Design and Simulation of a Mobile Ad-hoc Network in HLA Environment

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Abstract: - This paper presents a generalized design for MANET simulations to support any kind of widespread adoption, and standardized to allow universal interoperability, along with flexibility to permit runtime extension of its ontology. Traditional network simulation models often lack these desirable properties. IEEE's standard 1516 for simulation and modeling fulfill the need for a standard of the kind that has these desirable properties. MANET simulations always require simulated environment provided by some tools like OMNET, OPNET and NS2. Making such simulations HLA compliant, HLA Federation rule 3 depicts need of direct interfacing of federates with RTI. However, HLA doesn't address how this interfacing will be done. Proposed interface between MANET nodes and RTI is provided; each MANET node present in the OMNET is wrapped by the HLA layer. This approach will be incredibly beneficial for the researchers those are designing HLA based simulations in which MANET plays an active role and performance of MANET may affect overall simulation results e.g. mobile radar and disaster management simulations.

Key-Words: - HLA, OMT, RTI, MANET

1. Introduction

IEEE standard 1516 describes High Level Architecture (HLA) that provides a general framework within which simulation developers can structure and describe their simulation applications. In particular, HLA addresses two key issues: promoting interoperability between simulations and aiding the reuse of models in different contexts. Two main components are described within the set of products forming the HLA. The first is the Object Model Template (OMT), which forms a documentation standard describing the data used by a particular model, a necessary basis for reuse. The second component, the Federate Interface Specification, describes a generic communications interface that allows simulation models to be connected and coordinated, thus, addressing interoperability. HLA is a framework, not the software, use of Runtime Infrastructure (RTI) software is required to support operations of a federation execution. The RTI software provides a set of services, as defined by the Federate Interface Specification, used by federates to coordinate the operations and data exchange during a runtime execution [1]. Many real applications require a distributed network enabled modeling and simulation setup. A novel infrastructure is developed in which all components of

the simulator are HLA compliant. HLA was designed as component integration standard for cooperating distributed simulations [2]. This is a middleware standard for sharing information between distributed simulation components. It can acts as communication infrastructure for an enduring network of shared virtual simulations. All simulation based on HLA can interoperate effortlessly [3] [4]. Whereas, a mobile ad hoc network (MANET) consists of a group of mobile wireless nodes that self-configure to operate without infrastructure support. Network peers communicate beyond their individual transmission ranges by routing packets through intermediate nodes [5] [6]. Computer simulation is the most popular way to evaluate MANET protocols [7] [8]. Simulation of MANET offers four important advantages: First, it enables experimentation with large networks. Second, it enables experimentation with configurations that may not be possible with existing technology. Third, it allows for rapid prototyping: by significantly abstracting the complexity of the real system, simulators enable the development and debugging of new protocols with reduced effort. Finally, it makes reproducible experiments in a controlled environment possible. MANET has been proposed for scenarios such as disaster relief, police, and military applications, which take place in complex obstacle-rich indoor environments.

OMNET a discrete event simulation environment, its primary application area is the simulation of communication networks, but because of its generic and flexible architecture, it is successfully used in other areas like the simulation of complex IT systems, queuing networks or hardware architectures. OMNeT provides component architecture for models. Components (modules) are programmed in C++, and then assembled into larger components and models using a high-level language.

Integrating a simulation tool with HLA can help, making distributed mobile network enabled simulations, like battle field simulations, satellite system based simulation, tracking system based simulations, radar system based simulation, disaster management based simulations etc.

