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

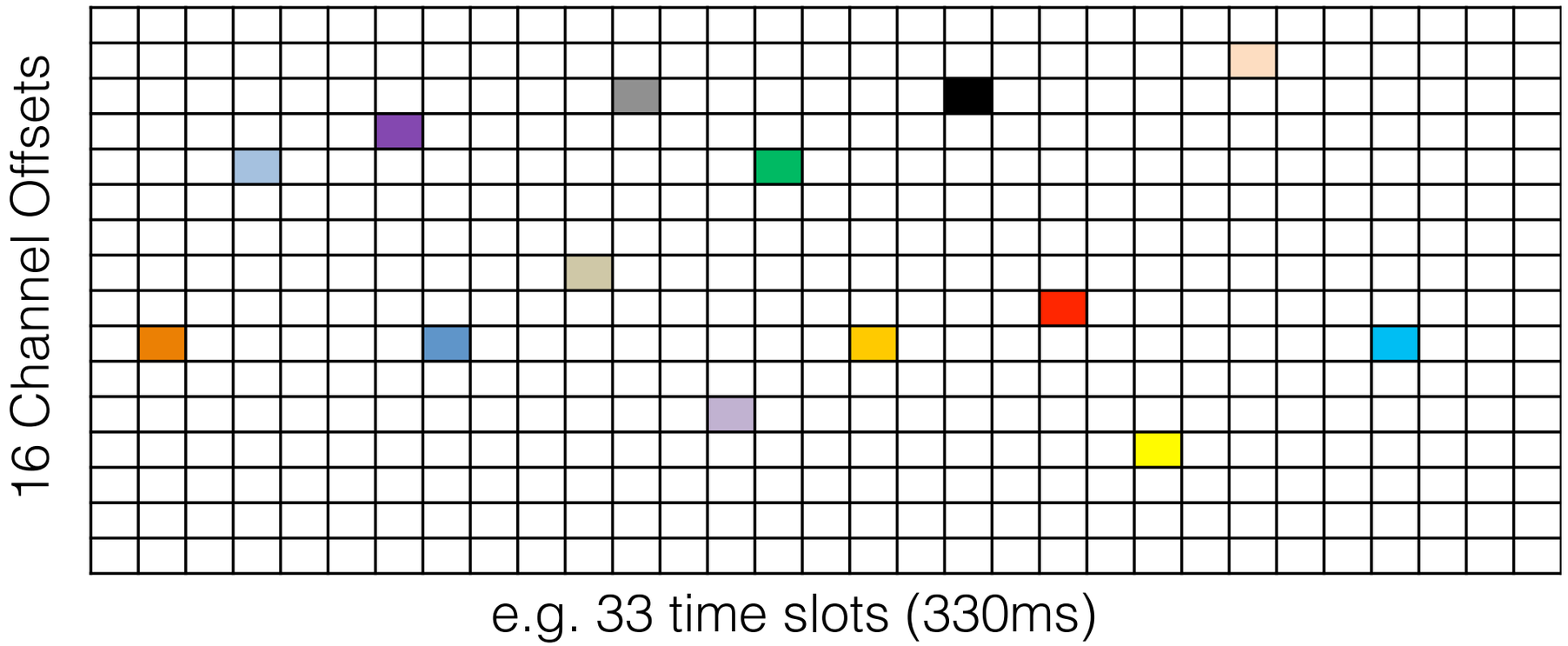
application	CoAP, HTTP
transport	UDP, TCP
IP/routing	IETF RPL
adaptation	IETF 6LoWPAN
medium access	IEEE802.15.4e
phy	IEEE802.15.4-2006

