Multiple Sensing Application on Wireless Sensor Network Simulation using NS3

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Abstract. Hardware enhancement provides opportunity to install various sensor device on single monitoring node which then enables users to acquire multiple data simultaneously. Constructing multiple sensing application in NS3 is a challenging task since numbers of aspects such as wireless communication, packet transmission pattern, and energy model must be taken into account. Despite of numerous types of monitoring data available, this study only considers two types such as periodic, and event-based data. Periodical data will generate monitoring data follows configured interval, while event-based transmit data when certain determined condition is met. Therefore, this study attempts to cover mentioned aspects in NS3. Several simulations are performed with different number of nodes on arbitrary communication scheme.

1. Introduction

Wireless Sensor Network (WSN) consists of a finite set of devices that have capability to sense surrounding condition and communicate to each other using wireless medium. These devices collaboratively exchange sensor data, and forward to sink node. According to [1], the device is known as mote which is autonomous, compact and have communication and computation capability. By installing these devices, user is able to get actual condition by looking into capture data. Several works have shown important roles of this technology such as garbage monitoring [2,3], and agriculture [4,5]. Those applications involve distributed nodes in large area. While, more simplistic and locale monitoring scheme is presented in [6] where nodes are installed to monitor temperature and humidity of office building via ZigBee networking protocols.

Latest hardware technology have enabled users to perform multiple monitoring task by providing several sensor instruments on single device. These sensors have various capture abilities depending on users’ requirement. This breakthrough is achieved by providing plug-and-play support of different sensors on board. Each sensor is installed on a board, and can be stacked each other. This is typical implementation on Arduino, and Raspberry Pi.

Regardless of mentioned contribution, this study aims to simulate multiple-sensing application in wide area using NS3. Simulation is still important stage to model nodes behavior prior to real deployment. Therefore, this study attempts to provide better view on NS3 classes to perform the simulation. A number of sensing devices are installed on each node in order to capture different reporting schemes, such as periodic and event-based.

Following section in this paper is organized as follows: section 2 discusses previous works conducted on Wireless Sensor Network, and NS3. Sequentially, section 3 provides system assumption that is used on simulation process. Implementation of sensing node, and conclusion are given in section 4, and 5, correspondingly.
2. Related Studies

Numerous WSN implementation have been studied by researchers in last decade. WSN has been widely applied on different area of application, such as military, environmental, logistics, human-centric, and robotics application [1]. The wide variety of implementation primarily depends on sensor usage on different context. For instance, WSN usage on military extents from information collection to enemy detection, surveillance on battleground, or target classification [7,8]. The classification method relies on seismic, and acoustic signal sensing as input data. Another example as described in [9] where sensor network aids the user by informing relative position and movements of the enemy units.

In environmental monitoring, WSN has played several roles not only in indoor and outdoor monitoring, but also emergency services. One example of indoor monitoring have been provided by [10] in which researchers and graduate students have utilized motes to monitor light and temperature condition. The sensors have capability to capture temperature, light, frames status (doors, windows), air flows, and indoor pollution. Consequently, indoor environment control can be optimized. More sophisticated application is written in [1] where WSN may support nature disaster mitigation effort. Author of this study can integrate fire and smoke detection system with light signals. This composition produces safety guidance for residents during fire accident. The collaborative sensor network can aid people to find safest route to escape the building.

Outdoor monitoring has shown common implementation area for WSN besides indoor monitoring. WSN implementation in [11] has enabled people to observe animal habitat remotely. Compared to indoor, outdoor monitoring has wider region and intended to sense temperature, barometric, pressure, as well as humidity condition. Furthermore, passive infrared sensors and photoresistors are used. This combination is intended to natural environment of one bird species. To achieve this, sensor nodes are distributed near birds’ burrows, and its surroundings. Bird’s spawn data are aggregated by nodes and passed through to a gateway. The sink node has more powerful ability such as data compilation and forwarding to local base station as database. Finally, people may access the surveillance information from database via internet. This shows WSN monitors in heterogeneous way, and multi-level network.

Prior to real life deployment, WSN demands good preparation in order to obtain efficient effort. Therefore, some studies make use of network simulator such as NS-3 [12] to substitute TinyOS application [13]. Initially entitled as Yet Another Network Simulator, NS-3 has gained attention of researchers due to its extensible and robustness property. This simulator has motivated [14] to do benchmarking on a number of open source network simulator frameworks. According to the study, NS-3 requires much less memory usage, and computational time than 4 other frameworks. Since then, many works have been accomplished with the help of this framework. Author of [15] proposes enhancement on physical layer to maximize WSN utility. The study modified typical NS-3 implementation of physical layer to give more accurate and detailed representation of signal. It further claims that completed work is able to conduct all signal processing steps which occur during transceiver frame decoding.