2. Problem Statement

Most of the distributed network simulations developed so far are platform and language dependent. Normally simulations are compatible with those simulations that are developed in the same language and same platform. Many of the network simulators are available like OMNET, PARSEC, SMURPH, NS, Ptolemy, NetSim++, and C++SIM, CLASS as non-commercial, and OPNET, COMNET III as commercial tools, but all of these do not allow communication with other simulations running on a different simulation environment. In case of a simulation in which there is a need to simulate a MANET, available choices are these simulators. Interoperability and reusability features can only be achieved by making this simulation HLA compliant. The problem is that HLA does not address how to provide interface between participants of a simulation (federates) that belong to a simulation tool with RTI. From HLA specification, it is clear if all the communication from simulations is not through the RTI then simulation is violating Federation rule 3 of HLA specification. This paper presents an infrastructure design for making

MANET based simulations HLA compliant.

3. Objective

To provide a communication interface between RTI and Federates running under different platforms and developed in different languages, that will help us in simulating large and special kind of networks especially MANET. To present an infrastructure design for making MANET based simulations HLA compliant.

4. Solution

Keeping in mind above mentioned problems, there is a need of a flexible and reliable mean of communication. The HLA layer around each federate running on OMNET (MANET Node) enables it to communicate directly with RTI. In Figure 2, MANET nodes have HLA wrapper around them that makes them act as Federates, thus they can communicate with other federates directly through RTI. According to the design MANET node consists of 5 layers as shown in figure 1: Application layer, Routing layer, MAC layer, Physical layer, Mobility layer. Physical layer handles issues regarding transmission media for instance channel error, channel data rate, channel delay and power of mobile host. It is also responsible for dynamic creation of gates that allow messages between the layers and with other hosts as well. Mobility layer decides what will be the new location for mobile host on basis of particular mobility model. MAC and Routing layers only have the simple function of passing messages to the corresponding layers. Class diagram depicts that Application layer is inherited from BaseFederateambassador class and cSimpleModule class. First class provides RTI based functioning while second class provides functioning related to OMNET architecture. So simulating MANET in HLA environment requires software architecture mention in class diagram in figure 3. Steps those are required are as follows: 1. Inherit core class of application from BaseFederateambassador and CSimpleModule class. 2. Implement virtual function present in abstract class of CSimpleModule i-e Activity () or HandleMessage() 3. run RTI first, then your application now application will be able to communicate with RTI retaining its presence in OMENT.

