

Project PtOWSN: Modeling OpenWSN MAC Layer using Ptolemy II

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Outline

- Motivation and Goals
- Background on OpenWSN
- Ptolemy Modeling
- Demo
- Results

Motivation and Goals

- **Gap** between WSN application design and deployment phase
- We want to investigate, in a simulation environment, the **energy consumption**, **time synchronization** scalability of the network
- Build part of the **tools** for Swarmlet development using OpenWSN stack and the Ptolemy framework

Background

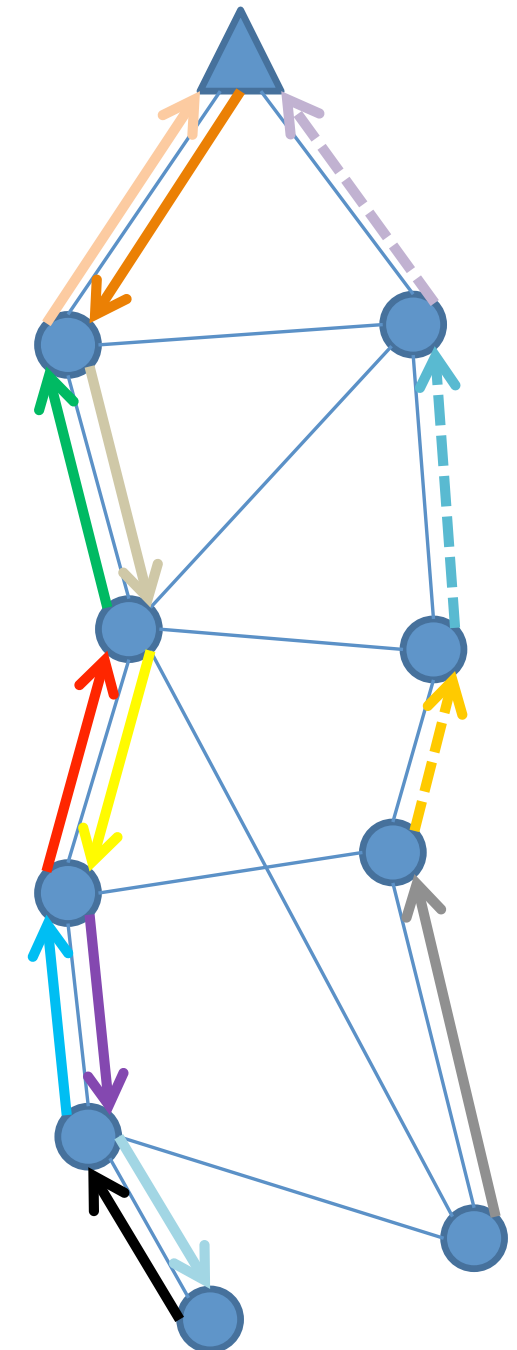
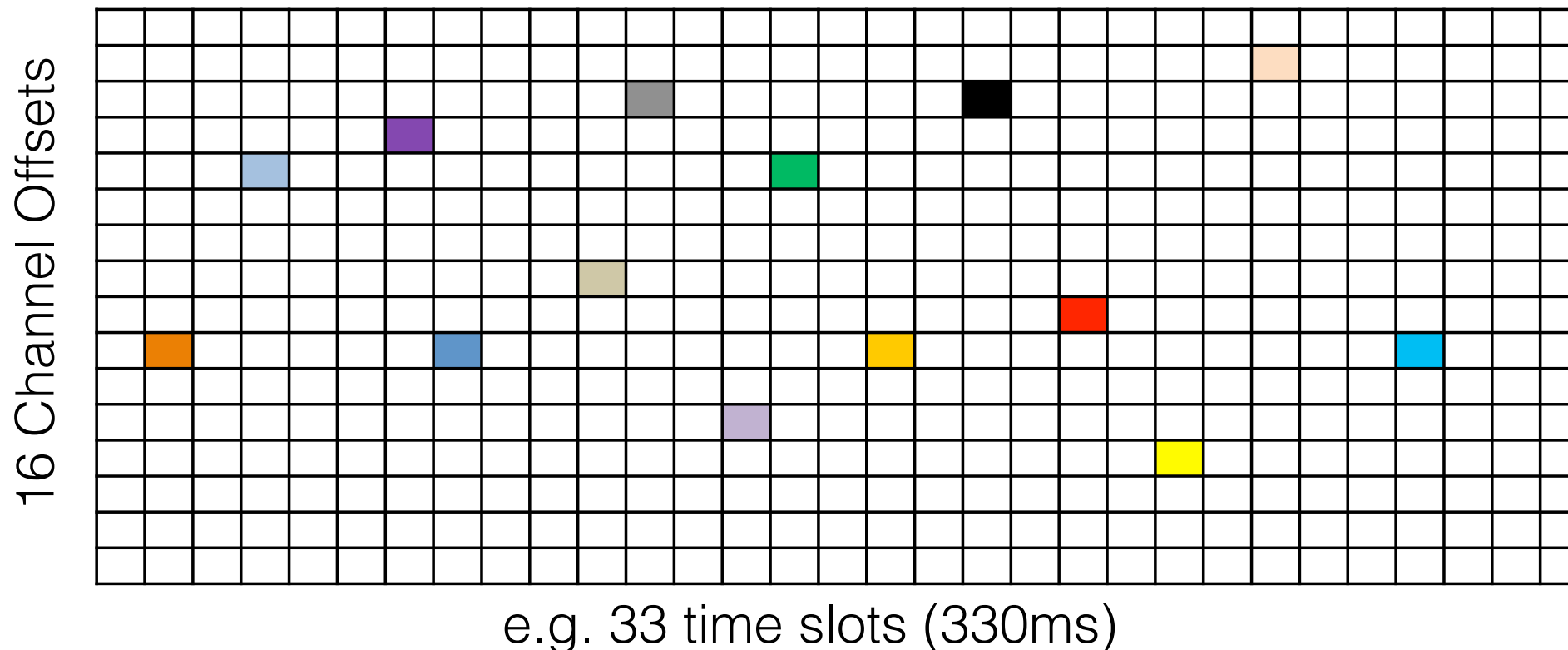


application	CoAP, HTTP
transport	UDP, TCP
IP/routing	IETF RPL
adaptation	IETF 6LoWPAN
medium access	IEEE802.15.4e
phy	IEEE802.15.4-2006