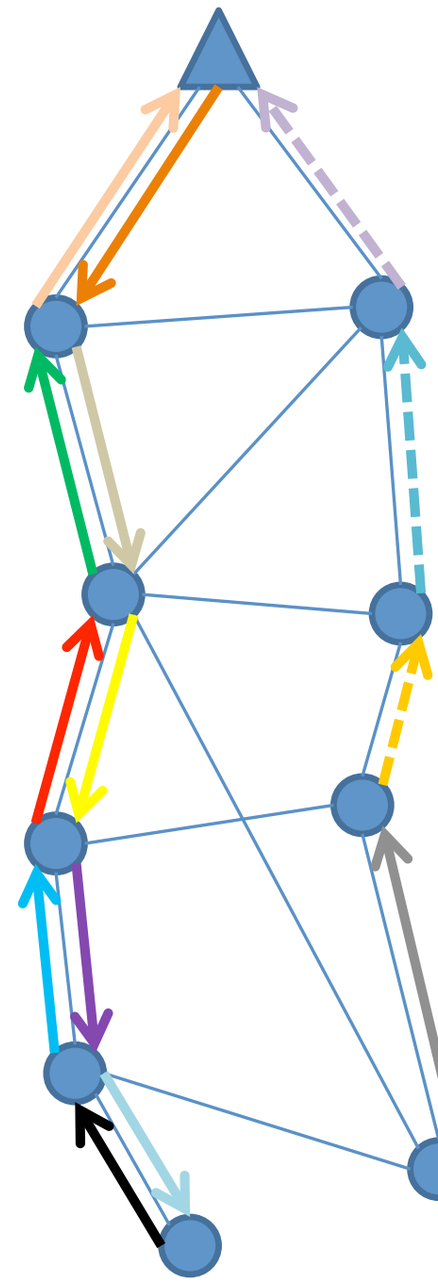
IEEE802.15.4e - TSCH

Time-Slotted (Synchronized) Channel Hopping

Tunable trade-off using different schedules

- packets/second
- latency
- robustness
- energy consumption

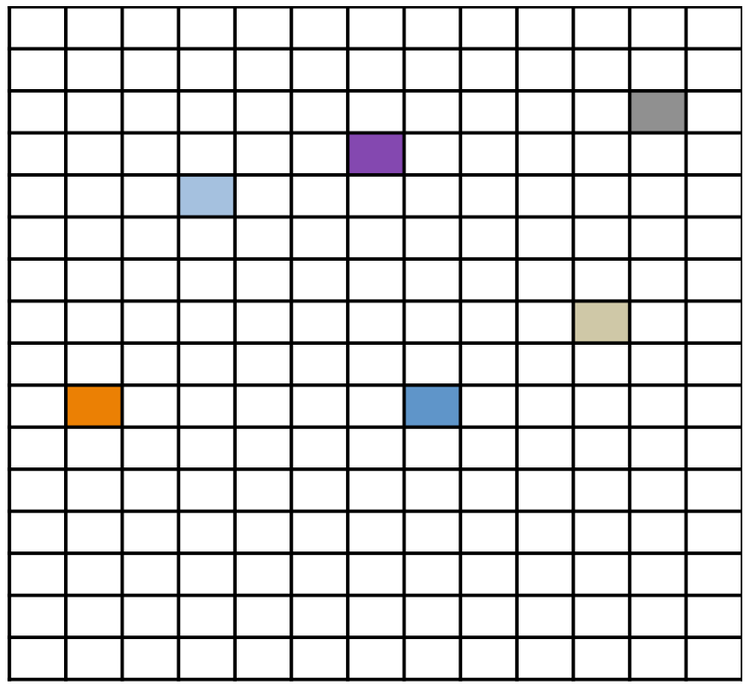




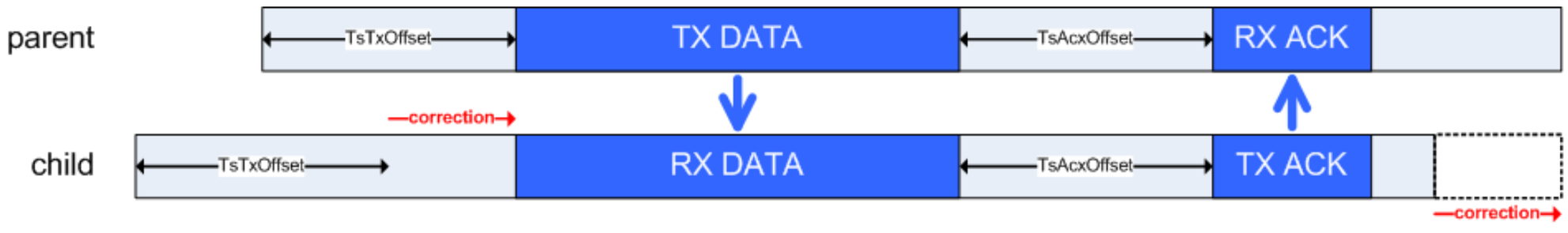
c.f. [Thomas, OpenWSN Overview]

IEEE802.15.4e - Synchronization

- Synchronization
  - Slot Synchronization
  - Absolute Slot Number Synchronization



- Re-synchronization



c.f. [OpenWSN Website]

Energy Background

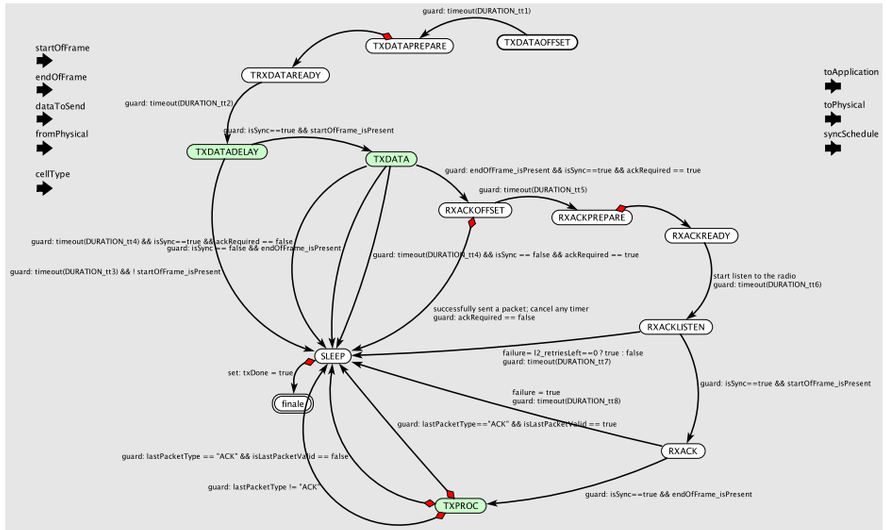


TABLE II

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

GenericMode	AT86RF231 Mode	Current	Measured
Sleep	TRX_OFF	0.4mA	0.49mA
ToReady	TRX_OFF $\Rightarrow PLL\_ON$	5.6mA	N/A
Ready	PLL_ON	5.6mA	5.4mA
Tx	$BUSY\_TX$	11.6mA (0dBm)	13.7mA (0dBm)
ToListen	TRX_OFF $\Rightarrow PLL\_ON$ $\Rightarrow RX\_ON$	12.3mA	N/A
Listen	RX_ON	12.3mA	11.6mA
Rx	RX_ON	12.3mA	11.6mA

