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Low Rate – Wireless Personal Area Network (LR-WPAN) - 802.14.5

The OPNET model and the documentation used to prepare this lesson can be found at http://www.open-zb.net/ and http://www.hurray.isep.ipp.pt/ web sites. We would also like to thank to Ricardo Severino and Petr Jurcik for contributions in the preparation of this lesson.

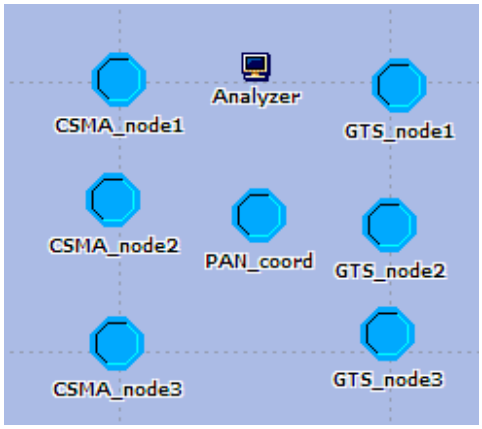
1.Introduction

The IEEE 802.15.4 protocol specifies the Medium Access Control (MAC) sub-layer and physical (PHY) layer for Low-Rate Wireless Private Area Networks (LR-WPAN).
In fact, the IEEE 802.15.4 protocol targets low data rate, low power consumption, low cost wireless networking, which typically fits the requirements of sensor networks.
The IEEE 802.15.4 offers three operational frequency bands: 2.4 GHz, 915 MHz and 868 MHz. There is a single channel between 868 and 868.6 MHz, 10 channels between 902 and 928 MHz, and 16 channels between 2.4 and 2.4835 GHz. The data rate is 250 kbps at 2.4 GHz, 40 kbps at 915 MHZ and 20 kbps at 868 MHz.
The MAC sub-layer of the IEEE 802.15.4 protocol provides an interface between the physical layer and the higher layer protocols of LR-WPANs.
The MAC sub-layer of the IEEE 802.15.4 protocol has many common features with the MAC sub-layer of the IEEE 802.11 protocol, such as the use of CSMA/CA (Carrier Sense Multiple Access / Contention Avoidance) as a channel access mechanism, the support of contention-free and contention-based periods. However, the specification of the IEEE 802.15.4 MAC sub-layer is adapted to the requirements of LR-WPAN, for instance the RTS/CTS mechanism (used in IEEE 802.11) is not used.
The MAC protocol supports two operational modes that may be selected by the coordinator:

- Beacon-enabled mode: beacons are periodically generated by the coordinator to synchronize attached devices and to identify the PAN. A beacon frame is (the first) part of a superframe, which also embeds all data frames exchanged between the nodes and the PAN coordinator. Data transmissions between nodes are also allowed during the superframe duration.
- Non Beacon-enabled mode: in this mode, the devices can simply send their data using unslotted CSMA/CA. There is no use of a superframe structure in this mode.

2.Network scenario

The base network scenario is composed by one PAN coordinator and six sensor nodes. There are two kinds of traffic flow from the sensor nodes to PAN coordinator. One kind requiring non-QoS guarantees and another kind requiring QoS guarantees. All sensor nodes generate non-QoS traffic, but only three (*GTS_node1*, *GTS node2* and *GTS node3*) also generate QoS traffic. The non-QoS traffic is composed by acknowledged and unacknowledged frames.



The analyzer node (Analyzer) is used only to capture global statistics.

3.Objectives

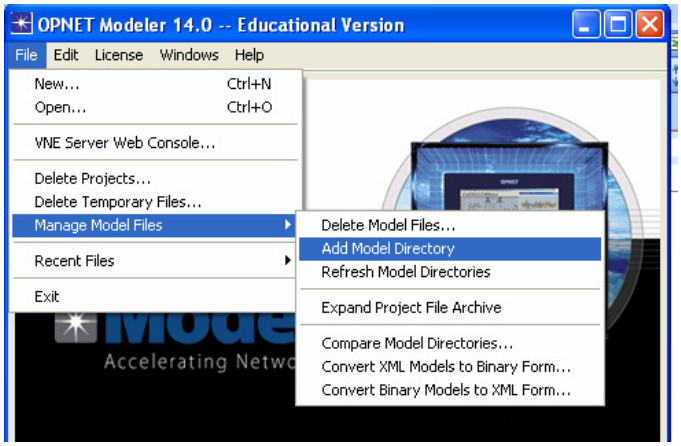
The objective of this lesson is to study and to understand the impact of the protocol attributes (superframe order, beacon order and backoff exponent), the number of nodes and the data frame size on the network performance.

