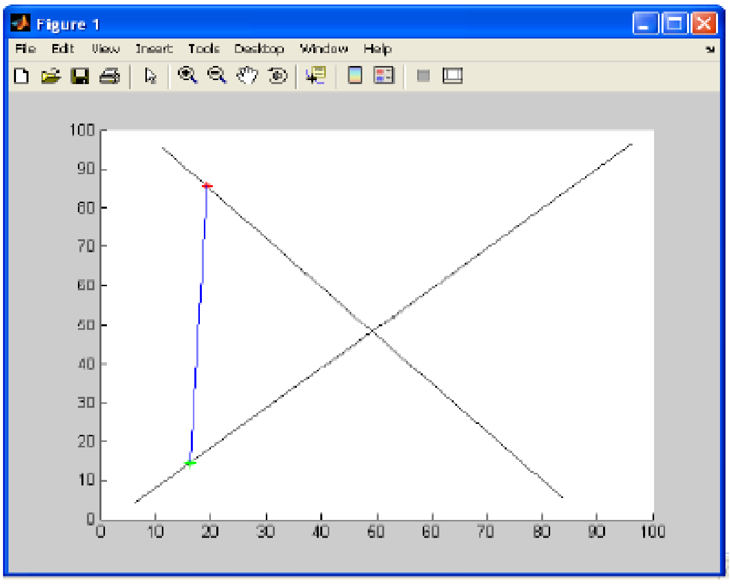

Fig. 1. VANET nodes at intersection of two nodes: Frame A

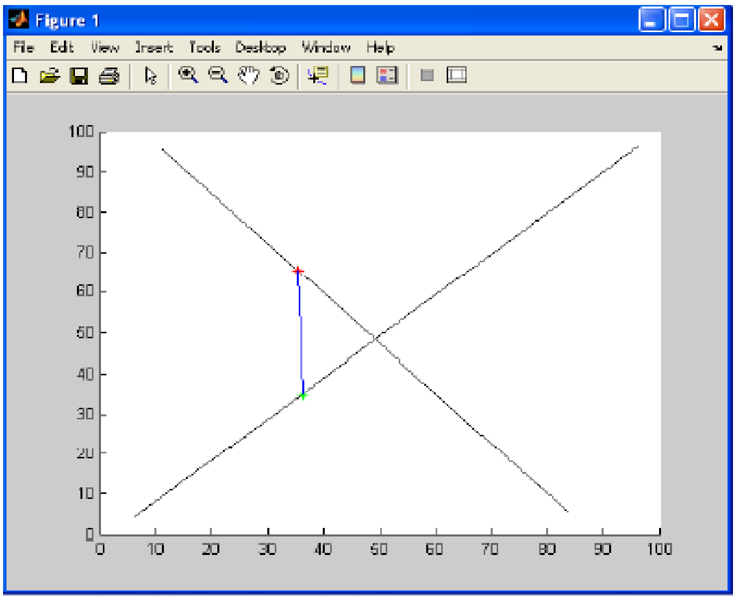

Fig. 2. VANET nodes at intersection of two nodes: Frame B

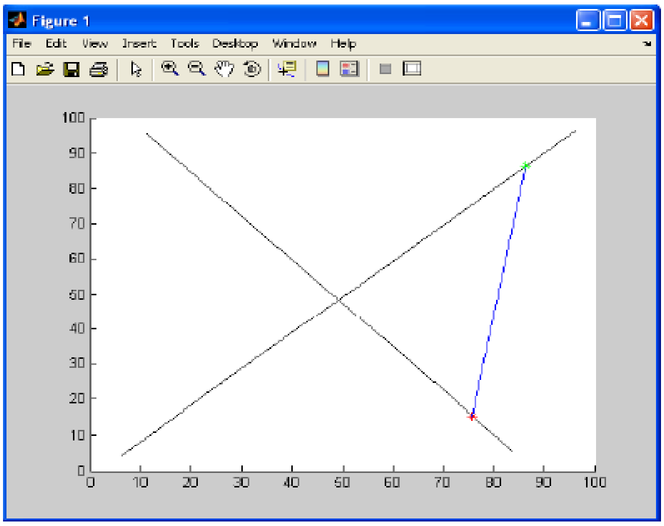

Fig. 3. VANET nodes at intersection of two nodes: Frame C

B. VANET Nodes at Single Road-Side Units

This model is similar to a cellular base station trying to provide range for traveling mobile node [4]. The model allows user to configure the range of the RSU. The communication platform facilitated by this model can be used to test the connection mechanisms between mobile VANET nodes and the stationary RSU which will act as hub or central controller for the given region. This also marks the second type of inter-connection in the VANET system which is Vehicle-to-Infrastructure unit. The figures show the GUIs obtained for VANET nodes entering and leaving the RSU range. Fig.4 shows the vehicle coming in range of the RSU. During this time the RSU can control the vehicle. Fig.5 shows the vehicular node moving away from the RSU range. In Fig.6 the vehicular node is out of the control of RSU.

