

Simulation of Powerline Communications with OMNeT++ in (static) Smart Grids

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What is Powerline Communication?

- **Basically: Use of existing mains network lines for communication – meaning both access and in home environments.**
- Works in the frequency range from 2 MHz to 30 MHz (in home BPLC and access BPLC) or below 500 kHz (only access PLC).
- Provides (theoretically) data rates up to 200 MBit/s (dLAN 200 BPLC) or 128 kBit/s (Prime PLC)
- All newer variants use some kind of OFDM with static notches on the PHY-Layer.
- Not yet fully standardized (but some exist, e.g. HomePlug, ITU G.hn, IEEE P1901.1 and P1901.2). Many proprietary solutions.
- **Different features on MAC-Layer at each variant.**

Implemented Features

- MAC-Layer
 - CSMA/CA or TDMA or both (dynamic change)
 - Inter System Protocol (according to IEEE P1901)
 - (Static Notching +) Smart Notching
 - Priotitized Channel Access (up to 4 levels)
- PHY-Layer
 - Varying data rate
 - Varying packet error rate (correlated with data rate)
 - Length depending data rate decrease
 - Topology depending data rate decrease

The different Modules

- **PLC Net Module**

- Does the PHY-Layer management
- Acts as central coordinator for a network (CCo)



- **PLC Encap Module**

- Packs and unpacks the frames
- Sets time stamps



- **PLC MAC Module**

- Manages the channel access
- Reacts on the PHY-Layer fluctuations



- **Data Collector Module (Help module)**

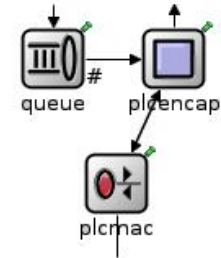
- Collects data from every PLC unit in the net



The different Compounds

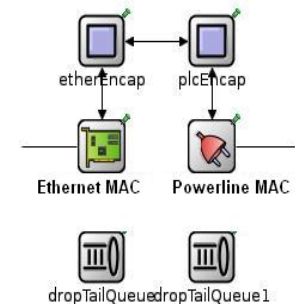
- **Internal PLC Modem**

- Is a common use case for narrowband PLC
- Works inside a standard host instead of Ethernet



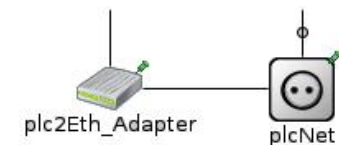
- **Socket Adapter Modem**

- Is a common use case for broadband PLC
- Works as a bridge between Ethernet and PLC

