DYNAMIC POWER MANAGEMENT IN WIRELESS SENSOR NETWORK

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Introduction

- Power management: maximizing battery power by switching the system to low-power state when they are in active
- A sensor is a device that responds to a stimulus, such as heat, light or pressure, and generates a signal that can be measured or interpreted
- The main purpose of sensor networks is to monitor an area, including detecting, identifying, localising and tracking one or more objects of interest.

Introduction cont’d

Wireless sensor networks (WSN)

- A WSN consist of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to main locations
- A WSN is a collection of nodes organized into a cooperative network. Each node consists of processing capability may contain multiple types of memory have an RF transceiver, have a power source (e.g., batteries and solar cells), and accommodate various sensors

Problem Statement

- Sensors are low cost tiny devices with limited storage, computational capability and power.
- The main issue is energy consumption of each individual sensor node in a wireless sensor network.
- To overcome this problem power management has a major role to play in Wireless sensor network.

Research Motivation

- Sensor are normally operated by an attached power supply that is usually a non rechargeable or non replaceable battery

- The motivation behind this research is to achieve a low power consumption by exploiting sleep, idle, receive and transmit states when the environment changes as expected.

Research Objective

- Design a power management technique that considers the applications constraints to exploit active and idle states

- Simulate a wireless network using a protocol that can distribute the energy consumption across all nodes equally

Methodology

The methodology adapted for the research work are listed below:

- A review of related literature on dynamic power management in wireless sensor network and on wireless network
- The sensor network lifetime is highly dependent on the power consumption performed at each sensor node. A more efficient power consumption model will be used which results in a longer network lifetime
- OPNET, will be used to examine how these ideas can indeed be realized and for simulation.

Literature Review

- Several important concepts that are related to this thesis were studied:
- Characteristics of WSN
- Generic Architecture of Sensor Nodes
- Typical WSN Architecture and Networking
- Applications of WSN
- Review of Related Work.

Characteristics of a WSNs

- Energy efficiency
  - •Low energy consumption → higher efficiency
  - •Battery powered → mobility
- Wireless communication
  - •The advantage of large networks → easy installation, no wiring
- Low price
  - •Allowed building a large number of sensor nodes
- Distributed data processing
  - •Local data processing (filtering, aggregation of data) in each node can relieve the main node

Generic Architecture of Sensor Nodes

- Sensor node is the fundamental building block for sensor networks
- Sensor network → consists of large number of nodes
- Basic architecture of sensor nodes
  - Power supply (Battery)
  - Processor unit (fast processor cores with low power consumption)
  - Storage unit (installed, additional external memory)
  - Sensor unit (analogue and digital sensors)
  - Communication unit

