# Analysis of Energy Efficiency in WSN by Considering SHM Application

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**Abstract:** The Wireless Sensor Network is composed of a significant number of autonomous nodes deployed in an extensive or remote area. In WSN, the sensor nodes have a limited transmission range, processing speed and storage capabilities as well as their energy resources are also limited. In WSN all nodes are not directly connected. The primary objective for all kind of WSN is to enhance and optimize the network lifetime i.e. to minimize the energy consumption in the WSN. There are lots of applications of WSN out of which this research paper focuses upon the Structural Health Monitoring application in which 50 Meter bridge has been taken as a test application for the simulation purpose.

**Keywords:** Castalia, Routing Protocols, SHM, WSN.

## 1. INTRODUCTION

Wireless Sensor Network is the wireless network which is the combination of autonomous sensors to monitor or control environment conditions like temperature, pressure, humidity, motion, heat, sound, light, electromagnetic field, vibration, images, pollutants etc.[1-7].The popularity of WSN has increased due to growth in Micro-Electro-Mechanical Systems (MEMS) technology. The concept of wireless sensor network is based on a simple equation: Sensing + CPU + Radio = Thousands of potential applications [8].There are limited resources like energy, size, memory, computational power, communication range, bandwidth in a sensor node. There are large no of sensor nodes which are distributed over an area of interest for collecting the information. So these nodes communicate with each other either directly or through intermediate nodes and thus form a network. So each node works as a router.

The concept of routing is to provide the path or route between sources to sink via intermediate nodes. The motive of the routing in the network layer is to find out the minimum cost path for the packets from source to the sink. Routing protocols specifies how routers (sensor nodes) communicate with each other. Routing algorithm chooses the routes between nodes. If WSNs nodes are more powerful in terms of their computation and communication resources, then it is beneficial to utilize for complex algorithms and as gateways to other networks. [9].

## 2. STRUCTURAL HEALTH MONITORING

Structural health monitoring as the name indicates it estimates the state of structural health by detecting the changes in structure that affect its performance. There are two major factors like time-scale of change and severity of change. Time-scale means how quickly the changes occur, and severity is the degree or amount of change. There are two major categories of SHM like disaster response which includes earthquake, explosion, etc. and continuous health monitoring which includes ambient vibrations, wind, etc [10-12]. This research work is focused on continuous health monitoring.

## 3. OVERVIEW OF CASTALIA SIMULATOR

Castalia is a simulator for Wireless Sensor Networks (WSN), Body Area Networks (BAN) and generally networks of low-power embedded devices. It is based on the OMNeT++ platform and can be used by researchers and developers who want to test their distributed algorithms and/or protocols in realistic wireless channel and radio models, with a realistic node behaviour especially relating to access of the radio. Castalia can also be used to evaluate different platform characteristics for specific applications, since it is highly parametric, and can simulate a wide range of platforms. The main features of Castalia are: [13]

*3.1 Advanced channel model based on empirically measured data*

- ✓ Model defines a map of path loss, not simply connections between nodes
- ✓ Complex model for temporal variation of path loss
- ✓ Fully supports mobility of the nodes
- ✓ Interference is handled as received signal strength, not as separate feature

*3.2 Advanced radio model based on real radios for low-power communication.*

- ✓ Probability of reception based on SINR, packet size, modulation type. PSK FSK supported, custom modulation allowed by defining SNR-BER curve.
- ✓ Multiple TX power levels with individual node variations allowed
- ✓ States with different power consumption and delays switching between them
- ✓ Realistic modeling of RSSI and carrier sensing

*3.3 Extended sensing modeling provisions*

- ✓ Highly flexible physical process model.
- ✓ Sensing device noise, bias, and power consumption.

*3.4 Node clock drift*

*3.5 MAC and routing protocols available.*

3.6 *Designed for adaptation and expansion.*

Concerning the last bullet, Castalia was designed right from the beginning so that the users can easily implement/import their algorithms and protocols into Castalia while making use of the features the simulator is providing. Proper modularization and a configurable, automated build procedure help towards this end. The modularity, reliability, and speed of Castalia is partly enabled by OMNeT++, an excellent framework to build event-driven simulators [OMNeT++ link].

The following diagram given below provides an easy way to see all the modules and also show their hierarchical relations. Note that sometimes a module can be one of several possible similar modules (modules that share a common interface). This happens with modules such as the Application, the Routing, the MAC, and the Mobility Manager. For example, we have multiple applications modules that all share the same full hierarchy name: SN.node[*].Application. Which of the different application modules we will use depends on a parameter of the node module called Application Name. Application Name gives the name of the NED file that implements the desired application module. In the diagram below, all possible module names are given in curly brackets {}.