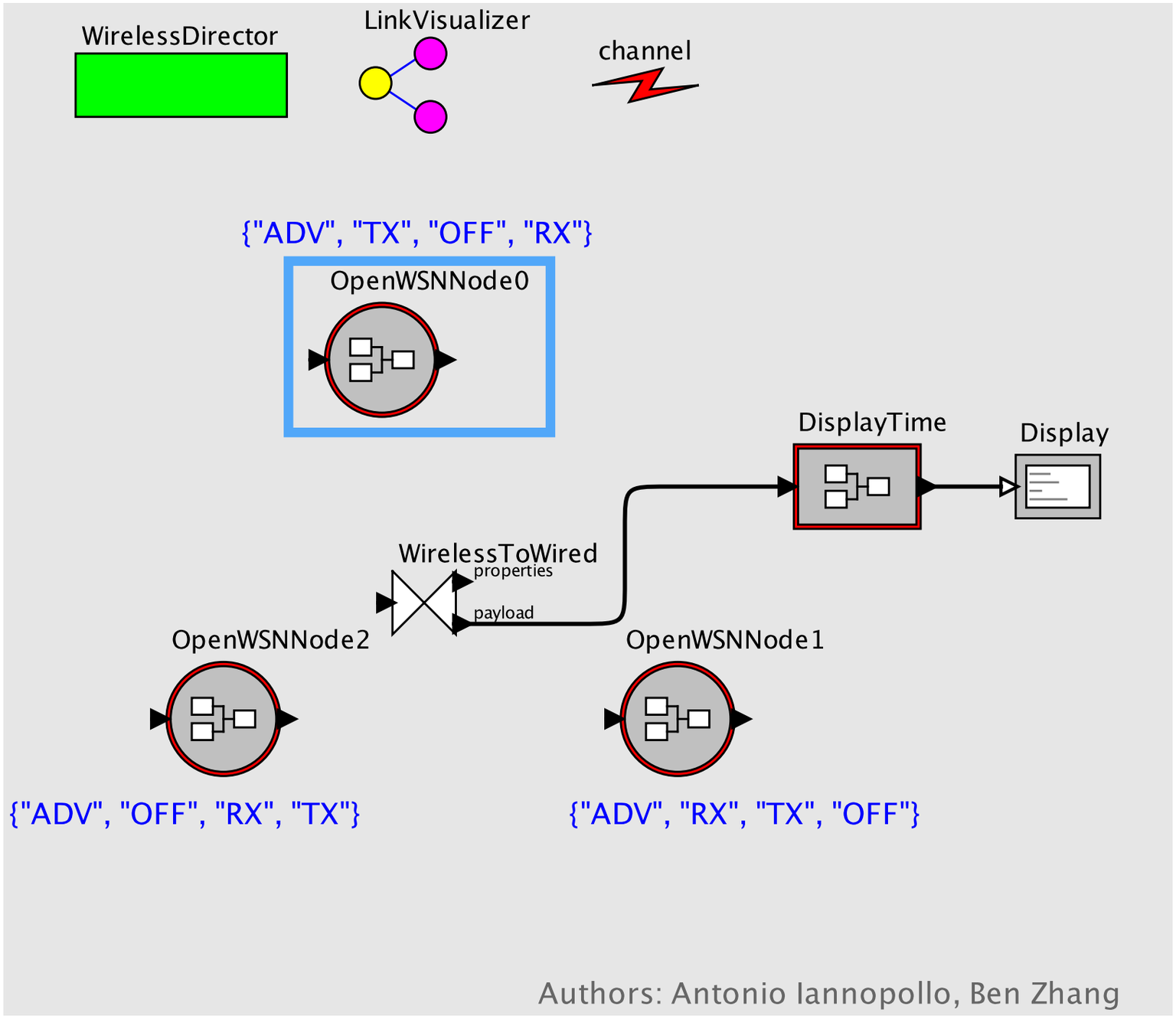
TABLE I

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

c.f. [VILAJOSANA et al.: REALISTIC ENERGY CONSUMPTION MODEL FOR TSCH NETWORKS]

Ptolemy Modeling - 1



Ptolemy Modeling - 2

DEDirector

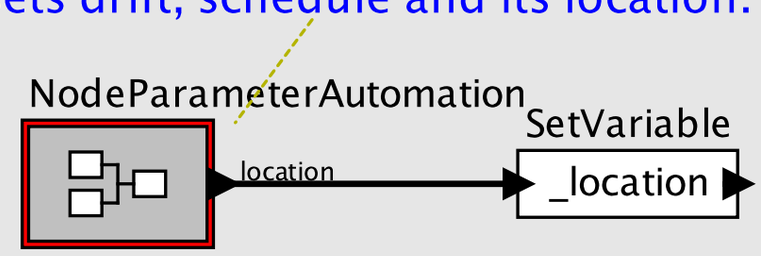
- drift: 2.6429852065262222E-6
- nominalClockFrequency: 1/32000
- localAddress: 0
- networkMaster: true
- schedule: {"ADV", "OFF", "RX", "TX"}