Generic Architecture of Sensor Nodes cont'd

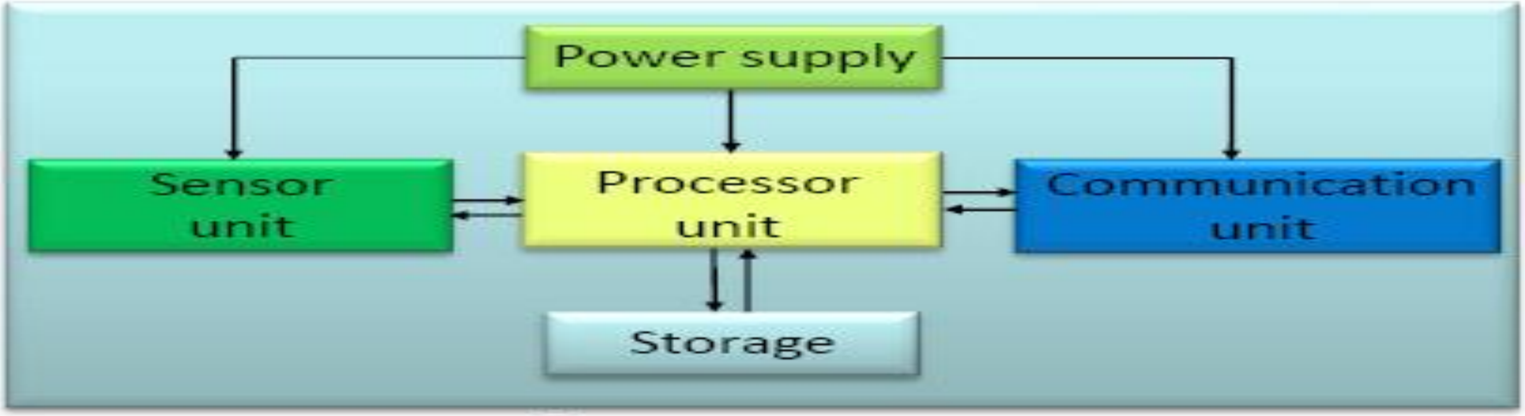

Figure 1: Sensor Node

Typical WSN Architecture and Networking

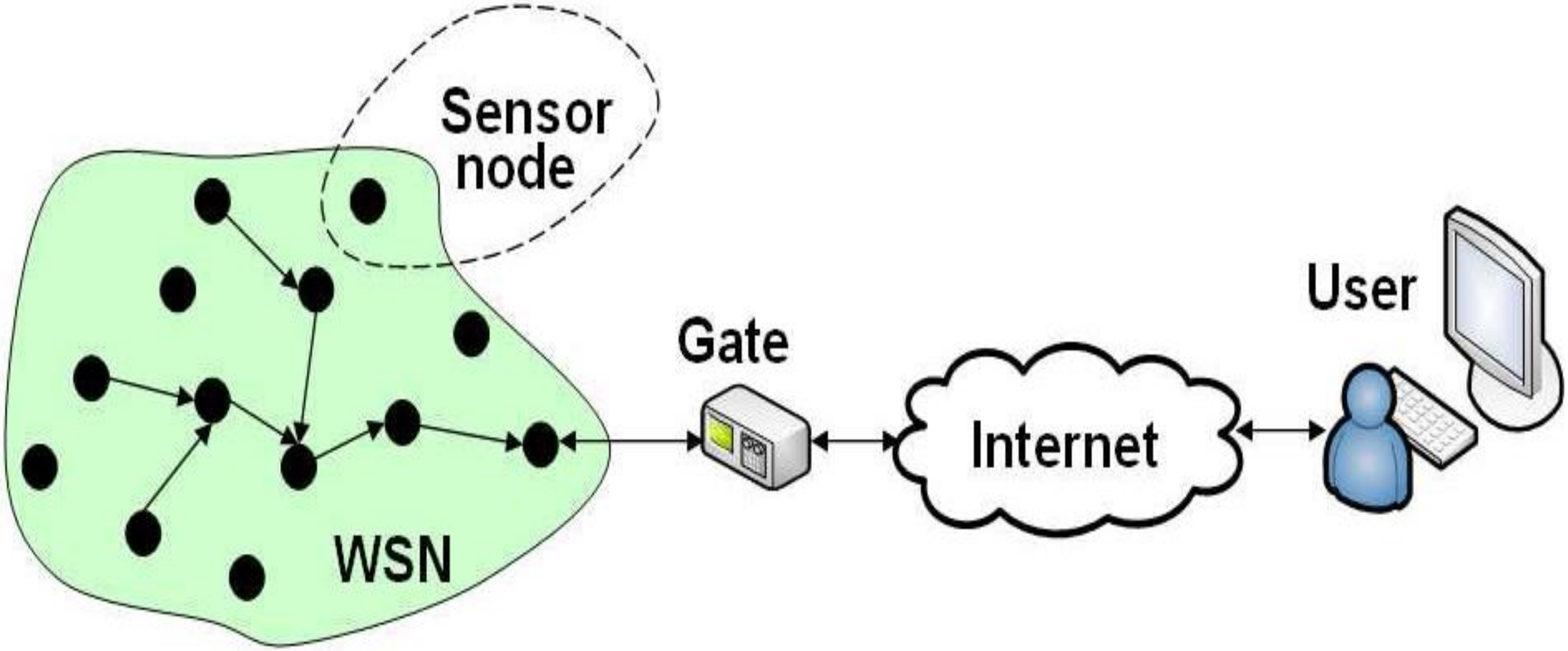

Figure 2: WSN Architecture

Applications of WSN

- Home Application
  - Heating, ventilation and air conditioning systems (HVAC)
  - Lightning
  - Shading
  - Air quality and window control
  - Systems switching off devices
  - Metering (smart meters)
  - Standard household applications (*e.g. televisions, washing machines)*
  - Security and safety (access control)
- Environmental Applications
  - Crops and agriculture forest fires
  - Flood detection and traffic control

Application of WSN cont’d

- Military Applications
  - Monitoring friendly forces, equipment and ammunition
  - Battlefield surveillance
  - Targeting and battle damage assessment
  - Nuclear, biological and chemical attack detection
- Health Applications
  - ring sensor to monitor blood oxygen saturation
  - sensor nodes embedded in clothes and human body
  - monitor patient physiological data
- Other Commercial Applications
  - Detecting and monitoring car thefts.