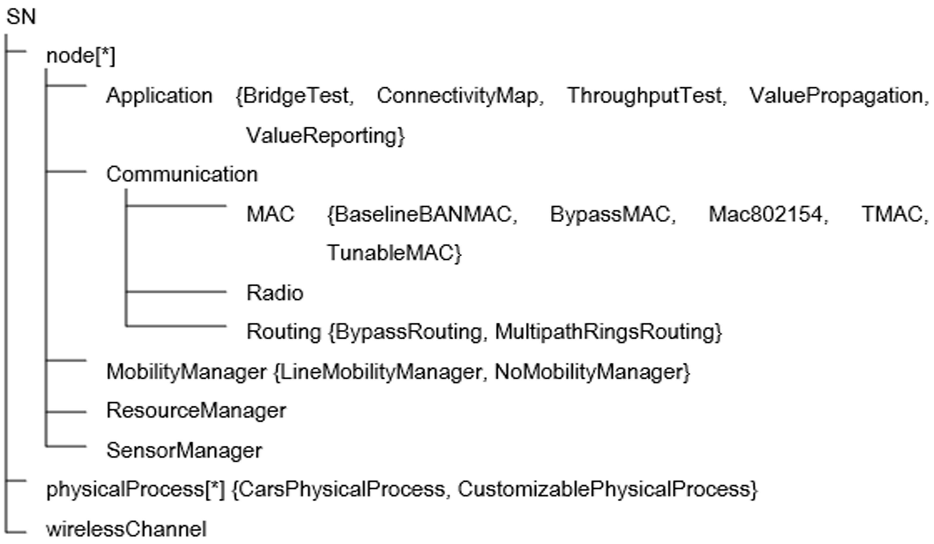


Fig 1: Module Diagram of Castalia

## 4. Results And Discussion

In this research paper the comparison has been done in between GPSR (Greedy Perimeter Stateless Routing), Multipath Ring Routing and no routing. The codes for Castalia simulator for individual algorithms have been developed. Post the design of Castalia code, simulations was run by considering the 50 meter Bridge test, which is one of the SHM applications, by taking constant values of pre-defined variables and the corresponding results were noted down. This research work has analyzed simulation results for 50m bridge.

*4.1 Simulation Setup:-* To explore the results, it has been conducted a detailed simulation using a Castalia 3.2 designed for Wireless Sensor Networks (WSN) and generally networks of low-power embedded devices. This simulation consists of no. of sensors from 9 to 49 for 50 m Bridge Test, one of the SHM applications. The simulation setup for 50m Bridge Test has been shown here:

| Sr. No. | Parameter Name | Value |
|---|---|---|
| 1 | Application Name | 50 meter Bridge Test, SHM Application |
| 2 | Simulation Time | 100 s |
| 3 | X axis | 50 m |
| 4 | Y axis | 10 m |
| 5 | No of sensor nodes | 9 |
| 6 | Deployment Type | Grid, [0]-->center[1..9]; 4×2 |
| 7 | Routing Protocols | GPSR, Multipath Ring, No Routing |
| 8 | Sink Node | Node 0 |
| 9 | Radio Type | CC2420 |

*Table 1: Simulation Parameters for 50m Bridge Test*

When no. of sensor nodes are 9, 19, 29,39 and 49 then respective deployment type will be Grid, [0]- > Center; 4×2, 9×2, 14×2, 19×2 and 24×2 and their relative energy consumption for GPSR, multipath ring routing and no routing schemes and is shown as following:

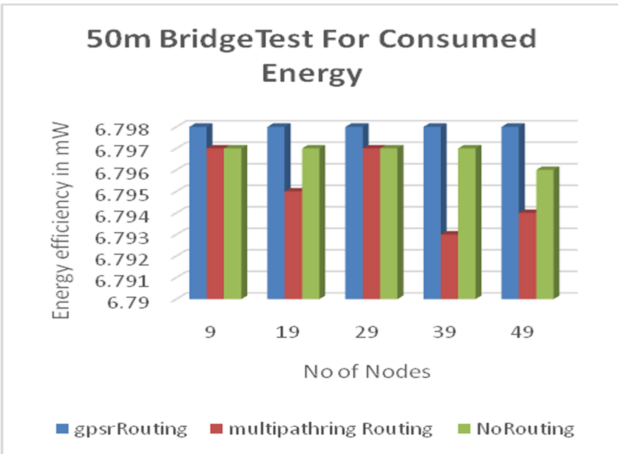

Fig. 2: Energy consumption with 9,19,29,39 and 49 no. of nodes.

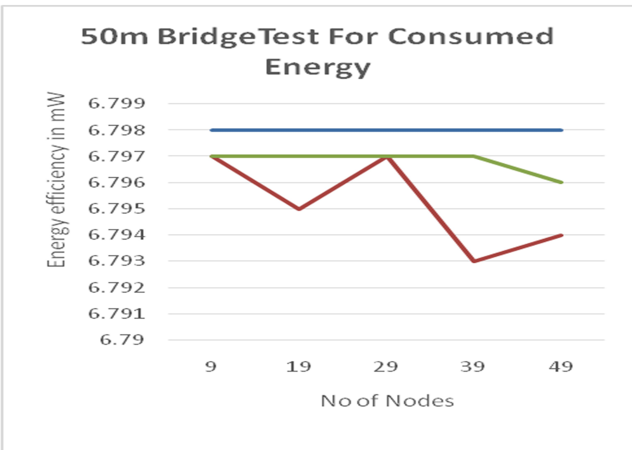


Fig. 3: Energy consumption with 9,19,29,39 and 49 no. of nodes with line graph.

## 5. Result Analysis & Conclusion

From above results it has been notified that as the no. of nodes increases then the energy consumption in multipath ring routing as compare to GPSR routing and no routing is less. After analysis of the above graphs it is clear that the average energy consumption of Multipath Ring routing protocol is minimum among all other routing protocols such that no Routing, GPSR Routing. GPSR allows nodes to figure out who its closest neighbors are (using beacons) that are also close to the final destination, from where the information is supposed to travel. To calculate a path, GPSR uses a greedy forwarding algorithm that will send the information to the final destination using the most efficient path possible. If the greedy forwarding fails, perimeter forwarding will be used which routes around the perimeter of the region.

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