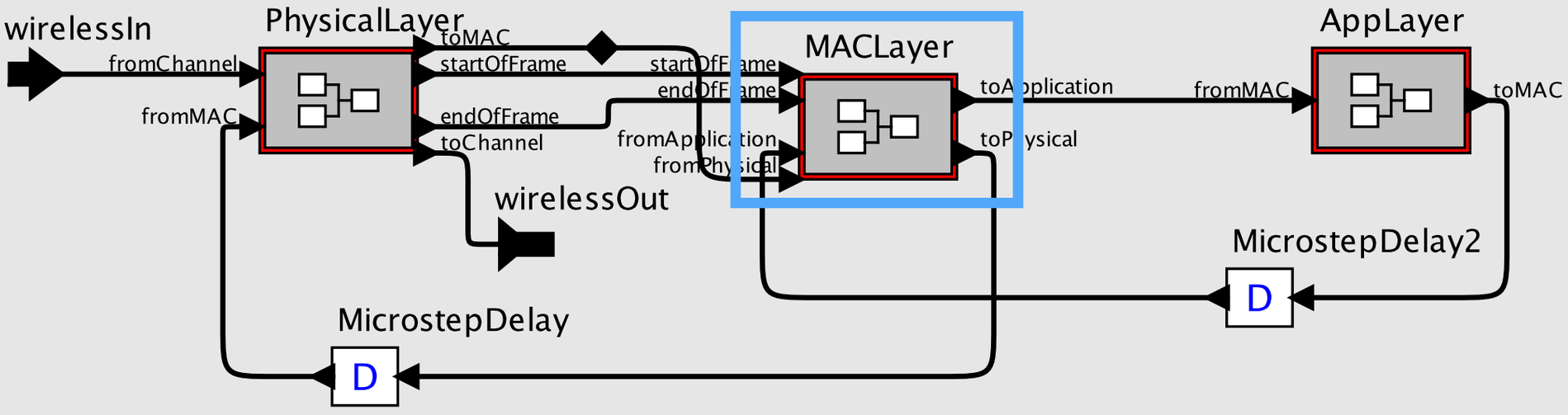
- PORT_delayTx: 0
- PORT_delayRx: 0
- PORT_TsSlotDuration: 491
- PORT_maxRxDataPrepare: 33
- PORT_maxTxDataPrepare: 66

Sensor node platform dependent values.

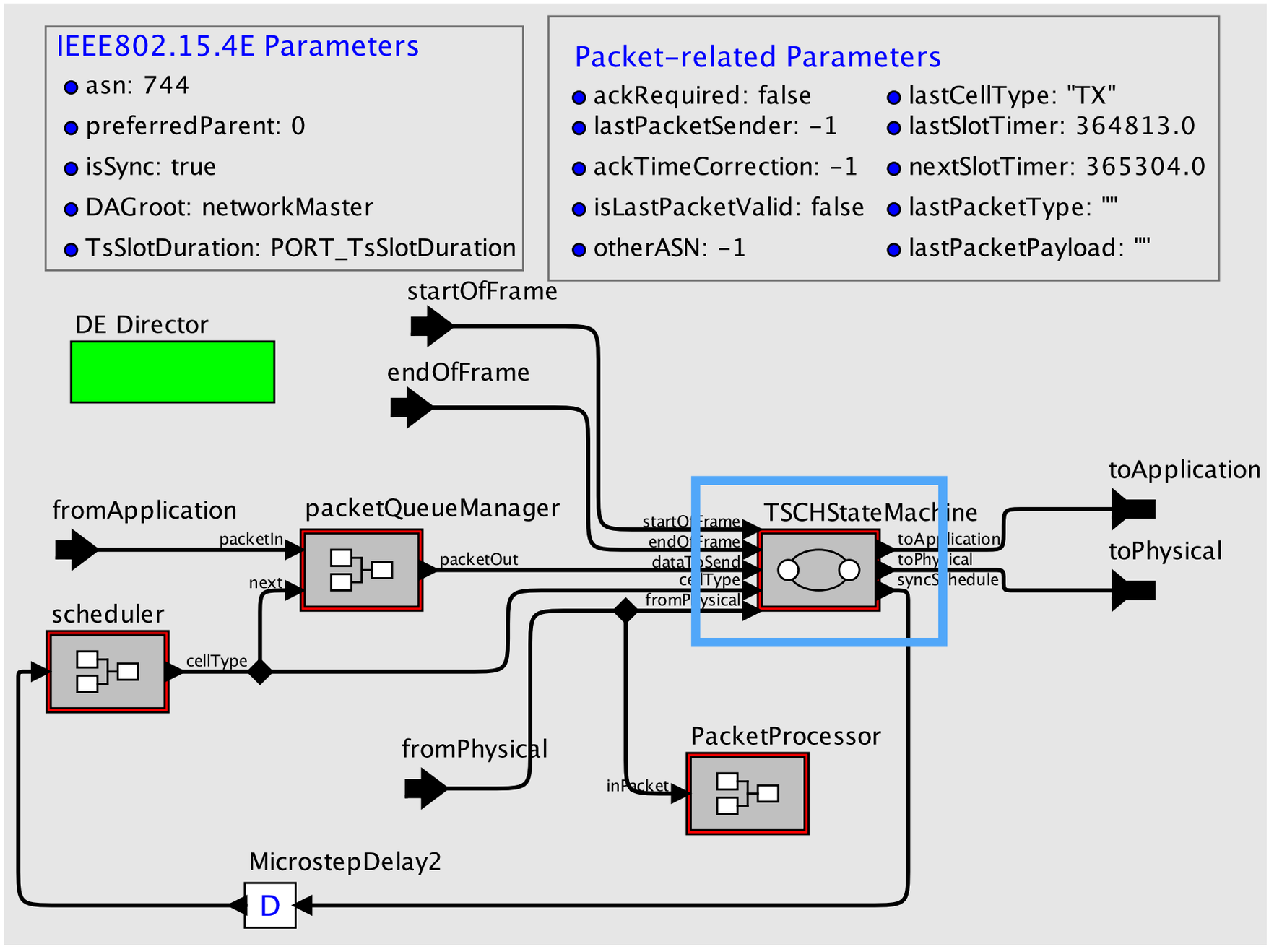
- PORT_maxRxAckPrepare: 10
- PORT_maxTxAckPrepare: 22