Review of Related Work

- (James, 2010), measured the power consumption of sensors, using an oscilloscope to determine power consumption in each of several states
- (Pan *et. al* 2010), observed the property that the first tier nodes are important for the lifetime of the whole network
- (Mhatre *et. al* 2009), obtained the minimum number of sensor nodes, cluster heads, and battery energy to ensure at least T unit of lifetime. They assume two types of sensor nodes: node 0 is sensor node and node 1 is cluster head

Review of Related Work cont'd

- (Anderson, *et. al* 2008), computed the upper bound of active lifetime in terms of the routing algorithms. They measured the lifetime of the network as the time of first loss of the coverage
- (Anastasi *et. al 2006),* measured energy consumption of a sensor node by measuring the average current consumption with a voltmeter
- Therefore, in order to minimize the energy consumption, sensor nodes should be in sleep mode (or lower power mode) as long as possible and to be awake when only necessary.

Power Management

- **Idle Power Management**

  Efficient DPM in idle mode requires power-differentiated states and optimal OS policies to transition to and from various states. The basic idea behind idle power management is to shut down devices when they are not needed and wake them when necessary

- **Active Power Management**

  The OS can be used to manage active power consumption in an energy-constrained sensor node. It reduces the operating frequency and voltage to a level just enough for the sensing application so that no visible loss is observed in performance while the energy consumption is reduced

Power Management Cont'd

$$P_m = t_{Sl} \times P_{Sl} + t_{Id} \times P_{Id} + t_{Rx} \times P_{Rx} + t_{Tx} \times P_{Tx} \quad , \qquad (1)$$

Where **P_m=** Power Management, t_{Sl}, t_{Id}, t_{Rx}, and t_{Tx} are fraction of time spent by the interface in each of the possible states: Sleep, Idle, Receive, and Transmit respectively. P_{Sl}, P_{Id}, P_{Rx}, and P_{Tx} are the powers consumed in the four states. Considering P_m and the initial energy of the node (E), we can calculate the node lifetime (T_v), which represents the time before the energy of the node reaches zero, as

$$T_v = \frac{E}{P_m} \quad . \qquad (2)$$

OPNET Simulator

- OPNET (Optimized Network Engineering Tool).
- Simulation and performance analysis of communication networks.
- The application can be used to test the performance of a modelled network configured with predefined parameters.
- After model construction, a simulation can be run to gather user-defined statistics
- Results are presented as graphs for easy evaluation.