IEEE802.15.4e - TSCH

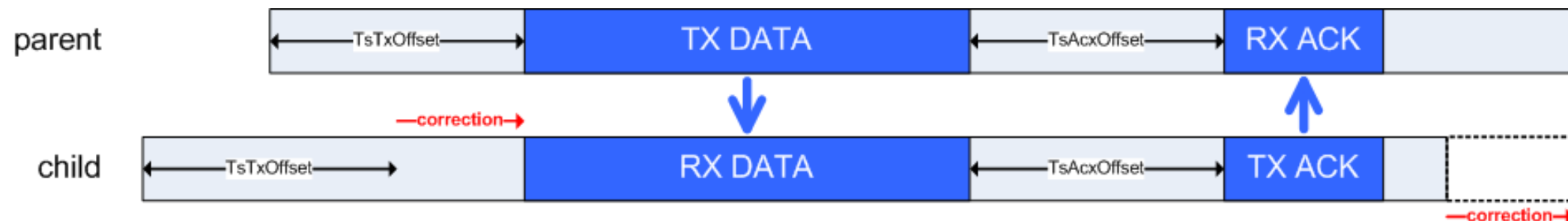
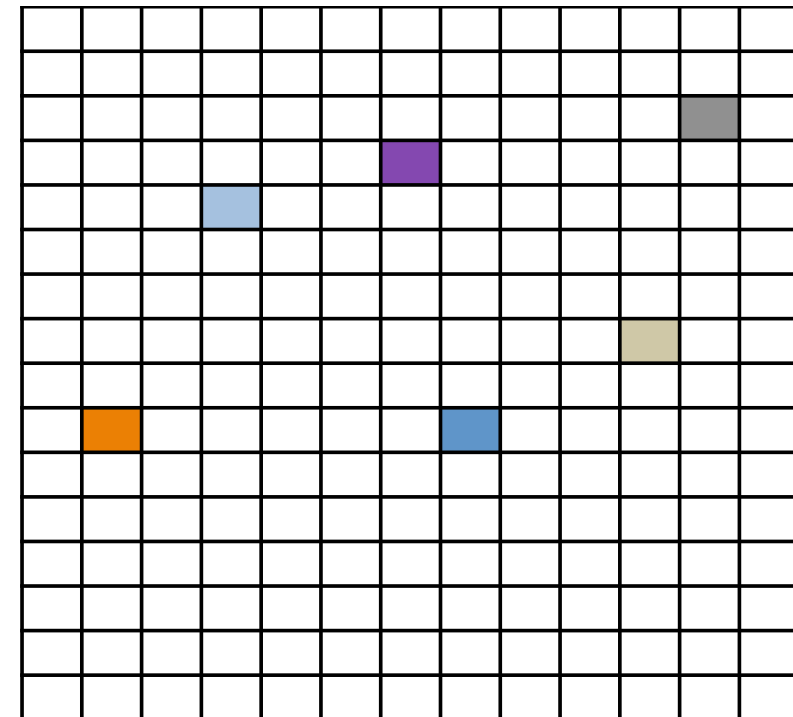
Time-Slotted (Synchronized) Channel Hopping
Tunable trade-off using different schedules

- packets/second
- latency
- robustness
- energy consumption



IEEE802.15.4e - Synchronization

- Synchronization
 - Slot Synchronization
 - Absolute Slot Number Synchronization
- Re-synchronization



Energy Background

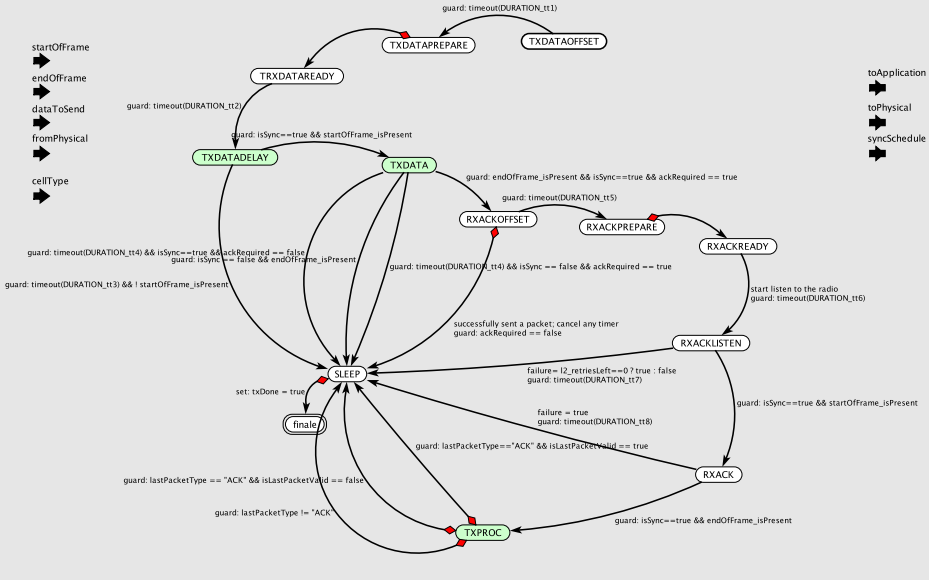


TABLE II

CURRENT DRAWN BY THE ATMEL AT86RF231 RADIO CHIP FOR
DIFFERENT STATES (THEORETICAL AND MEASURED)