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

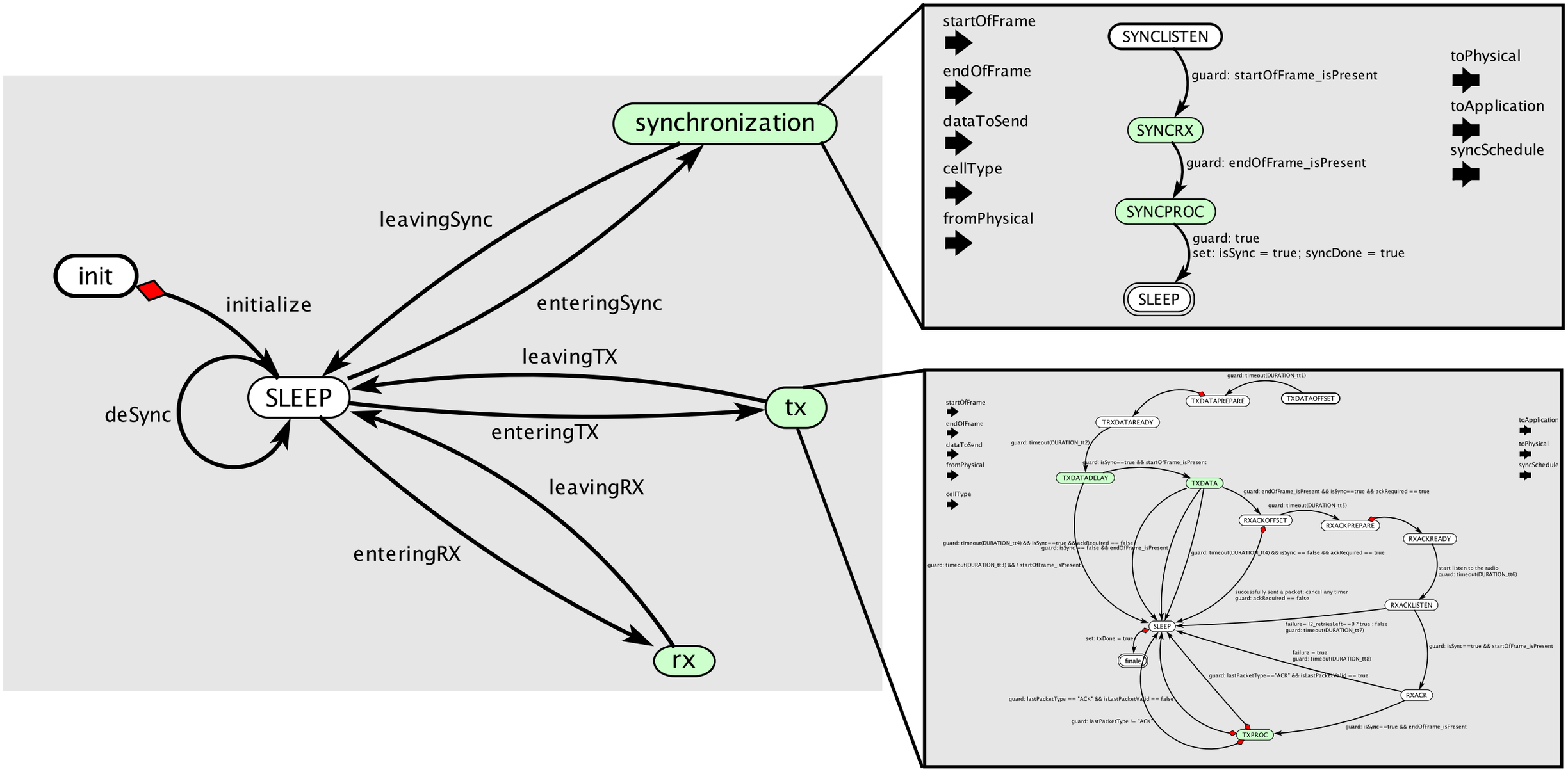




Ptolemy Modeling - 3



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.