OPNET Simulator Cont'd

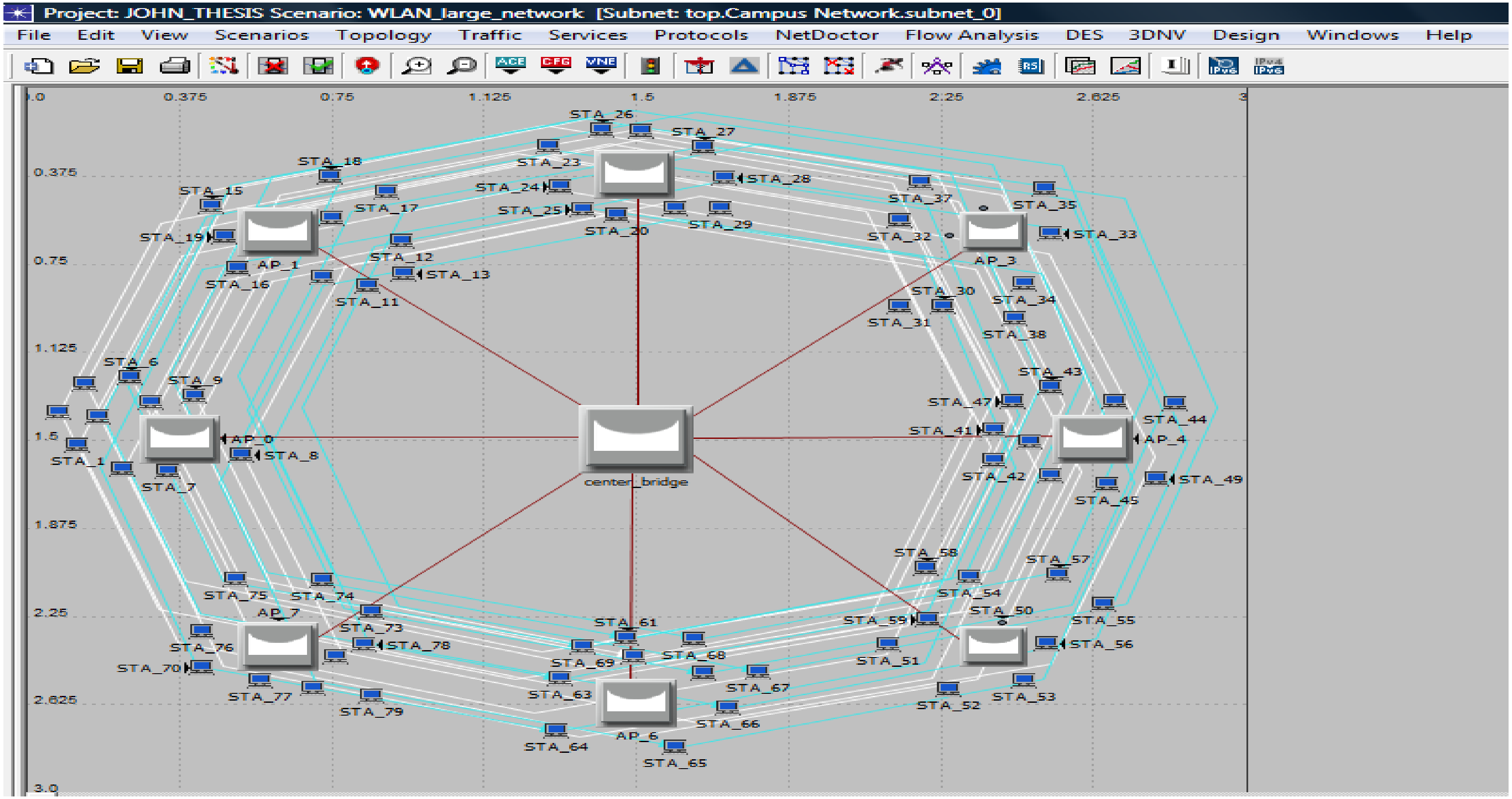

Figure 3: WLAN Campus Network

Results and Discussion

- **To evaluate the following:**
- WLAN data traffic received by APs
- WLAN throughput
- Nodes Energy Consumption.
- Regression Analysis