4.Getting Started

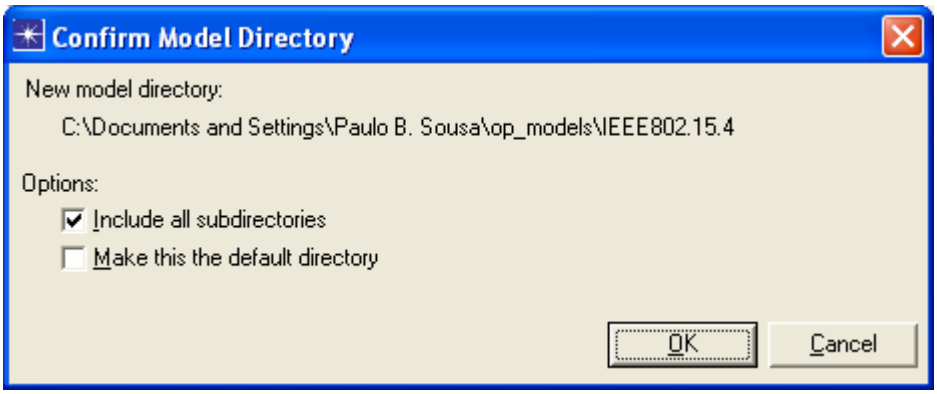
1.Download the IEEE802.15.4.zip file from the http://www.dei.isep.ipp.pt/~pbsousa/aulas/dei/simov/2007_08_1s/index.html web site.

2.Unzip downloaded file to **C:\Documents and Settings\<user>\op_models**

3. Add this directory to the OPNET Model directories: File → Model Files → Add Model Directory.



4. Check “include all subdirectories” option and then click **OK**.



5.Open the project file

5.1. Select the project file: File→Open→ **"C:\Documents and Settings\<user>\op_models\IEEE802.15.4\wpan_ieee802_15_4.project\ wpan_ieee802_15_4.prj"**

5.2. Click Open

5.Run a simulation

1.Run simulation

1.1. Select DES > Configure/Run Discrete Event Simulation….

1.2. Type **1** in the **Duration:** field to simulate 40 seconds of network activity.

1.3. Type **10000** (events) in the **Update interval:** field to specify how often the simulation calculates events/second data. In this case, the simulation calculates and displays events/second data at 10,000-event intervals. The default setting for this is 500,000 for larger network simulations.

1.4. Set the Simulation Kernel to **Optimized**. You can use one of two types of kernels to run your simulation. The development kernel collects simulation data you can use to debug your models, but the optimized kernel runs faster.