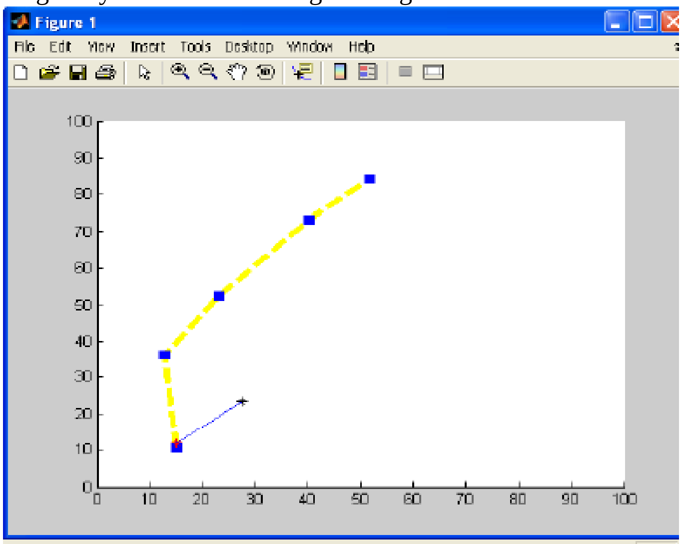

Fig. 4. VANET node entering RSU range

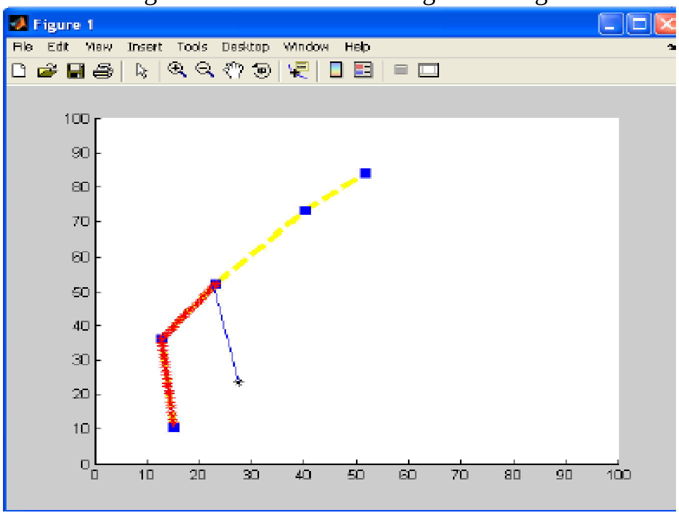

Fig. 5. VANET node leaving RSU range

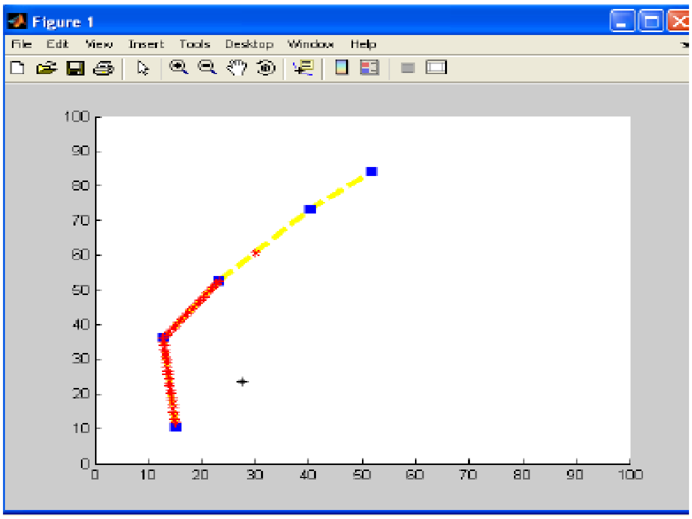

Fig. 6. VANET node out of RSU range

C. VANET Nodes Passing Across RSUs

This is analogous to handover of mobile nodes from one base station to another in cellular networks. However, there are significant differences. There is no central Mobile Switching Center to coordinate the transfer of mobile VANET node from one roadside infrastructure unit to another roadside infrastructure unit. This model could be used to study mechanisms that involve continuous connection maintenance over large distances in VANET systems. The analogous handoff of VANET nodes could be studied using this model. The following figures show the handover of nodes in detail. The analogous handoff of VANET nodes could be studied using this model. The following figures show the handover of nodes in detail. Fig.7 Illustrate nodes moving out of first RSUs range, Fig.8 Shows hand off from first RSU to next and finally Fig.9 Shows the node moving out of the system.