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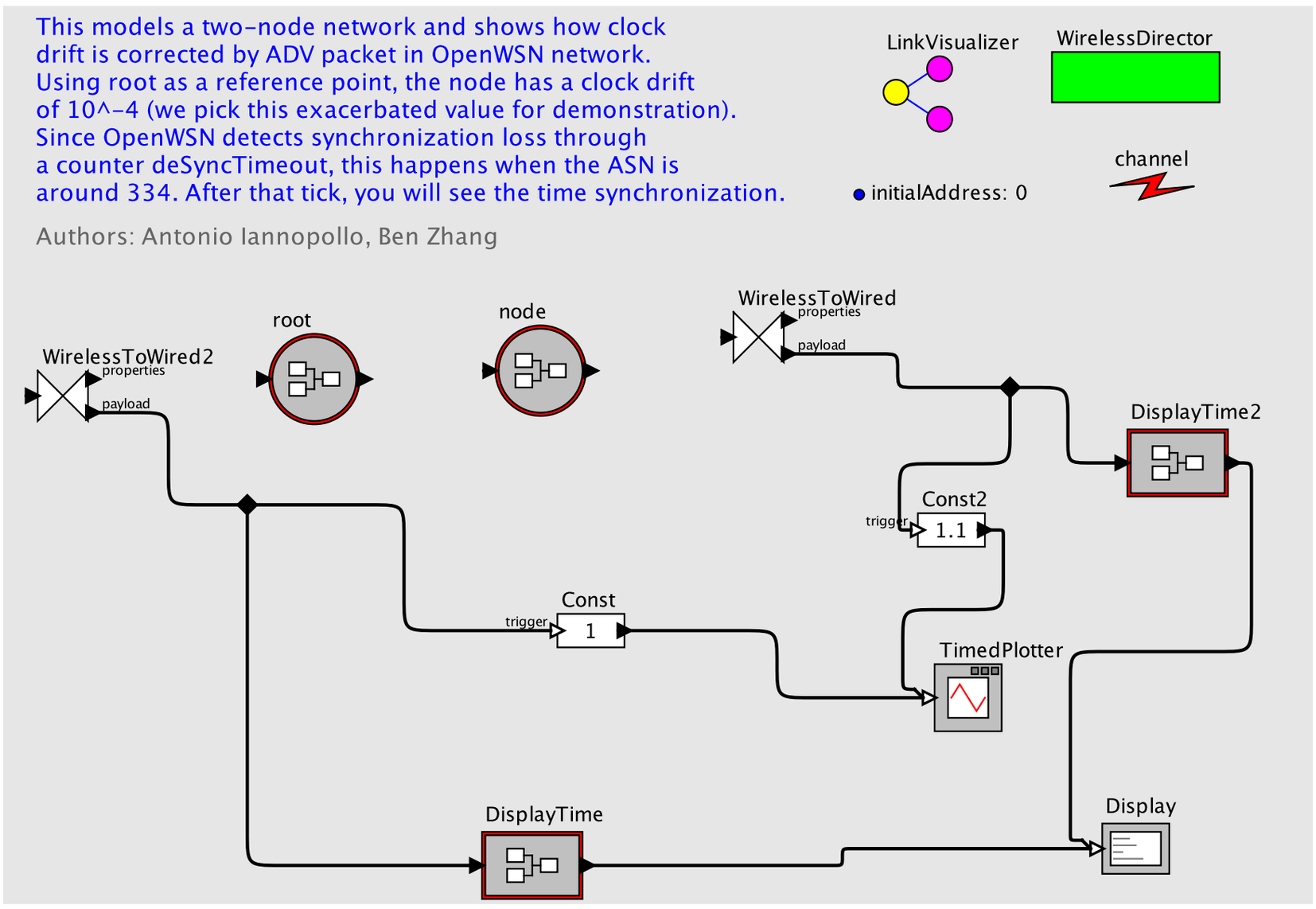
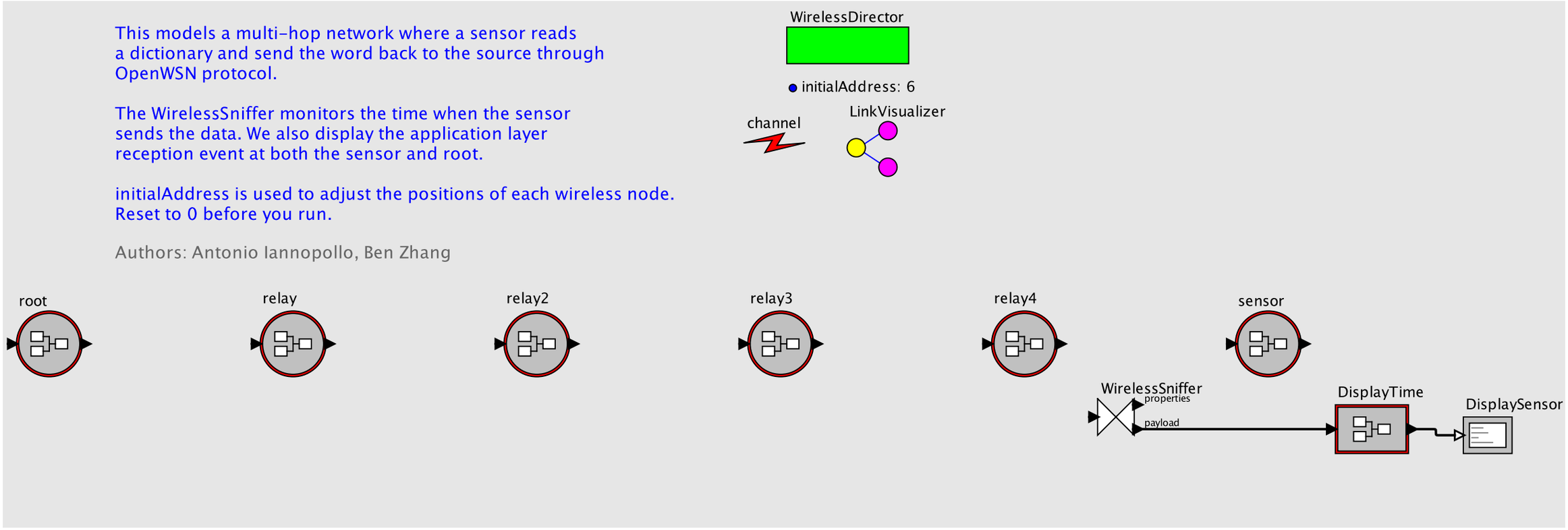