Results and Discussion cont'd

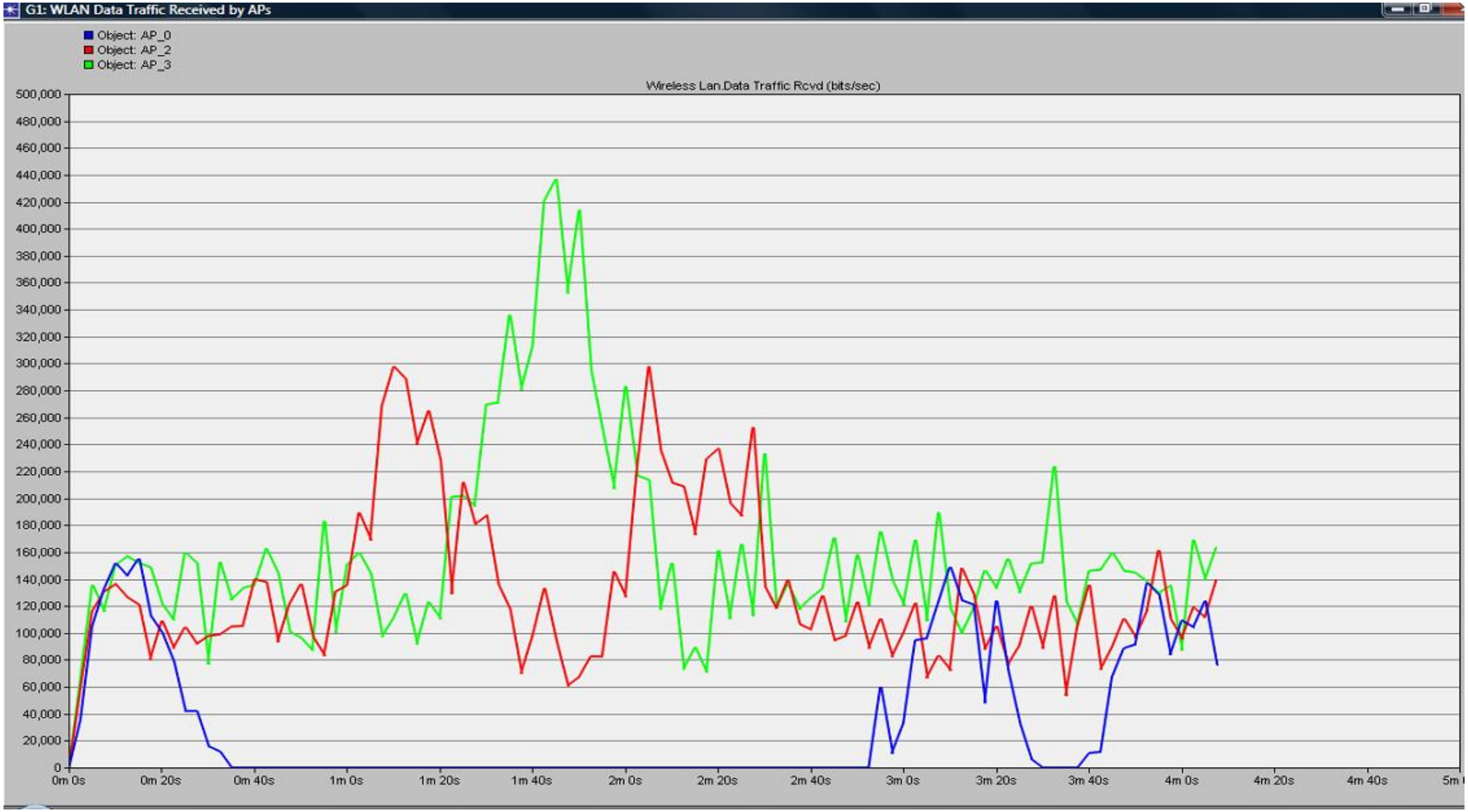

Figure 4: WLAN data traffic received by APs

Results and Discussion cont'd

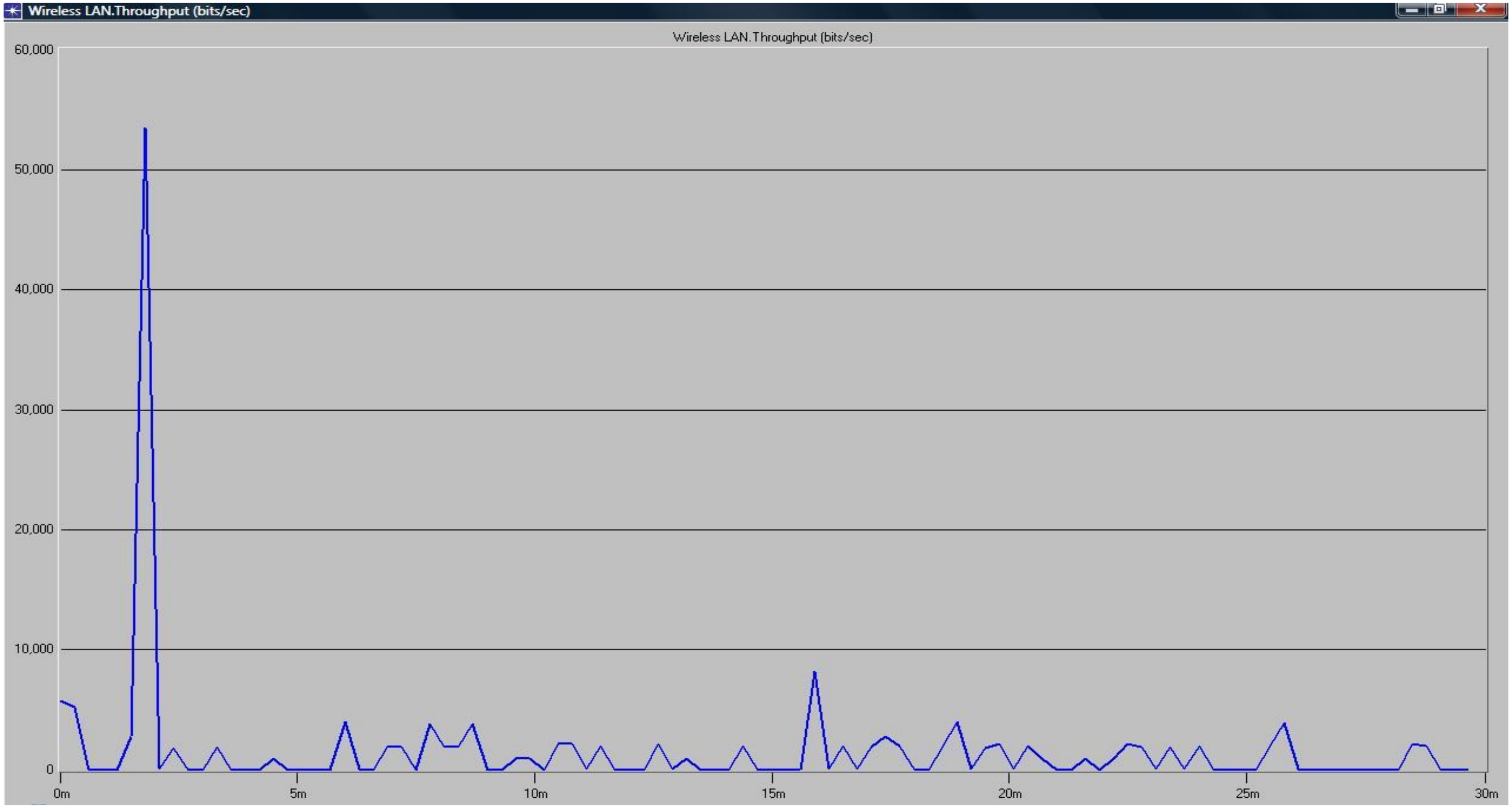

Figure 6: WLAN Throughput

Results and Discussion cont'd

- This graph compares the data traffic received by different APs in the network, namely AP_0, AP_2 and AP_3.

- The speed at which the network processes data. Rate at which data is received by the wireless LAN destination.

Results and Discussion cont'd

Stations	Pm (mA/s)	Qsl (mA/s)	Qid (mA/s)	Qrx (mA/s)	Qtx (mA/s)
STA_0	0.220	0.280	0.660	1.376	2.332
STA_1	0.248	0.384	0.805	1.428	2.430
STA_2	0.219	0.273	0.744	1.728	2.365
STA_3	0.259	0.425	0.900	1.551	2.444
STA_4	0.261	0.437	0.672	1.540	2.592
STA_5	0.252	0.390	0.816	1.710	2.378
STA_6	0.266	0.435	0.759	1.599	2.565
STA_7	0.249	0.364	0.840	1.480	2.352
STA_8	0.285	0.450	1.102	1.748	2.596
STA_9	0.233	0.322	0.999	1.260	2.450

Table 1: Nodes Energy Consumption AP_0

Results and Discussion

The data obtained from OPNET simulation were used to run the regression analysis we have **Pm** $= C_0 + C_1Q_{sl} + C_2Q_{id} + C_3Q_{rx} + C_4Q_{tx}$

Where Pm = Power management, C are the coefficient,

$Q_n = P_n * T_n$, n=sl, id, rx and tx.

(i.e the power consumptions at Sleep, Ideal, Received and Transmit state).

Power consumption at sensor node level described the lifetime of the network. From a functionality perspective, energy is consumed for sensing, computation, and communications.

Contributions of thesis to knowledge

- The findings of this research work has established an improved power management framework and a proposed model

- Finally, the research shows that energy consumption is a critical constraint in wireless sensor networks.

Future Work

- The scope of this research could be improved to cover the evaluated, performance of two simple time synchronization algorithms suitable for wireless sensor networks.
- More also, the scope of thesis could be expanded to security protocol for wireless sensor network WSNs.

Conclusion

- Generally lifetime of wireless sensor node is correlated with the battery current usage profile. As most WSN nodes are battery powered, their lifetime is highly dependent on their power consumption

- From the description we provided, It is clear that the system achieved all the stated objectives of the research work

THANK YOU.