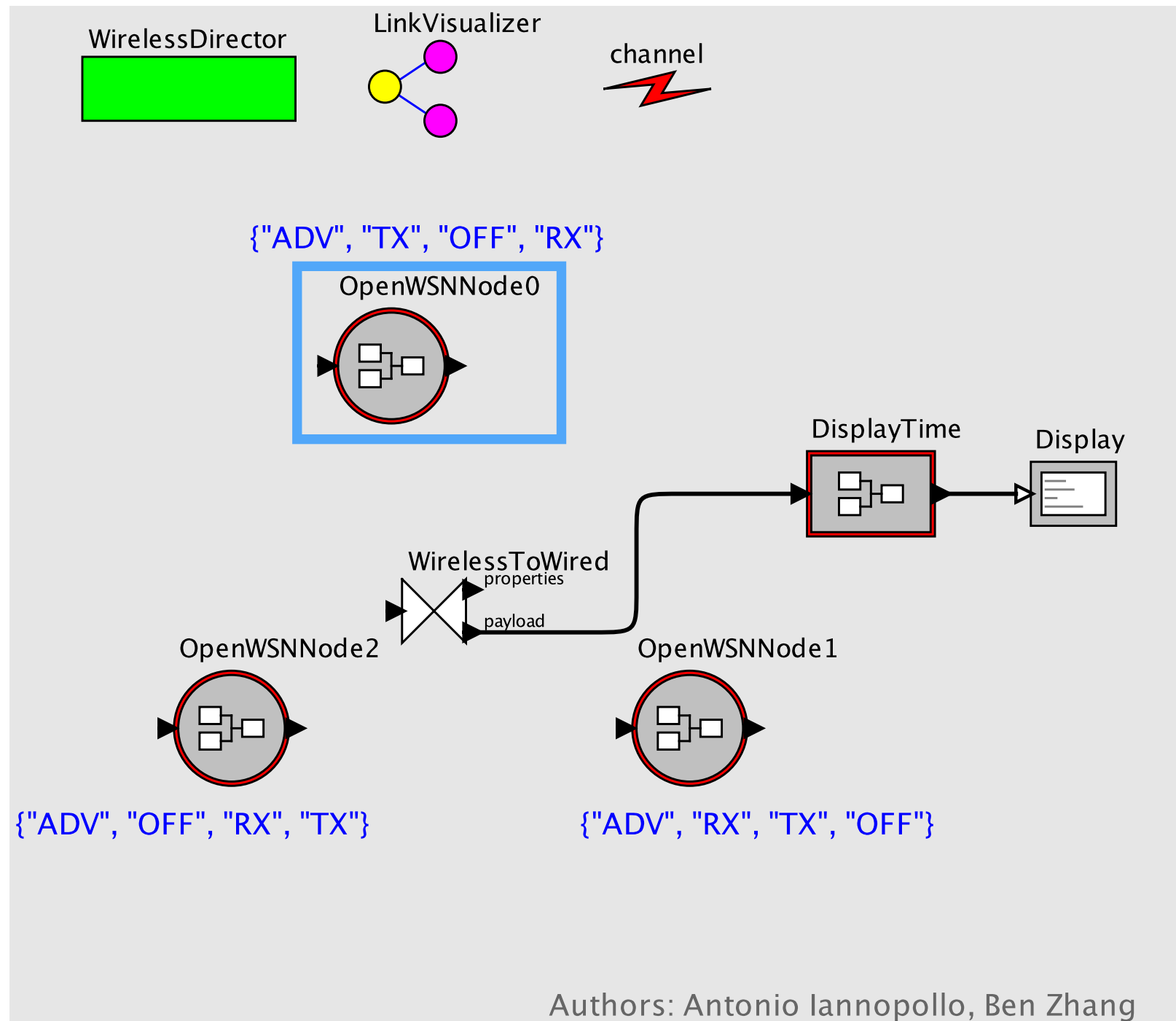
GenericMode	AT86RF231 Mode	Current	Measured
Sleep	<i>TRX_OFF</i>	0.4mA	0.49mA
ToReady	<i>TRX_OFF</i> ⇒ <i>PLL_ON</i>	5.6mA	N/A
Ready	<i>PLL_ON</i>	5.6mA	5.4mA
Tx	<i>BUSY_TX</i>	11.6mA (0dBm)	13.7mA (0dBm)
ToListen	<i>TRX_OFF</i> ⇒ <i>PLL_ON</i> ⇒ <i>RX_ON</i>	12.3mA	N/A
Listen	<i>RX_ON</i>	12.3mA	11.6mA
Rx	<i>RX_ON</i>	12.3mA	11.6mA

TABLE I

MAPPING FROM PERIODS IN TEMPLATE TO STATES OF MOTE MODULES

Period in Template	State of motes	μP state	Radio state
StartOfTimeslot	NewSlot	Active	Sleep
TsTxOffset	TxDataOffset	Active	Sleep
	PostTxDataOffset	Sleep	Sleep
	TxDataPrepare	Active	ToReady
	PostTxDataPrepare	Sleep	Ready
TxPacket	TxDtataStart	Active	ToTx
	TxData	Active	Tx
	PostTxData	Sleep	Tx
TsRxAckDelay	TxRxAckOffset	Active	Sleep
	PostTxRxAckOffset	Sleep	Sleep
AGT	RxAckPrepare	Active	ToListen
	RxAckReady	Sleep	Listen
RxAck	RxAckStart	Active	Rx
	RxAck	Sleep	Rx
	PostRxAck	Active	Sleep
BeforeEnd	Sleep	Sleep	Sleep
EndOfTimeslot	EndSlot	Active	Sleep

Ptolemy Modeling - 1



Ptolemy Modeling - 2

DEDirector



- drift: 2.642985206526222E-6
- nominalClockFrequency: 1/32000
- localAddress: 0
- networkMaster: true
- schedule: {"ADV", "OFF", "RX", "TX"}

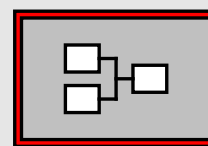
- PORT_delayTx: 0
- PORT_delayRx: 0
- PORT_TsSlotDuration: 491
- PORT_maxRxDataPrepare: 33
- PORT_maxTxDataPrepare: 66

Sensor node platform
dependent values.