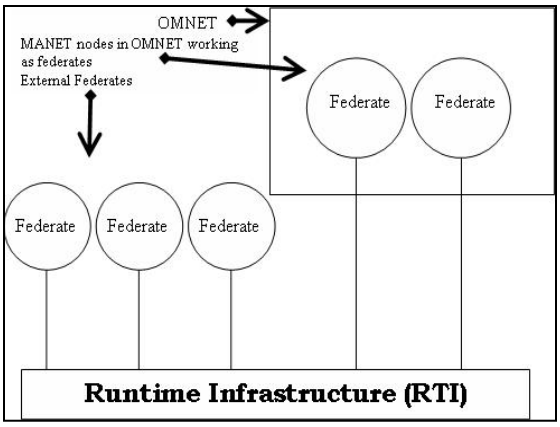

Figure 2: Federates inside MANET has direct interface with RTI

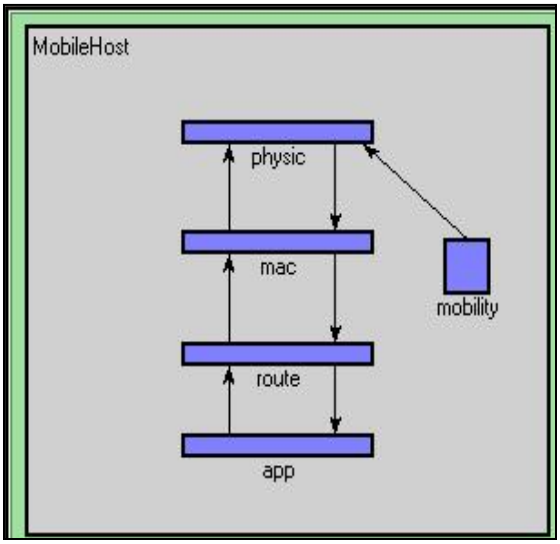

Figure 1: MANET Node Layers

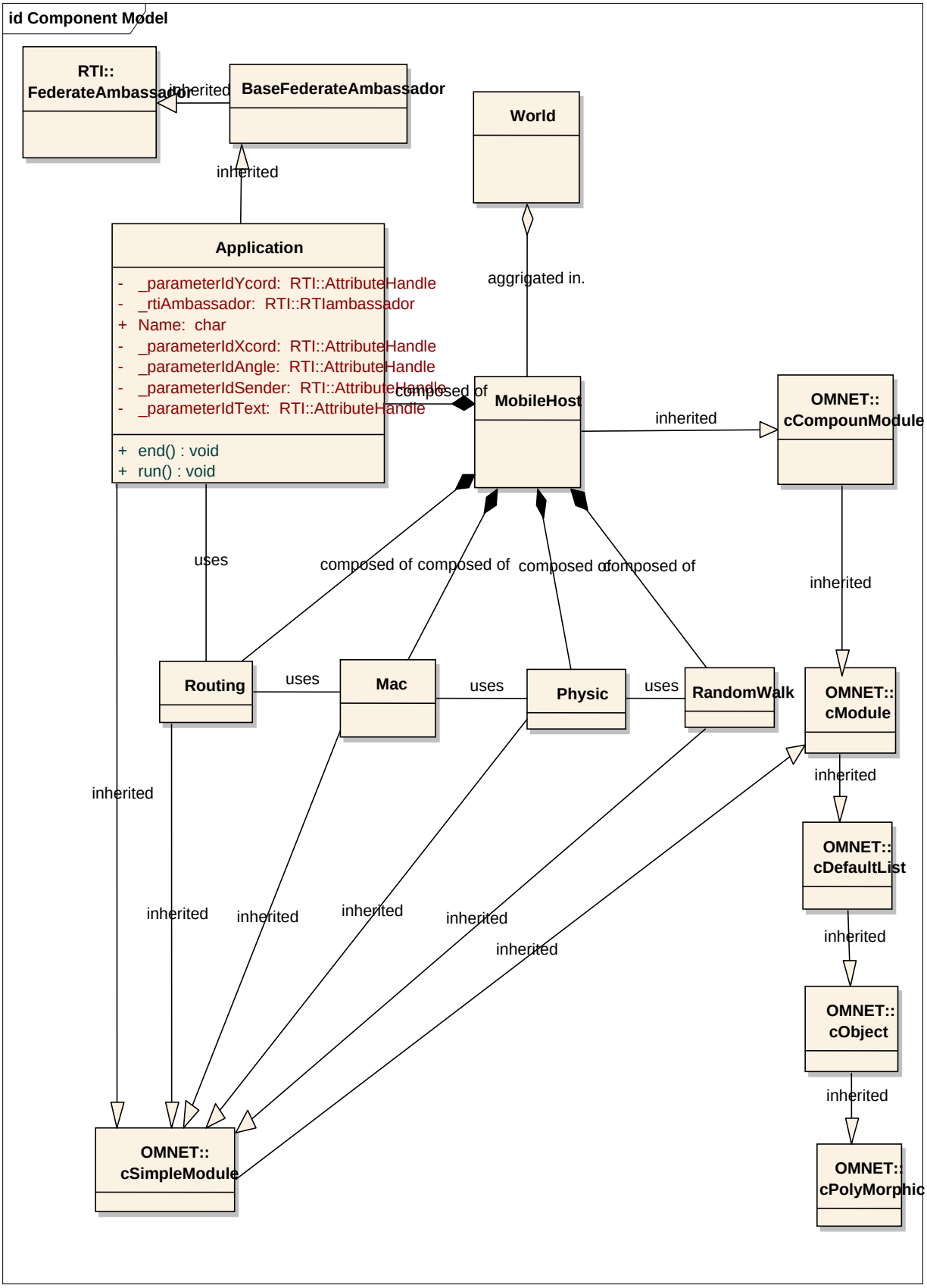

Figure 3: Class Diagram that depicts minimum inheritance hierarchy required for HLA compliance