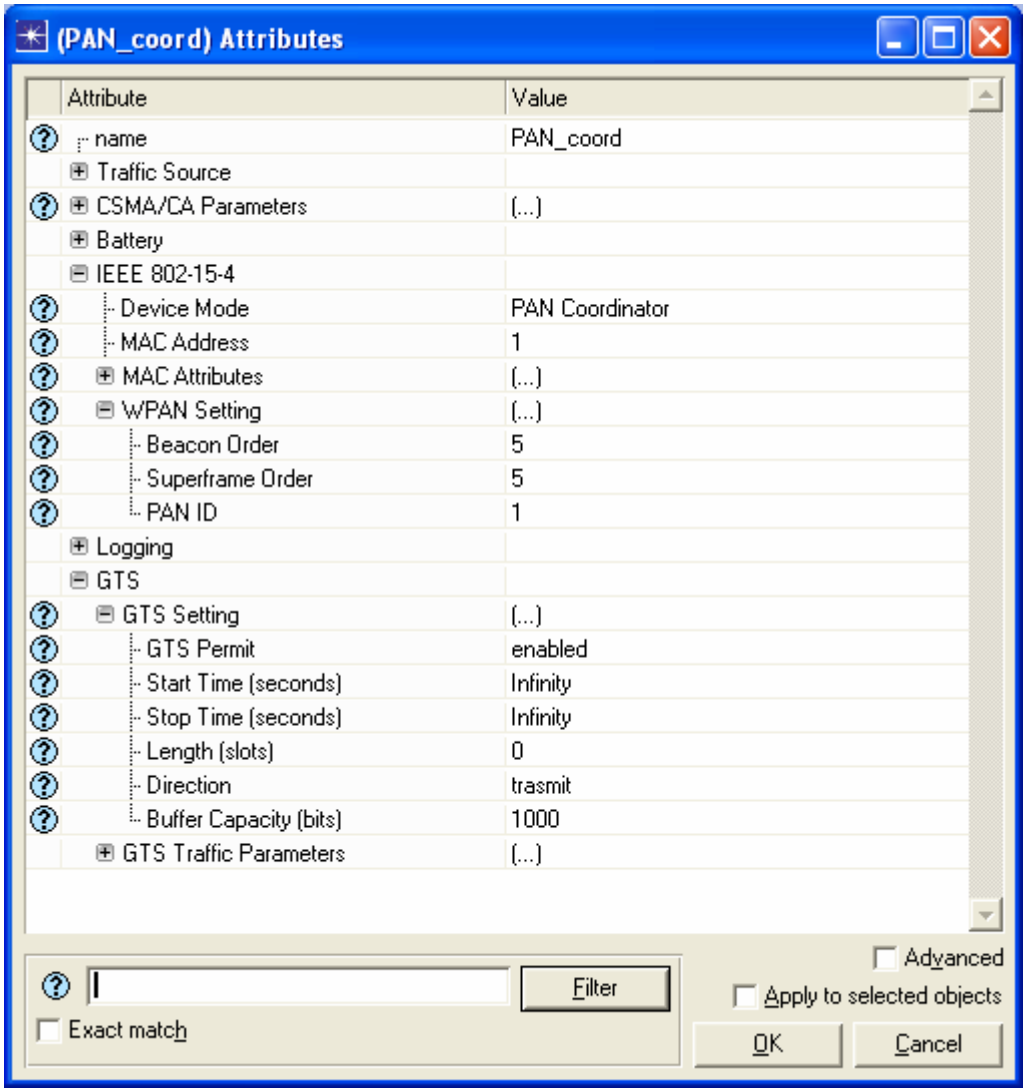
1.5. Click the **Run** button to begin the simulation. While the simulation runs, a dialog box appears showing the simulation's progress.

6.Configuring 802.14.5 devices

1.Configuring PAN coordinator

1.1. Select the PAN, right-click on it and select **Edit Attributes.**

1.1.1. Set **IEEE208-15-4 (**(Device Mode and MAC Address), **WPAN Settings (**Beacon Order, Superframe Order and PAN ID) and **GTS settings** (GTS permit) attributes according to the following figure.