- PORT_maxRxAckPrepare: 10
- PORT_maxTxAckPrepare: 22

Run when the model starts.
This sets drift, schedule and its location.

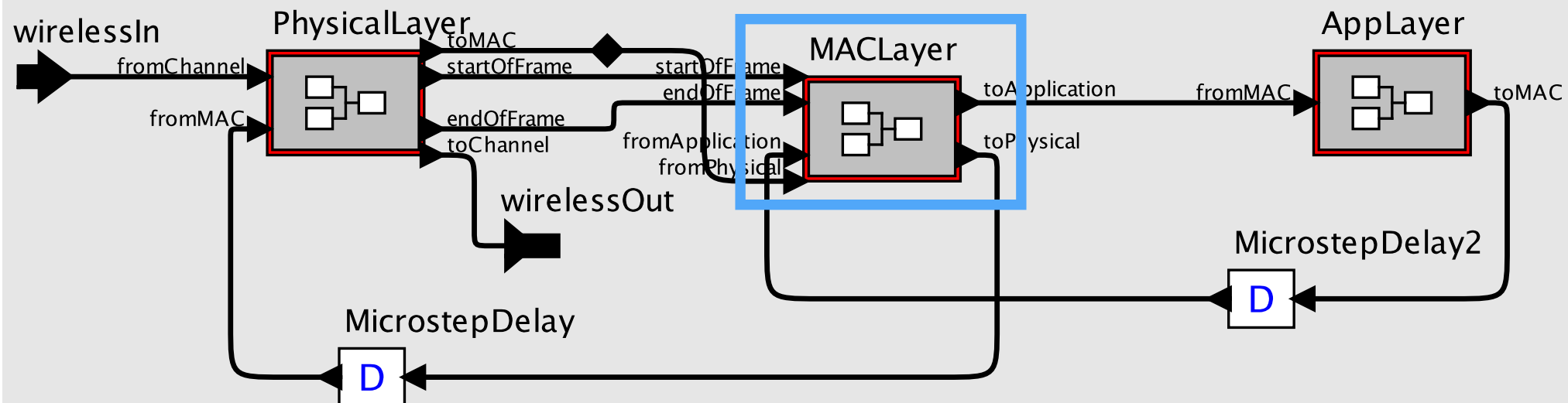
NodeParameterAutomation



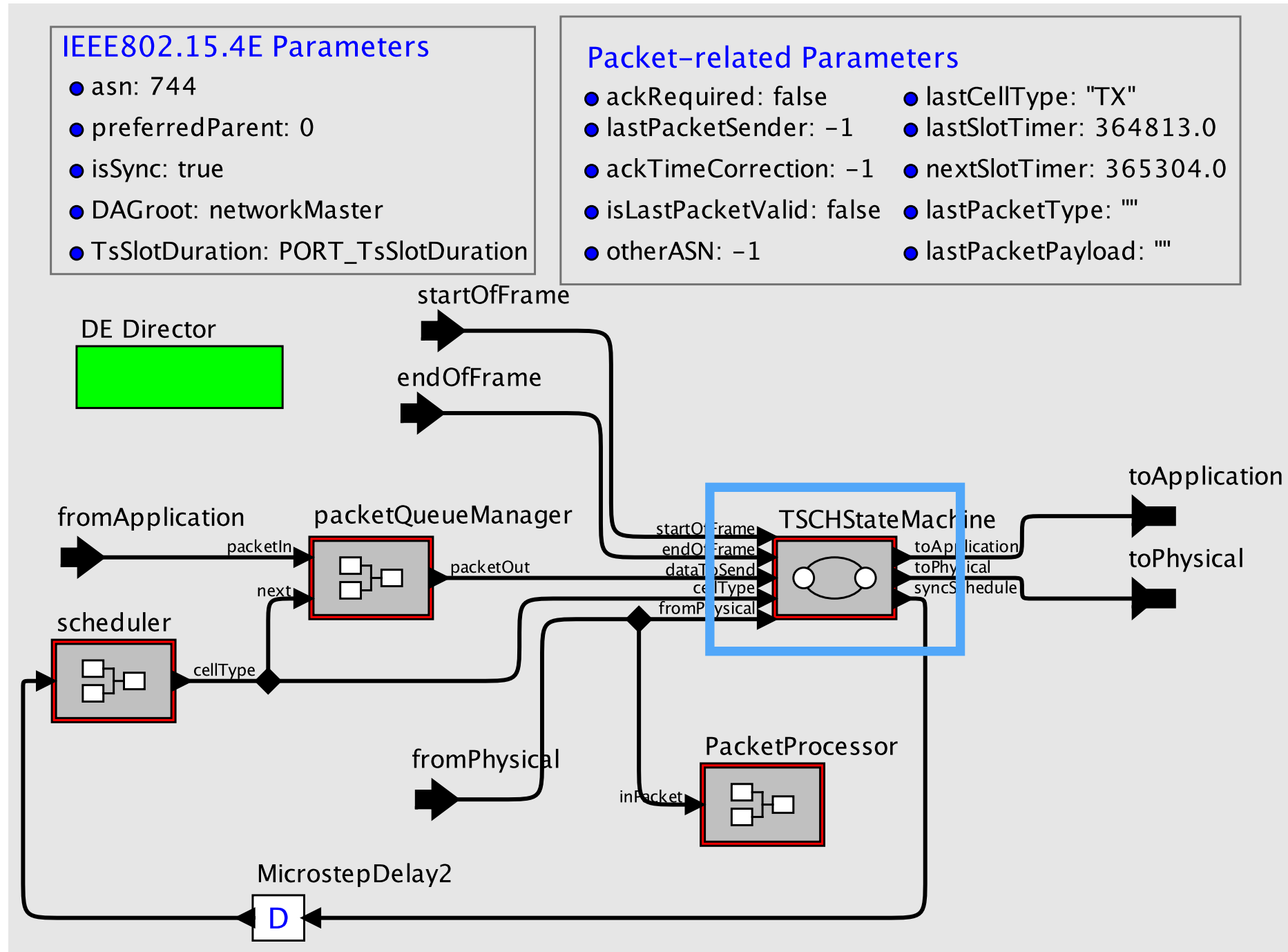
SetVariable



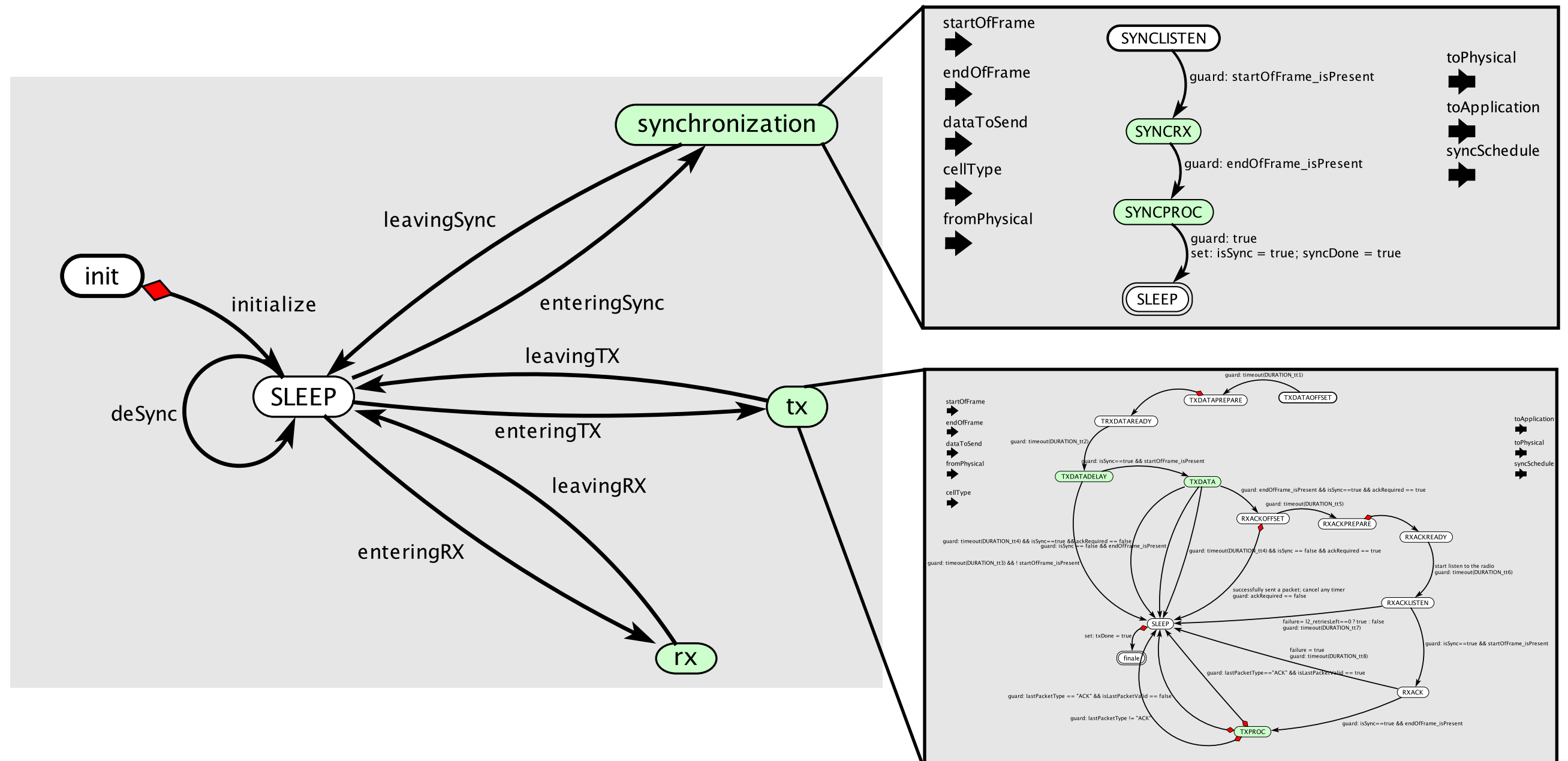
location



Ptolemy Modeling - 3



Ptolemy Modeling - 4

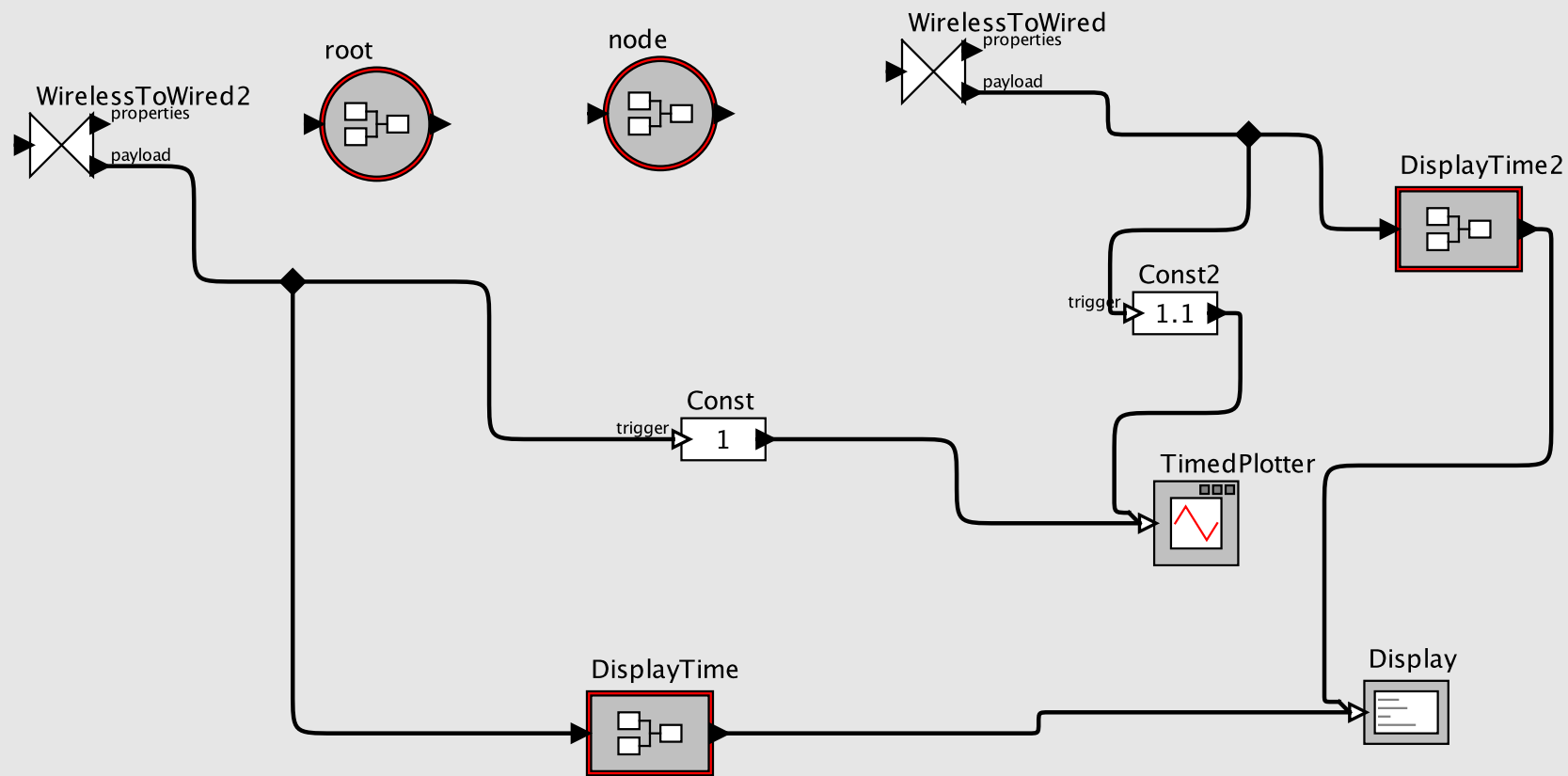