3. System Model

This study environment uses a number of sensing nodes with equal attributes such as computation ability, limited energy capacity, and wireless transmission range. Additionally, these nodes are equipped with environment sensor device, and able to directly transmit data to single base station (BS) node. Contrast to sensing nodes, BS acts as sink node that accepts any monitoring data from sensing nodes. These data will be aggregated by application type and stored in local storage for future user’s needs.
Figure 1. Network Topology used

Figure 1 depicts network topology used in this study. Sensing nodes (SN) are deployed randomly throughout area \((r \times r)\) and able to deliver packet to one BS node which is located in simulation area. These nodes are configured to deliver monitoring data according to its availability. While periodic data are produced in regular fashion, event-based are obtained occasionally. Therefore, each sensing nodes are expected to transmit periodic data, at least. If there is event occurs, then the data will be transmitted together with periodic ones. To achieve this, packet transmission rate in simulation needs to be configured to follow certain distribution. This study uses uniform random distribution. Periodic data have shorter delay transmission, in contrast event-based ones have longer. These intervals are determined in initial phase of simulation.

Communication among these nodes are established using WiFi standards (802.11). These nodes have wireless transmission coverage with \(r\) distance. Furthermore, wireless propagation delay and loss are set to constant and fixed RSS, correspondingly.

4. NS3 Implementation

A set of operation in NS3 must be followed to begin new application development. Main application SensorNodeApplication serves as model application, while SensorNodeHelper is provided to ease SensorNodeApplication instantiation. These files are located in model and helper folder, respectively. To complete this new application setup in NS3, wafscript file needs reconfiguration to accommodate proper .waf compilation process. Brief sensing node class diagram is provided on fig. 2.

Sensing node implementation in NS3 can be achieved by adopting existing OnOffApplication model due to its basic functionality of sending and receiving packets based on certain distribution. Each sensing node are deployed randomly, initially configured its packet interval and technical capabilities from main class. Since this study deals two types of sensing application, two uniform random generators are used during sensing node’s lifetime. Method AssignStreams is written to handle random number generation. During its initial operation, within StartApplication to be exact, some of event handler such as accepted (HandleAccept), closed (HandlePeerClose), failed (HandlePeerError) and incoming connection (HandleRead) are registered and packet transmission is scheduled.

NS3 provides scheduling mechanism in which programmer may instruct specific upcoming task/event occurrence. Interestingly, NS3 also enables programmer to cancel this schedule. By utilizing this features, different sensing application are preconfigured its transmission time according to random generator. This task is handled by SchedulePeriodicData and ScheduleEventData function for periodic, and event-based data, respectively. Additionally, schedule cancelation needs to be carried out to accomodate either unexpected or scheduled
stop, such as power outage, and Simulation::Stop call. In our simulation, this is handled by CancelEvents.

NS3 simulation is began with constructing main application which acts as entry execution point. In this file, set of operation is conducted which extent from random number seed generation, nodes creation, wireless physical, and medium layer configuration, speed and range propagation loss setup, to IP address assignments. After this setup completes, SensorNodeApplication is created and embedded to each nodes and schedule simulation start and end time. Finally, any packet generated from these sensing nodes are consumed by BS which is implemented using PacketSink application.

Finally, after successfully constructing the sensing nodes, main application for running experiments is prepared. In this last step, several steps are done such as wireless environment, wireless device setup, simulation timing, and trace file configuration. In wireless environment and device setup, loss and delay propagation as well as channel properties are set. Meanwhile, nodes setup includes NetDevices, Internet suite protocol, location, and energy installation step. At last, to capture any actions done in simulation, trace file and NetAnim instance are prepared.

5. Conclusion

In this article, sensing node with multiple sensor instruments are developed by using NS3 framework. The provided class diagram is constructed based on existing OnOffApplication with several modifications, such as event-based and periodical scheduling, and incoming packet handling. Whereas, constant mobility, and energy source, and consumption model are configured in main simulation class.

Due to NS3’s modularity, future simulation with different strategies and attributes are possible to achieved. WSN nodes with movement capabilities and various energy consumption model provide many research possibility. These area requires good strategy to keep entire system last longer.
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