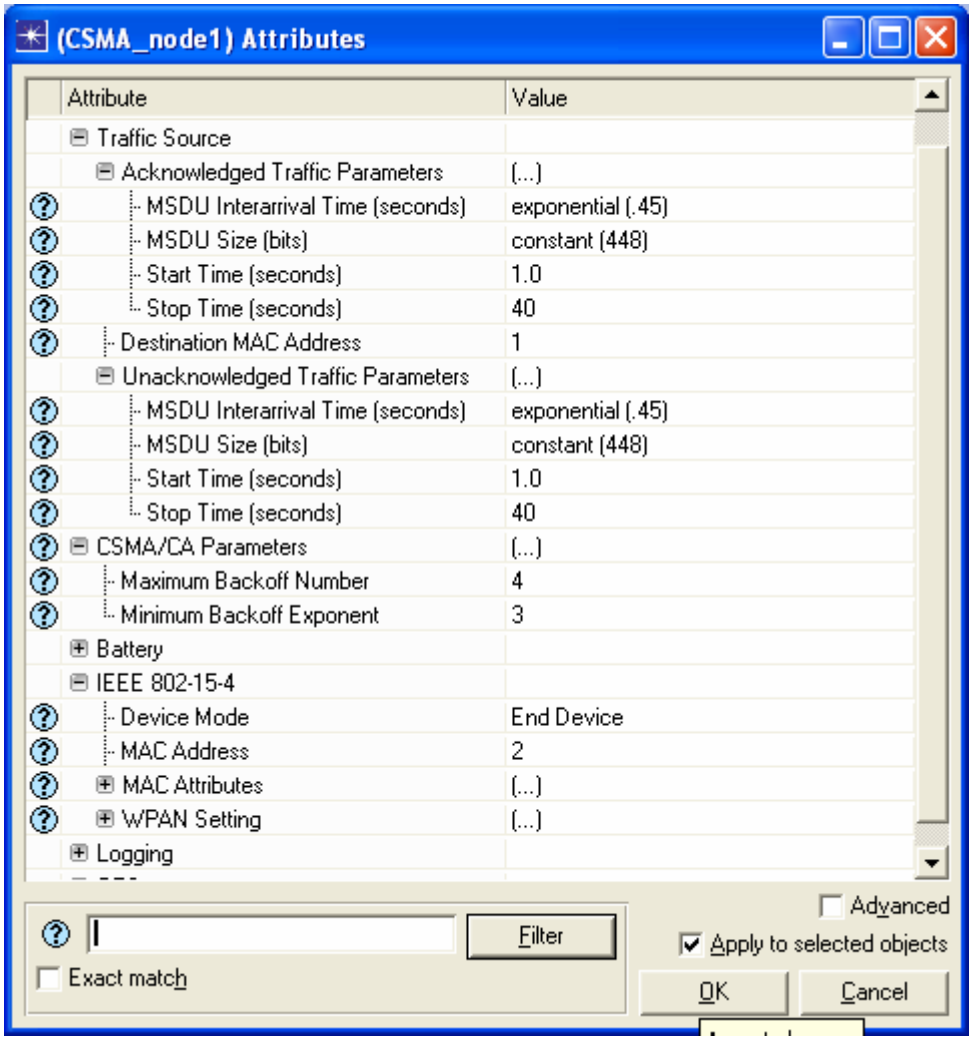


2.Configuring CSMA_node*x*

2.1. Select all sensor nodes, right-click on one and select **Edit Attributes.**

2.1.1. Set parameters according to the following table.

Attribute	**Parameters**		**Value**
Traffic Source	Acknowledged Traffic Parameters	MSDU Interarrival Time	Exponential(0.45)
		MSDU Size	Constant(488)
		Start Time	1.0
		Stop Time	40.0
	Destination MAC Address	1	
	Unacknowledged Traffic Parameters	MSDU Interarrival Time	Exponential(0.45)
		MSDU Size	Constant(488)
		Start Time	1.0
		Stop Time	40.0
CSMA/CA Parameters	Maximum Backoff Number	4	
	Minimum Backoff Exponent	3	
IEEE 802-15-4	Device Mode	End Device	



2.1.2. Do not forget to check “Apply to selected objects” and then click OK.

2.2. Set the MAC Address

2.2.1. Select each sensor node, right-click on one and select **Edit Attributes.**

2.2.2. Set **MAC Address** parameters according to the following table.

Node (name)	**Attribute**	**Parameters**	**Value**
CSMA_node1	IEEE 802-15-4	MAC Address	2
CSMA_node2	IEEE 802-15-4	MAC Address	3
CSMA_node3	IEEE 802-15-4	MAC Address	4