Demo 1:

Time Synchronization

This models a two-node network and shows how clock drift is corrected by ADV packet in OpenWSN network. Using root as a reference point, the node has a clock drift of 10^{-4} (we pick this exacerbated value for demonstration). Since OpenWSN detects synchronization loss through a counter deSyncTimeout, this happens when the ASN is around 334. After that tick, you will see the time synchronization.

Authors: Antonio Iannopolo, Ben Zhang



vergil ~/repos/ModelingOpenWSN/apps/demo_sync.xml

Demo 2:

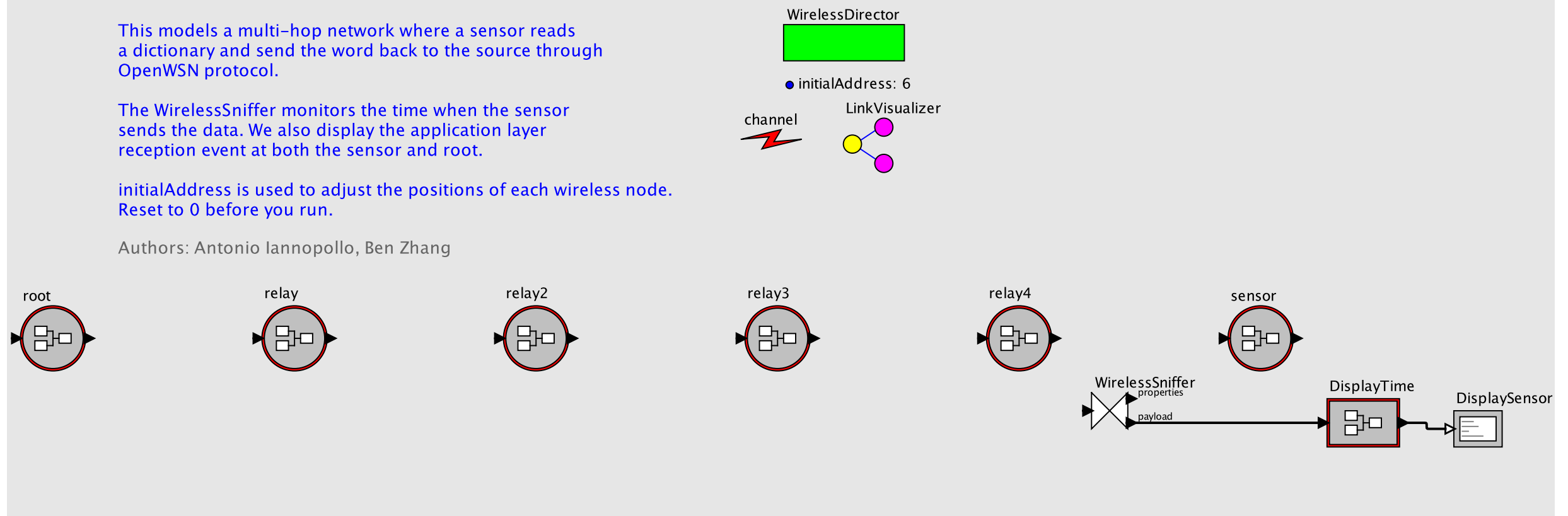
Multihop Transmission

This models a multi-hop network where a sensor reads a dictionary and send the word back to the source through OpenWSN protocol.