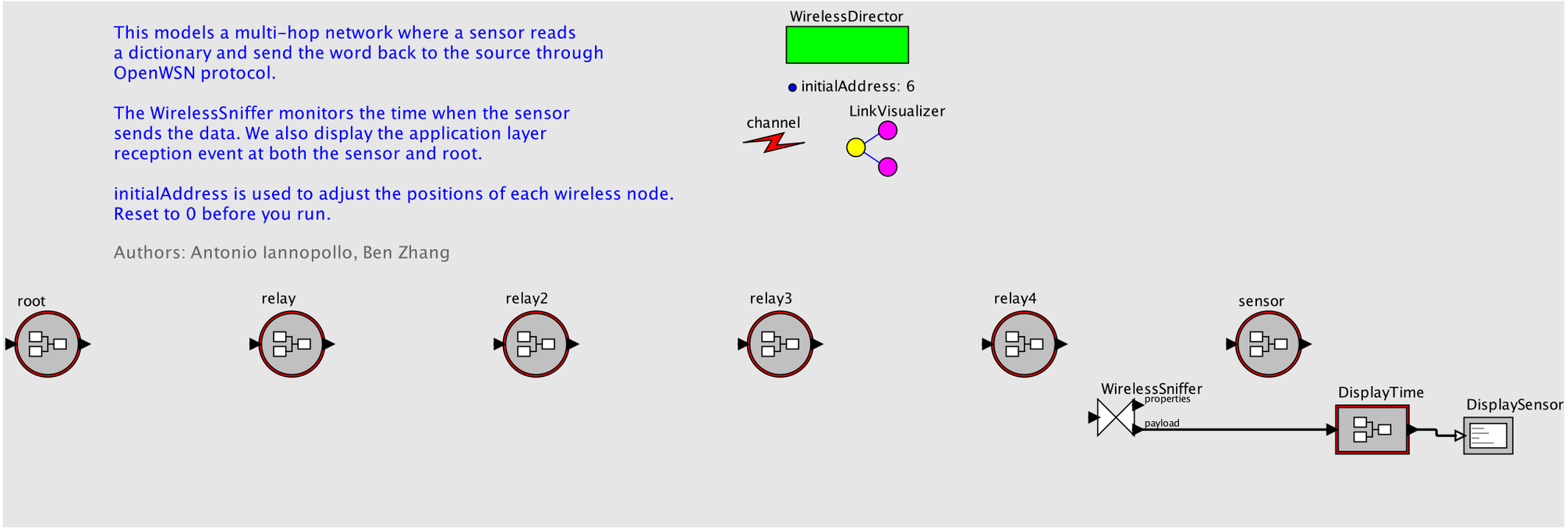
vergil ~/repos/ModelingOpenWSN/apps/demo_sync.xml