5. Country Wide HLA Compliant Mobile Radar Simulation A design Example

This Design can be used for several real time simulations especially in the area of battle field simulations. Consider a scenario where we have multiple radars deployed in various border areas of the country. These radars are used to keep eye on activities in their vicinity. Information about normal activities are not required to send higher authorities for taking appropriate action in response. But abnormal activities (e.g. arrival of an invader) need immediate action by the authorities. Now Communication media and network of devices based on troop's formation is a major focus of the simulation. To test network architecture specifying communication media characteristics designers and researchers have to use available simulation tools for networks like OPNET, NS2, OMNET etc. Moreover, simulation requires standardization that comes with its compliance to IEEE's standard of simulation & modeling. Designers have to make simulation entities (radars in this scenario) as HLA Federates by giving these entities an interface with RTI. In above mentioned scenario based simulation, designer has to interface these radars (present in simulation tool) with RTI, so that information can be sent to the higher authorities through RTI. In case of fixed radars existing design [10] can be used in simulation, but if these radars are mobile and they are changing their location then only new design solves the purpose. If a situation arises where two Jets reach within the vicinity of two different mobile radars then this abnormal activity should send to the higher authorities so they may take action against them. This information should be sent through RTI according to the HLA requirement. These mobile radars interfaced with RTI reports the arrival of these Jet planes to the RTI which is responsible to send information to the interested federates (commanders). Federates (The decision makers or commanders) can in turn take appropriate decision and float the information back to RTI which is again responsible of handing over this information to interested federates(weapons or interceptors). Through this infrastructure design there is no wastage of time even if thousands of the mobile radars are deployed in the battle field simulation.

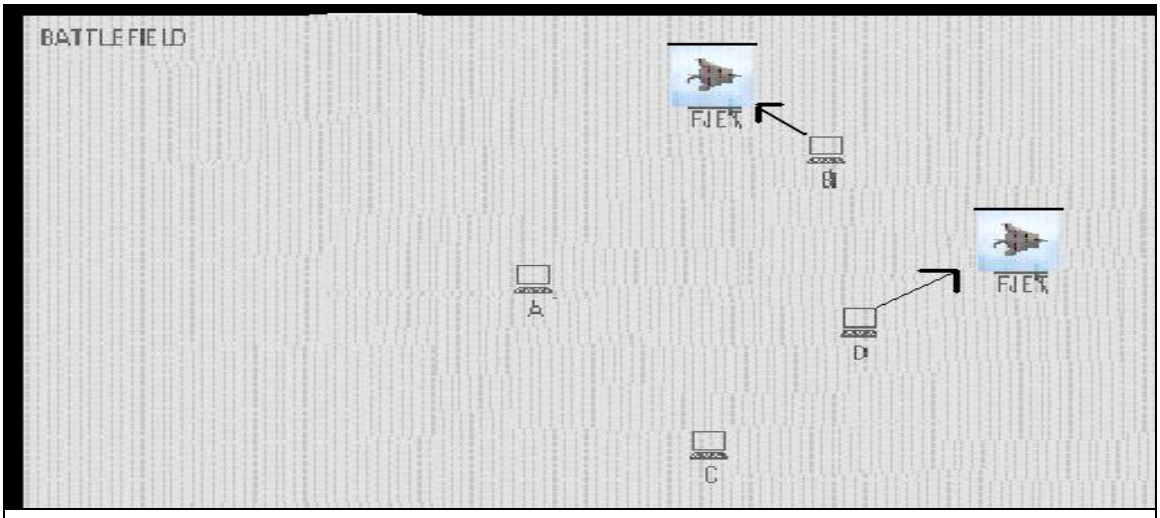

Figure 4: Mobile Radar Simulation

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