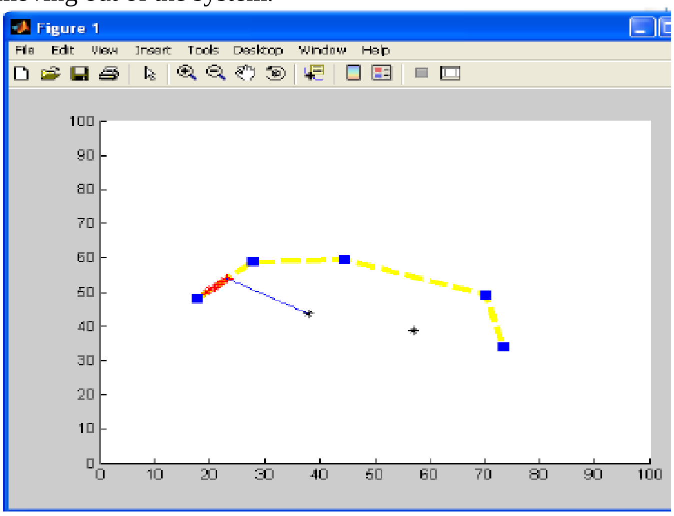

Fig. 7. VANET node moving away from RSU1

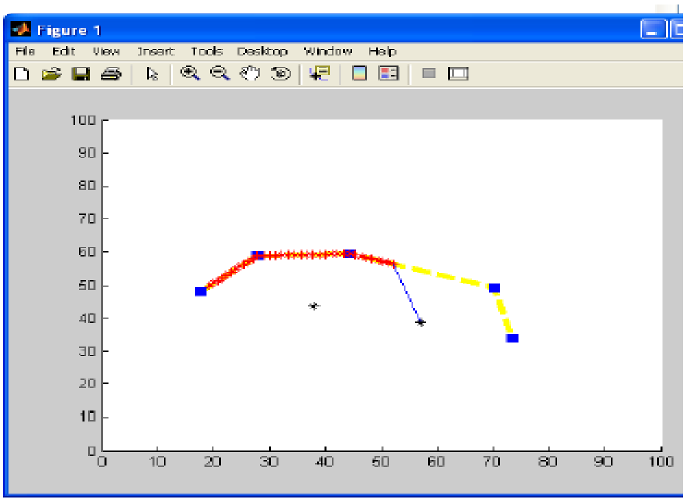

Fig. 8. Completing transfer from RSU1 to RSU2

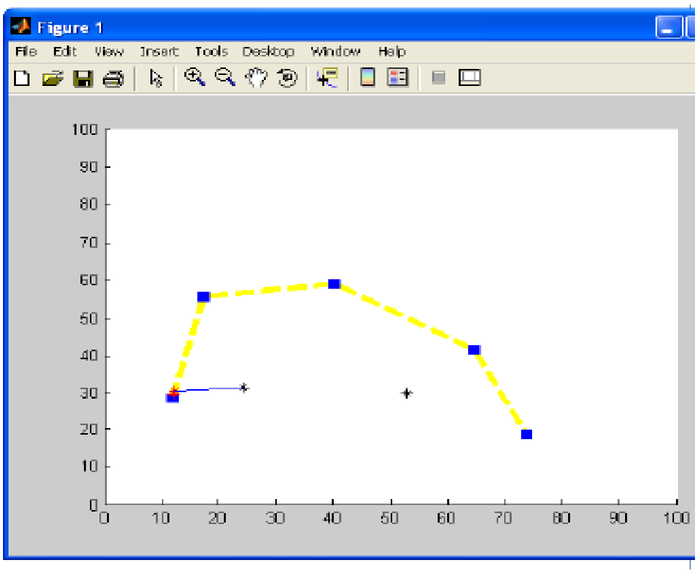

Fig. 9. VANET node out of the system

D. Urban Scale Model and Random Node Generation

This macro scale model doesn't allow user to create a custom road but instead offers an entire network of roads which is modelled and used by the nodes to populate and simulate. The direction of the nodes is randomly chosen at the time of their generation. This Network shows that the models created using MATLAB can be used for studying various aspects of VANET systems. In this model the nodes are formed in rectangular format representing the house on the block. This model offers an entire network of roads which is modelled and used by the nodes to populate and simulate. The rectangular roadway structure is occupied by nodes which are generated using in-built random function in MATLAB. Fig.10 is an urban scenario which consists of 200 nodes. Fig. 11 consists of 500 vehicular nodes whose direction is chosen randomly at the time of generation.