Demo 2:
Multihop Transmission



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

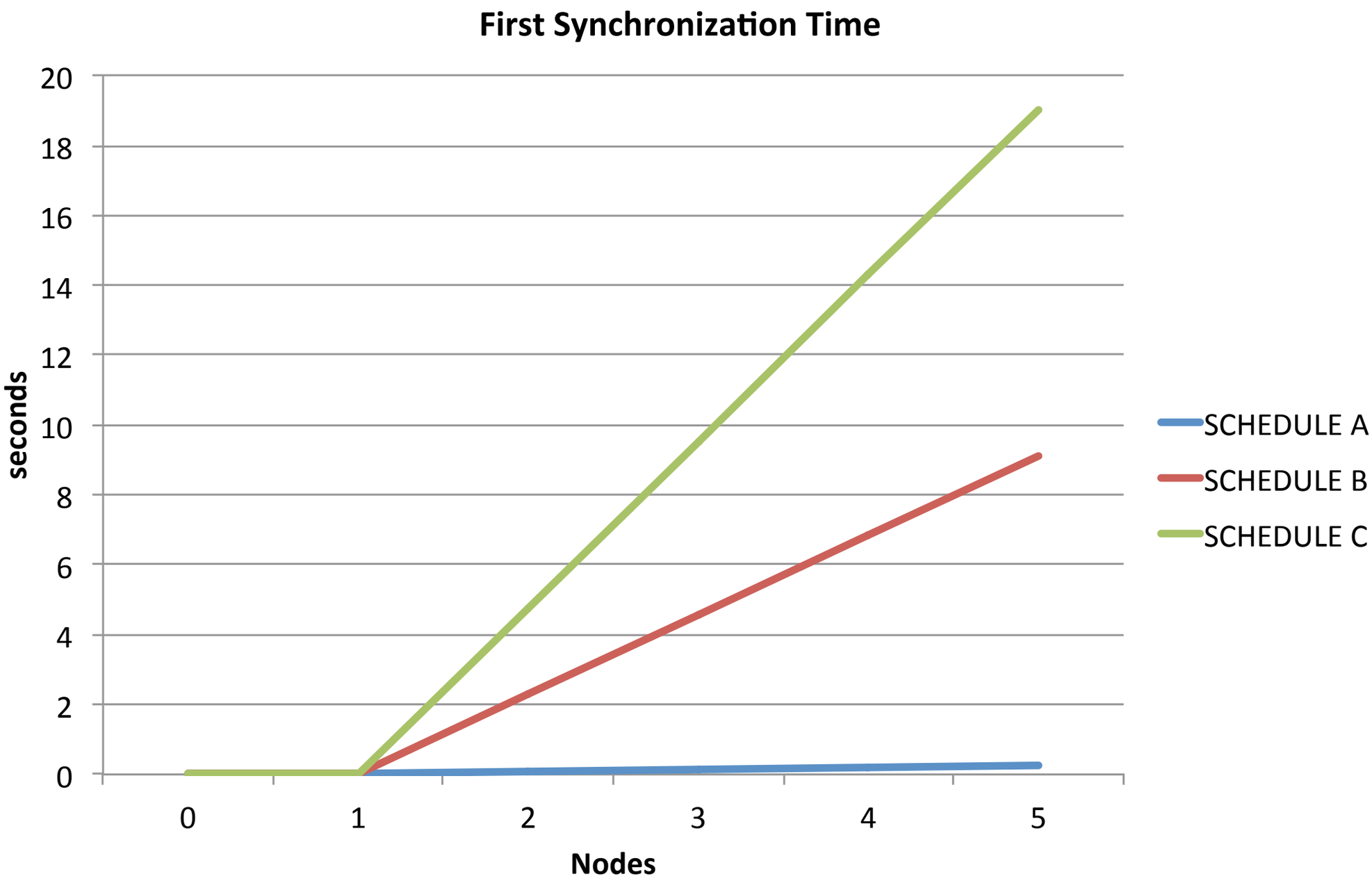
Case Study



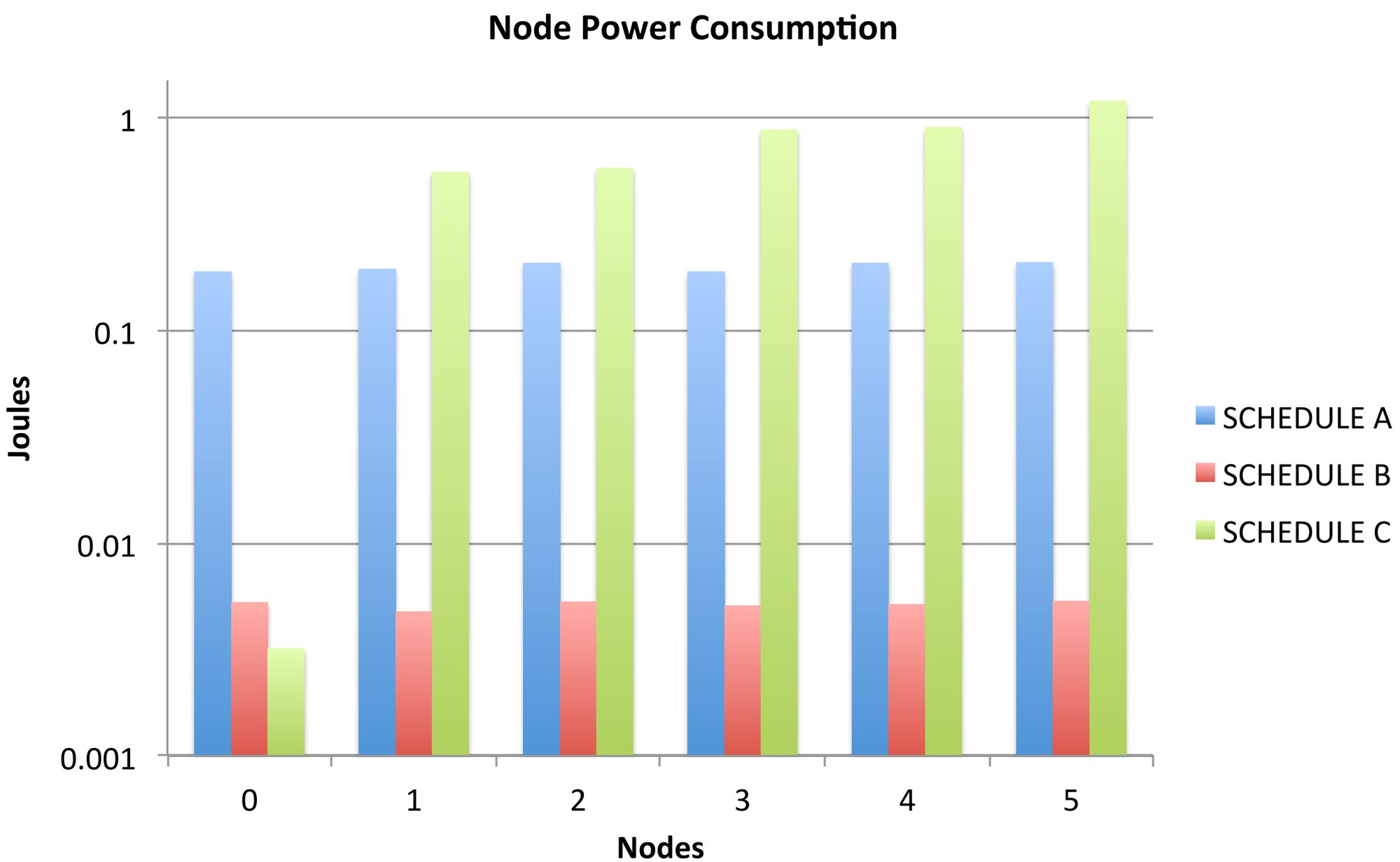
NodeId	Schedules				
$3i+0$	ADV	TX	RX	OFF	$k \times$ OFF
$3i+1$	ADV	RX	OFF	TX	$k \times$ OFF
$3i+2$	ADV	OFF	TX	RX	$k \times$ OFF

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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