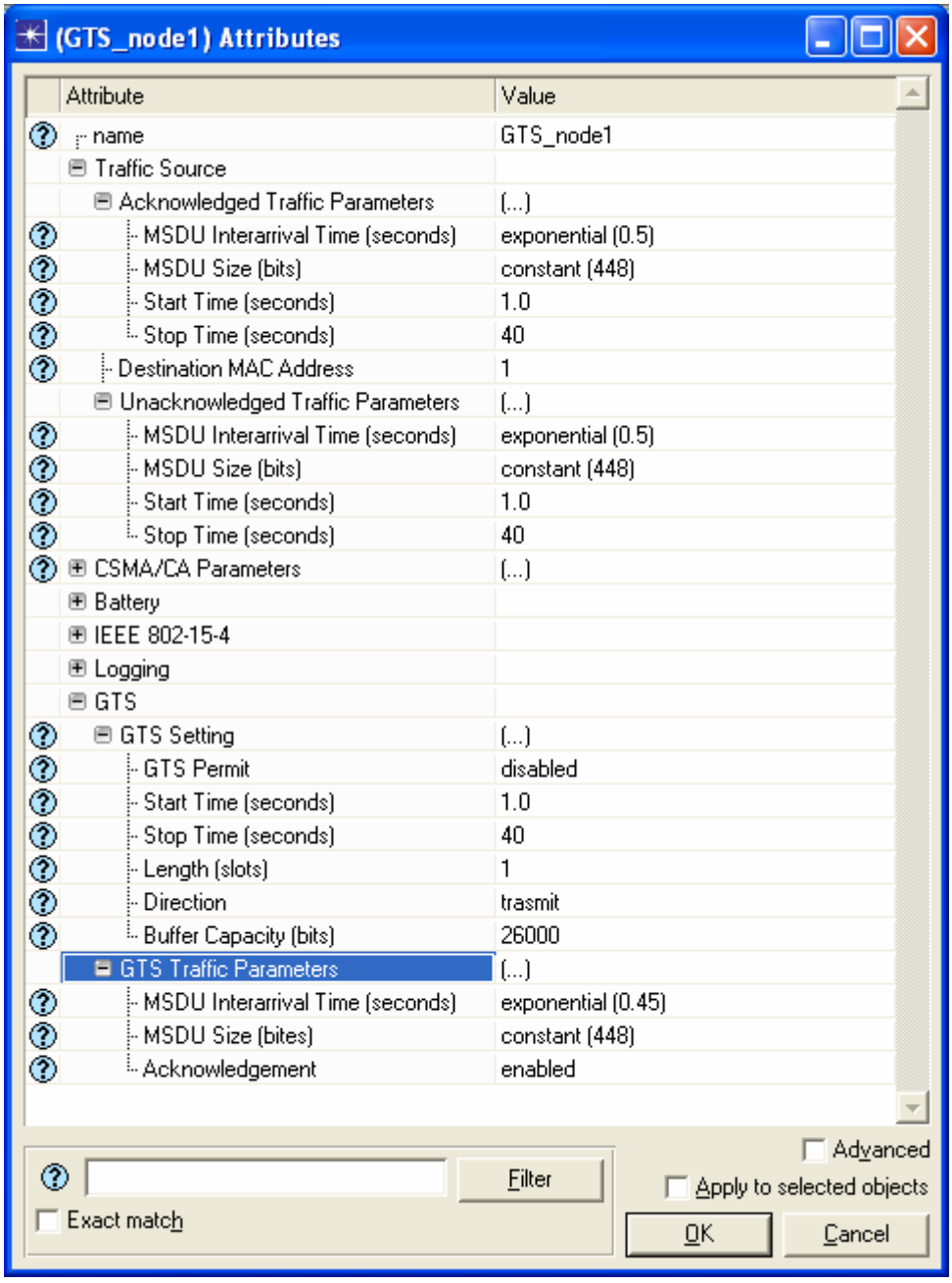
3.Configuring GTS_node*x*

3.1. Select all sensor nodes, right-click on one and select **Edit Attributes.**

3.1.1. Set parameters according to the following table.

Attribute	**Parameters**		**Value**
Traffic Source	Acknowledged Traffic Parameters	MSDU Interarrival Time	Exponential(0.45)
		MSDU Size	Constant(488)
		Start Time	1.0
		Stop Time	40.0
	Destination MAC Address	1	
	Unacknowledged Traffic Parameters	MSDU Interarrival Time	Exponential(0.45)
		MSDU Size	Constant(488)

		Start Time	1.0
		Stop Time	40.0
CSMA/CA Parameters	Maximum Backoff Number	4	
	Minimum Backoff Exponent	3	
IEEE 802-15-4	Device Mode	End Device	
GTS	GTS Setting	Start Time	1.0
		Stop Time	40.0
		Length (slots)	1
		Direction	transmit
		Buffer (bits)	26000
	GTS Traffic Parameters	MSDU Interarrival Time	Exponential(0.45)
		MSDU Size	Constant(488)
		Acknowledgement	enabled



3.1.2. Do not forget to check “Apply to selected objects” and then click OK.

3.2. Set the MAC Address

3.2.1. Select each sensor node, right-click on one and select **Edit Attributes.**

3.2.2. Set **MAC Address** parameters according to the following table.

Node (name)	**Attribute**	**Parameters**	**Value**
GTS_node1	IEEE 802-15-4	MAC Address	12
GTS_node2	IEEE 802-15-4	MAC Address	13
GTS_node3	IEEE 802-15-4	MAC Address	14