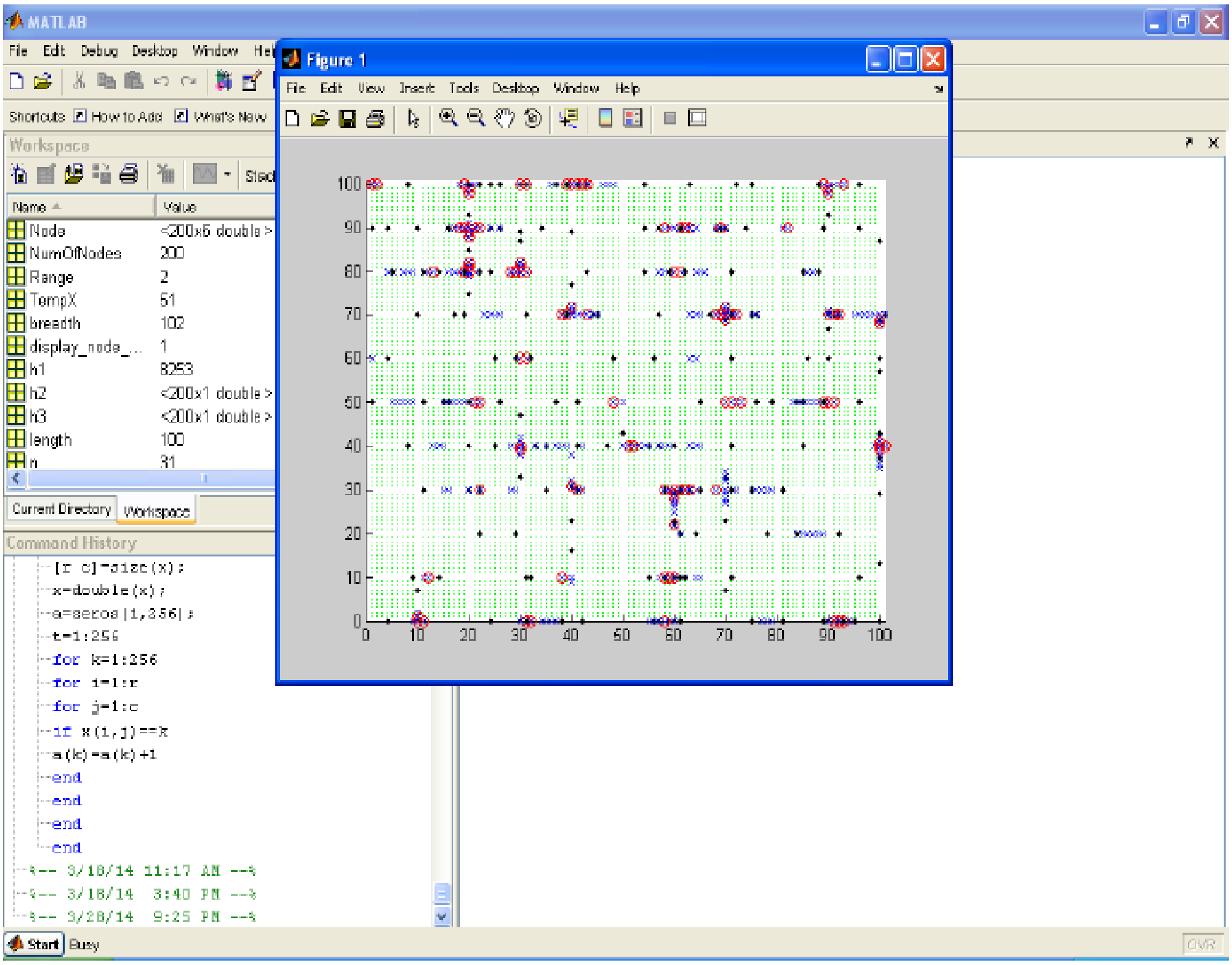

Fig. 10. Urban structure with 200 nodes

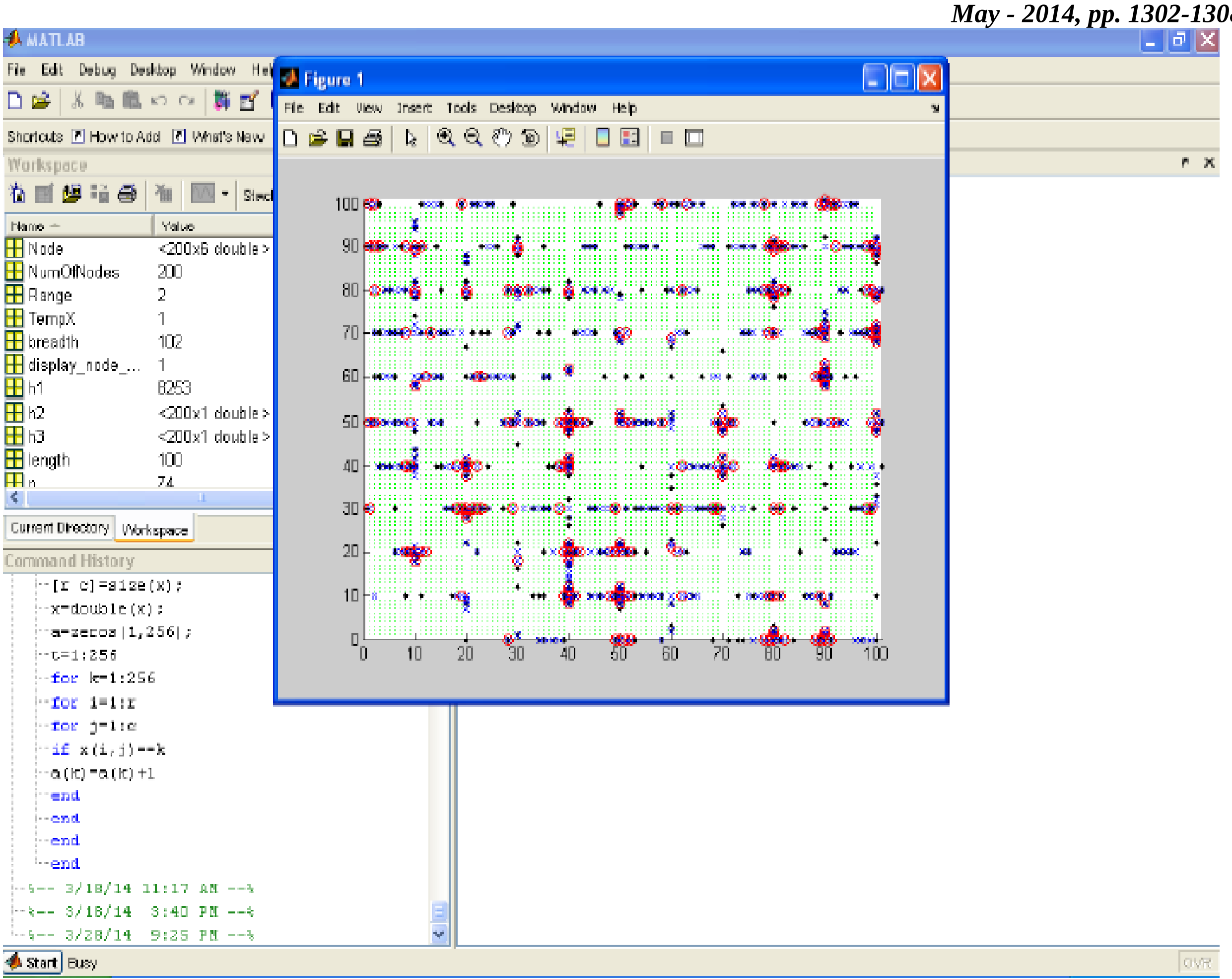

Fig. 11. Urban structure with 500 node

III. Summary And Evaluation

There are various tools available for study of VANET mobility like Fleet Net from Daimler Chrysler which used simple Wi-Fi based interface with framework data provided from real world systems, NHTSA (National High-way Traffic Safety Application) simulator, Clarion simulator and many more. The advantage that MATLAB offers is that it is widely available, continuously updated and has wider reach. The lack of real parallel threads as it was observed does not diminish the utility of the tool for building up models for VANET system tests.

Also the mobility and generation topologies for various models are already available for MATLAB which can be made use of to save development time. As the majority of tools available at present do not have the ease and widespread reach, using MATLAB offers unique advantage over other systems.

IV. Conclusions

There are various tools available for study of VANET mobility like FleetNet from Daimler Chrysler which used simple Wi-Fi based interface with framework data provided from real world systems, NHTSA (National High-way Traffic Safety Application) simulator, Clarion simulator and many more. The advantage that MATLAB offers is that it is widely available, continuously updated and has wider reach. The lack of real parallel threads as it was observed does not diminish the utility of the tool for building up models for VANET system tests. Common scenarios of VANET nodal locomotion were identified and simulated for this work. The entire code length for all models combined was 300 lines of MATLAB code. The simulative models developed could be used as a basis for further tests.

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