A Study on Various Simulation Tools for Wireless Sensor Networks

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***Abstract*— Wireless sensor network refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSN (Wireless Sensor Networks)is mainly used to measure environmental conditions like temperature, sound, pollution levels, wind speed and direction, pressure, etc.**

The wireless sensor nodes gather the data from the sensing field and send the information to the end user. These sensor nodes can be deployed on many applications. Current wireless sensor network is working on the problems of low-power communication, computation, energy storage, and sensing. Sensor nodes are usually attached to microcontroller and are powered by battery. Simulation is essential to study WSNs, which is the common way to test new applications and protocols in the field Protocols, schemes, even new ideas can be evaluated in a very large scale.. This leads to the recent boom of simulation tool development.

***Index Terms*— Wireless Sensor Network, NS2, J-Sim, OPNET, MATLAB, QualNet, TOSSIM**

I. INTRODUCTION TO WIRELESS SENSOR NETWORK SIMULATORS

A) Network Simulator 2 (ns-2)

The Network Simulator version 2 (ns-2) was developed in the University of Berkeley, CA, USA. NS2 is an object-oriented, distinct event driven network simulator that simulates a variety of IP networks, written in C++ and OTcl languages . It is primarily useful for simulating local and wide area networks(WANs). It can be implemented using network protocols such as Transmission Control Protocol(TCP) and UDP, traffic behavior such as File Transfer protocol(FTP), Telnet, CBR and VBR, router queue management mechanism such as Drop Tail , CBR, routing algorithms etc. NS2 implements multicasting and some of the MAC layer protocols for Local area network simulations. NS2 is mostly used to develop tools for simulation results display, analysis and converters which convert network topologies to NS2 formats. [2]

B) Java Simulator (J-Sim)

The Java Simulator (J-Sim), developed by the Ohio State University, USA and its construction is based on the Autonomous Component Architecture. This simulator uses two languages, Java and OTcl(Object Tool Command Language). J-Sim is component-oriented, so the basic entities are components that communicate with each other via send/receive data through ports. Ports are also components whose behavior is defined by another component named contract. J-Sim also provides a script interface that allows integration with different script languages such as Perl, Tcl or Python. [1]

C) OPNET

OPNET is a high level event based network level simulator. Simulation operates at "packet-level and it was originally built for the simulation of fixed networks. OPNET contains a huge library of accurate models of commercially available fixed network hardware and protocols .The simulator has lot of potentiality, but there exists typically a lack of recent wireless systems. OPNET can be used as a research tool and also as a network design/analysis tool (end user). The threshold for the usage is high for the developer, but its low for the end user.

D) MATLAB

MATLAB is a software package for high-performance numerical computation and visualization.It is a product of The MathWorks, Incorporated. MatLab provides an interactive environment with hundreds of built-in-functions for technical computation ,animations and graphics. MATLAB's built-in functions provide excellent tools for linear algebra computations, signal processing, optimization ,data analysis, and many different types of scientific computations .[4]

E) QualNet

QualNet is a planning, training and testing tool that "mimics" the behaviour of a real communication network. QualNet provides a comprehensive environment for designing protocols, creating and animate network scenarios, and analyzing their performance. QualNet can be used effectively to enable users for designing new protocol models, optimizing new and existing models, designing large wired and wireless networks using pre-configured or user-designed models, analyzing the performance of networks and performing what-if analysis to optimize them.

F) TOSSIM

TOSSIM (TinyOS mote simulator) is a distinct event simulator for TinyOS sensor networks which is part of the official TinyOS package. TOSSIM takes advantage of the component based architecture of TinyOS by integrating it transparently ,providing a new hardware resource abstraction layer that simulates the TinyOS network stack at the bit level for normal personal computer. Due to this approach, from low-level protocols till top-level applications can be simulated with TOSSIM. TOSSIM has got an external communication system so that transmitted packets can be monitored and new packets can also be injected to network.

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Moreover, the configuration of the debug options is fine grained that provides the desired debug output at runtime. TOSSIM offers three network connectivity models: simple , static and space connectivity. Furthermore,the running simulations can be visualized and controlled by the Java-based GUI TinyViz[5].

II. CRITERIA FOR SELECTING GOOD WSN SIMULATOR

1. Reusability and availability
   Simulation is used to test novel techniques in realistic and controllable scenarios. Researchers usually are interested in comparing the performance of a new technique against systems.
2. Performance and scalability
   Performance and scalability is a major concern when facing WSN simulation. The performance usually bounded to the effectiveness of programming language. Scalability is constrained to the memory, processor bounded to the programming language effectiveness.
3. Support for rich-semantics scripting languages in defining experiments and process results
   The large amount of variables involved in the definition of a WSN experiment requires the use of specific input scripting languages, having high-level semantics. Large quantities of output data will also be generated through many replicas of the experiments. Therefore, a suitable output scripting language, which helps to obtain the results from the experiments efficiently, is recommendable.

3. COMPARITIVE STUDY ON VARIOUS SIMULATORS

S.NO	SIMULATOR	MERITS	DEMERITS
A)	Network Simulator 2 (ns-2)	* It supports protocol stack for all layer functions. * The cost of simulation is less because of open source *It also allows modifying and customizing the codes easily by the researchers.	*Difficult to understand and write. *More complex and time-consuming. *Provides a poor graphical support with no Graphical User Interface (GUI)
B)	Java Simulator (J-Sim)	*Good reusability and interchangeability. *Can support data diffusions, routings and localization simulations in WSNs *Can simulate radio channels and power consumptions in WSNs. *Provides a GUI library *Independent platform *Can simulate larger number of sensor nodes, around 500 *Can save lots of memory sizes.	*Relatively complicated to use. *The execution time is much longer than that of NS-2
D)	OPNET	* Has a lot of potentiality *Model parameters can be changed	*OPNET is not open source software. *Scalability problems are introduced due to Object-oriented design of OPNET.
E)	MATLAB	*Programming capability *Very easy to learn and to use *Allows user-developed functions	*Due to high level of abstraction, only coarse energy consumption evaluation can be expected
F)	QualNet	*Due to its modular design and GUI facility, Qualnet is easy to learn and modify.	*It will be available only for commercial usage
G)	TOSSIM	*Provided as Open Source and online documentation *Graphical User Support (Tiny ViZ) *Simple and powerful emulator *Support thousand of Nodes	*Energy consumed by different hardware, software and firmware components of a WSN node cannot be measured.

CONCLUSION

Simulation tools are broadly used in checking the algorithms and protocols for the tentative analysis due to the rapid prototyping and tackling of large scale systems. Emulators can be used by researchers after simulation to verify that the intended application working as per the specifications and requirements. Emulators embed hardware with the software applications and simulates in real-time environment. But emulator approach is considered as relatively difficult because it uses the complete profiling requirements of components and protocols involved in the application. Due to these drawbacks of simulators and emulators, the performance can be evaluated by using WSN test beds before applying them into real world environments. To enhance the lifetime of the WSNs the other experimental tools for data visualization, debugging, code updating /reprogramming and network monitoring are also used before or after real implementation.

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