The WirelessSniffer monitors the time when the sensor sends the data. We also display the application layer reception event at both the sensor and root.

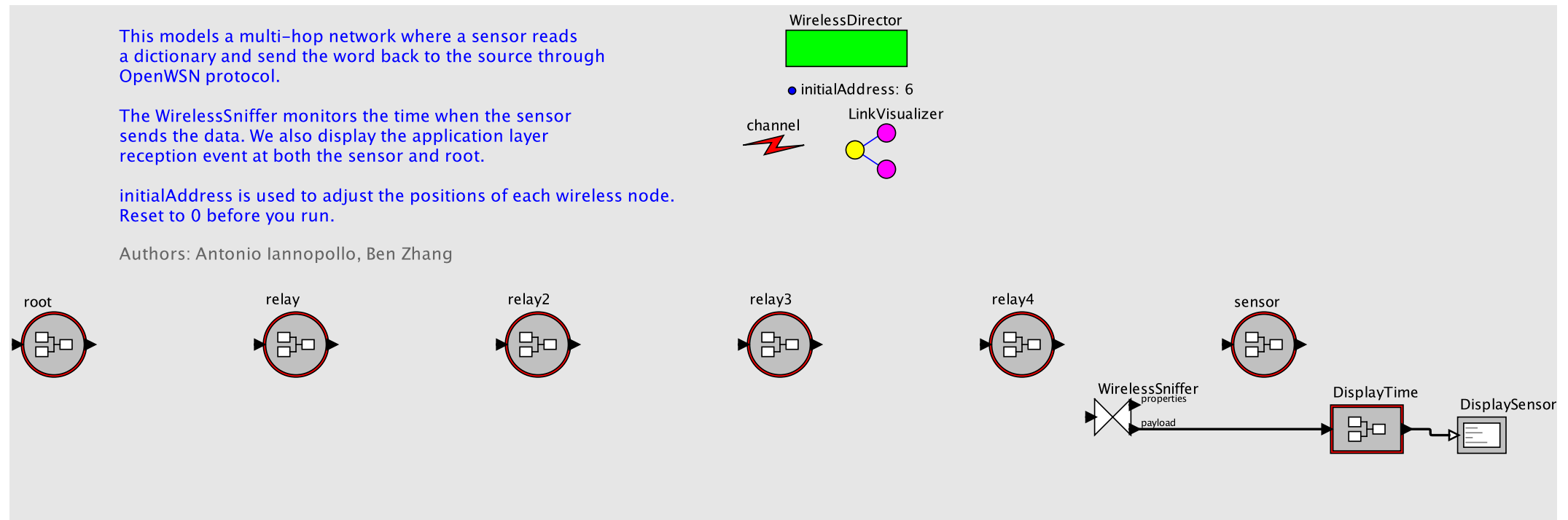
initialAddress is used to adjust the positions of each wireless node. Reset to 0 before you run.

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vergil ~/repos/ModelingOpenWSN/apps/demo_multihop_dict_nopower.xml

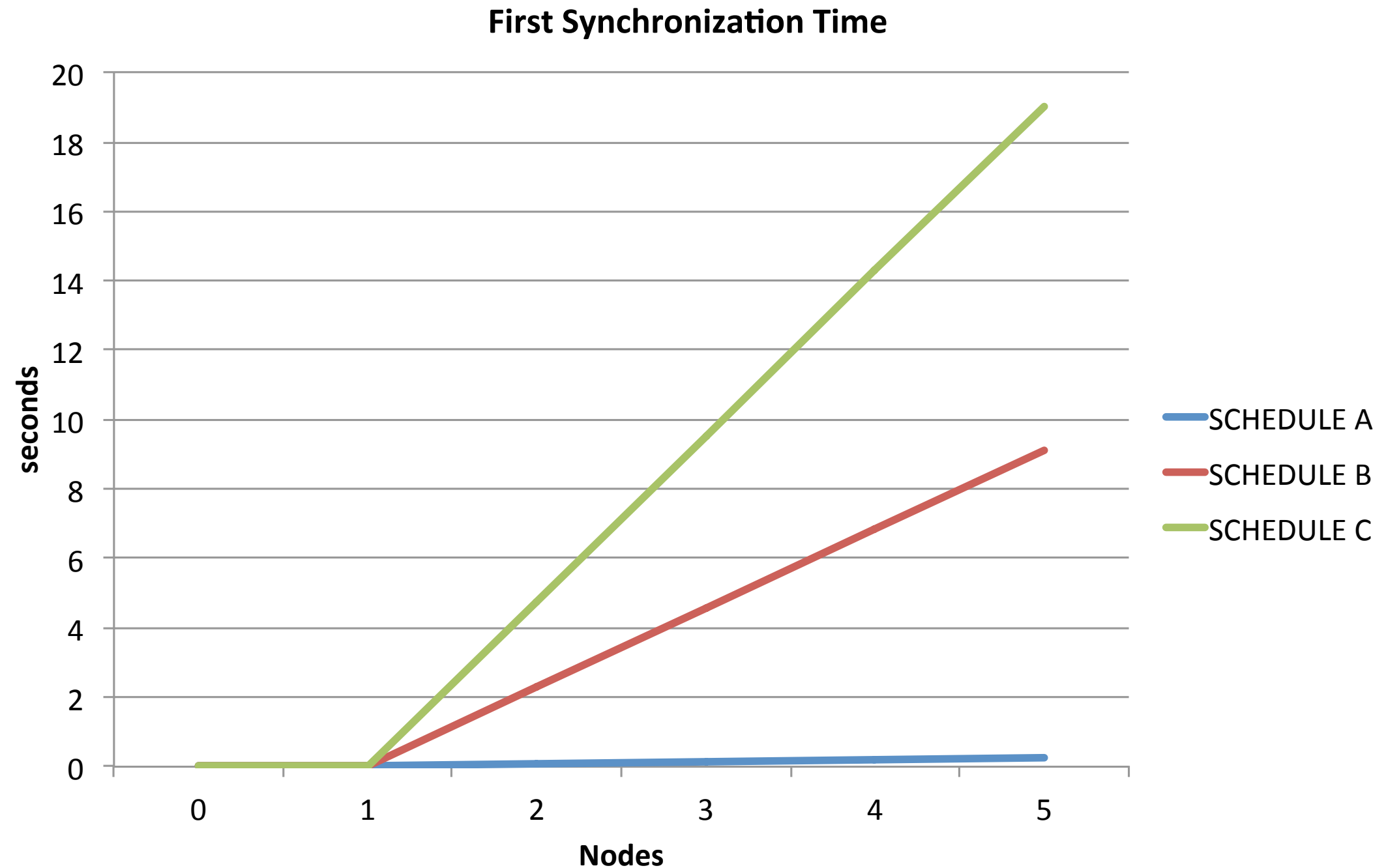
Case Study



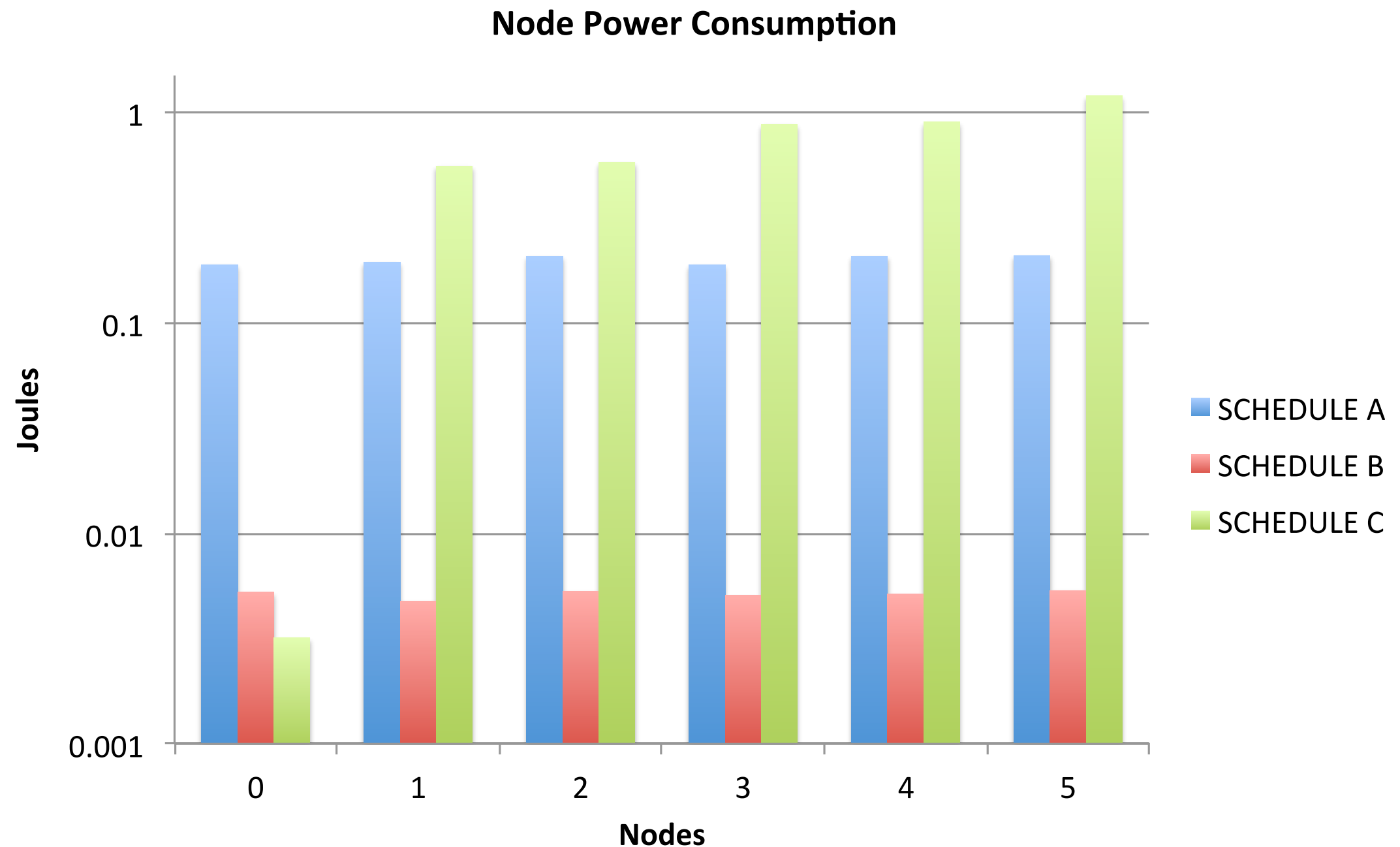
NodeId	Schedules				
$3i + 0$	ADV	TX	RX	OFF	$k \times \text{OFF}$
$3i + 1$	ADV	RX	OFF	TX	$k \times \text{OFF}$
$3i + 2$	ADV	OFF	TX	RX	$k \times \text{OFF}$

Schedule A, B, C — $k = 0, 144, 306$

Results: Time Synchronization



Results: Energy



Conclusion

- We modeled OpenWSN TSCH protocol in Ptolemy
- We studied properties (time synchronization, energy) of a particular network and schedule
- The model can serve as a platform for future Swarmlet construction

Q & A



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