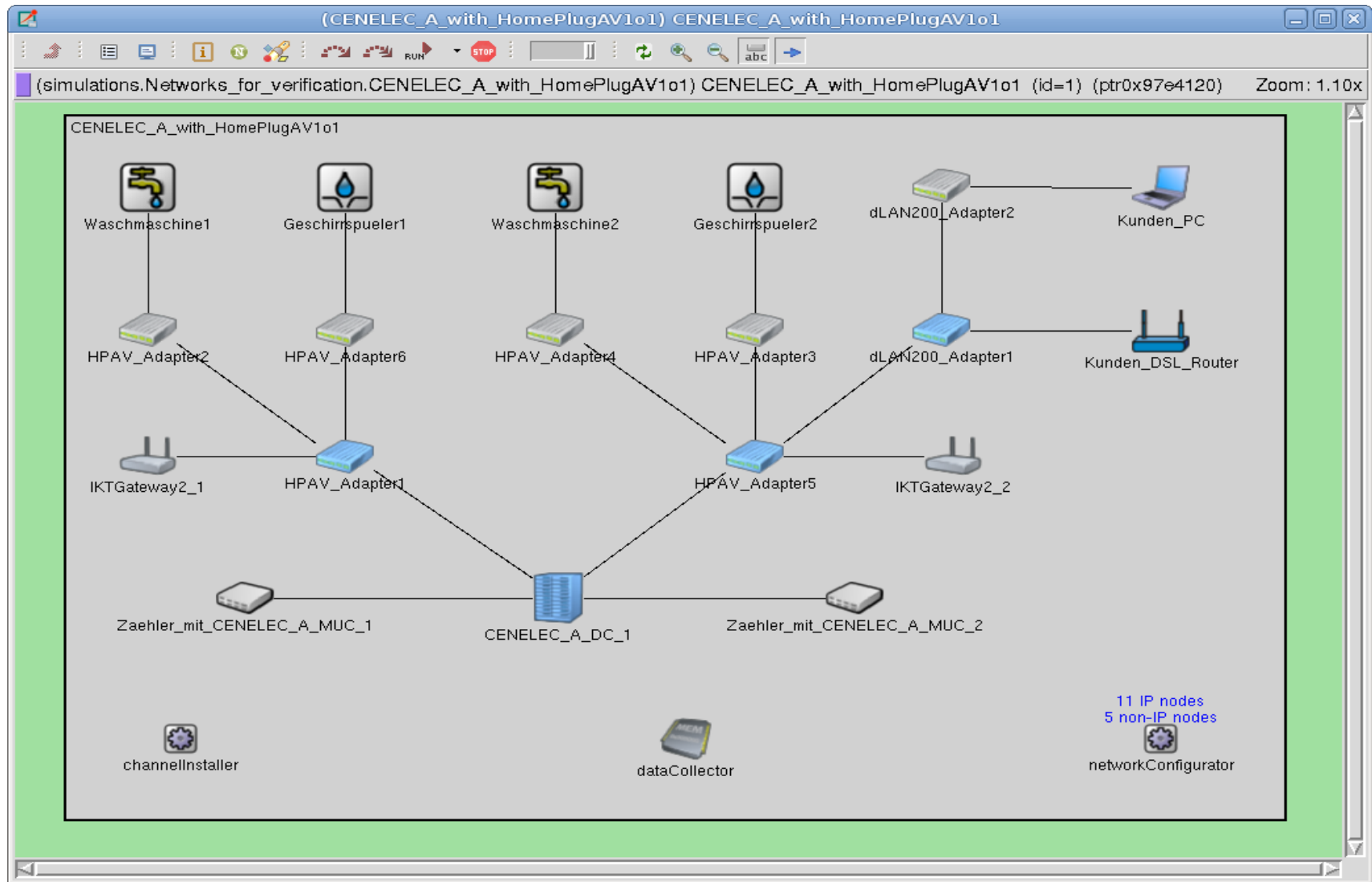


- **CCo Modem**

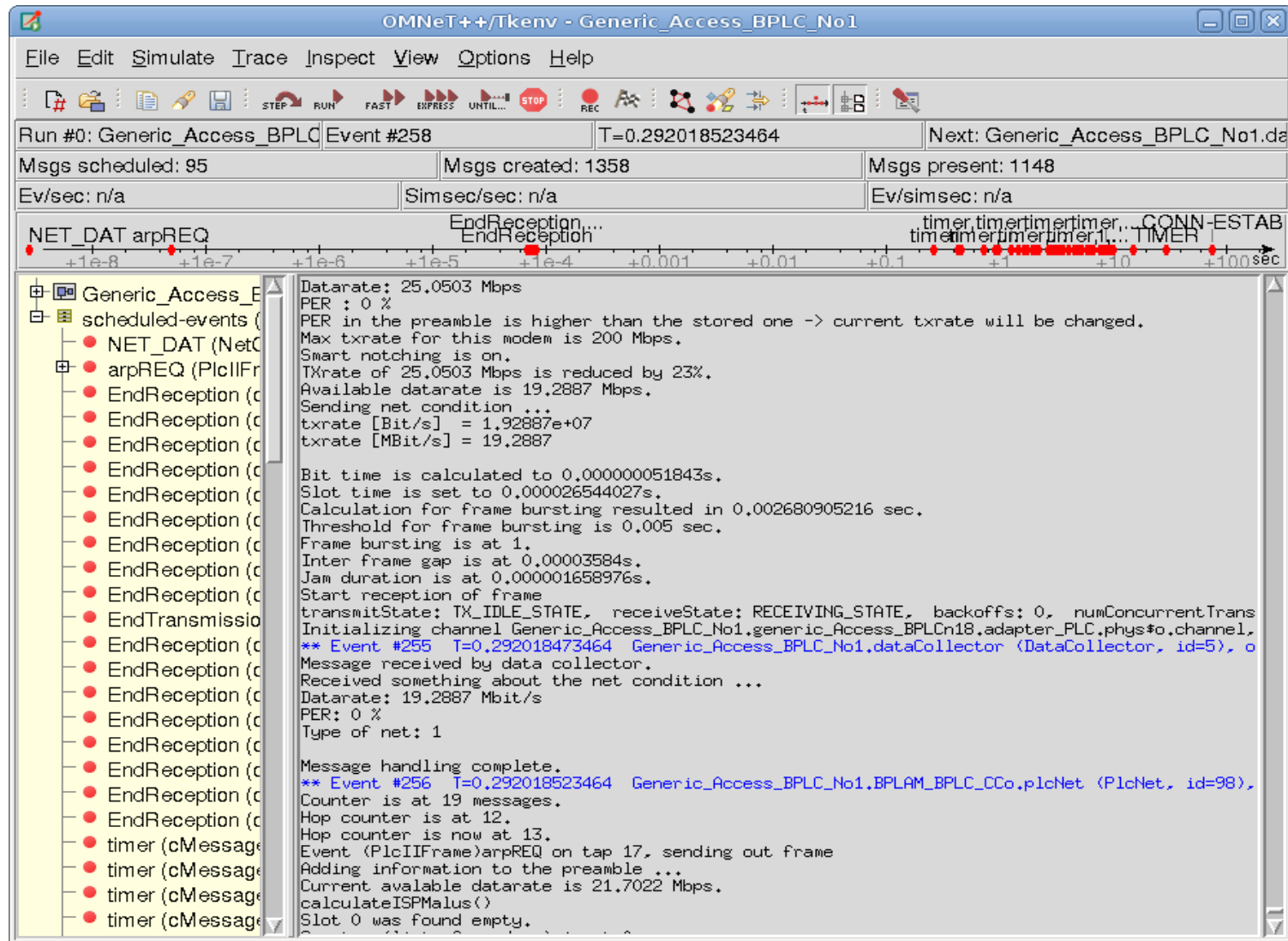
- Is a variant of both with a PLC Net Module
- One CCo is necessary for every different system in a single mains network
(this is meanwhile different from the information in the paper)



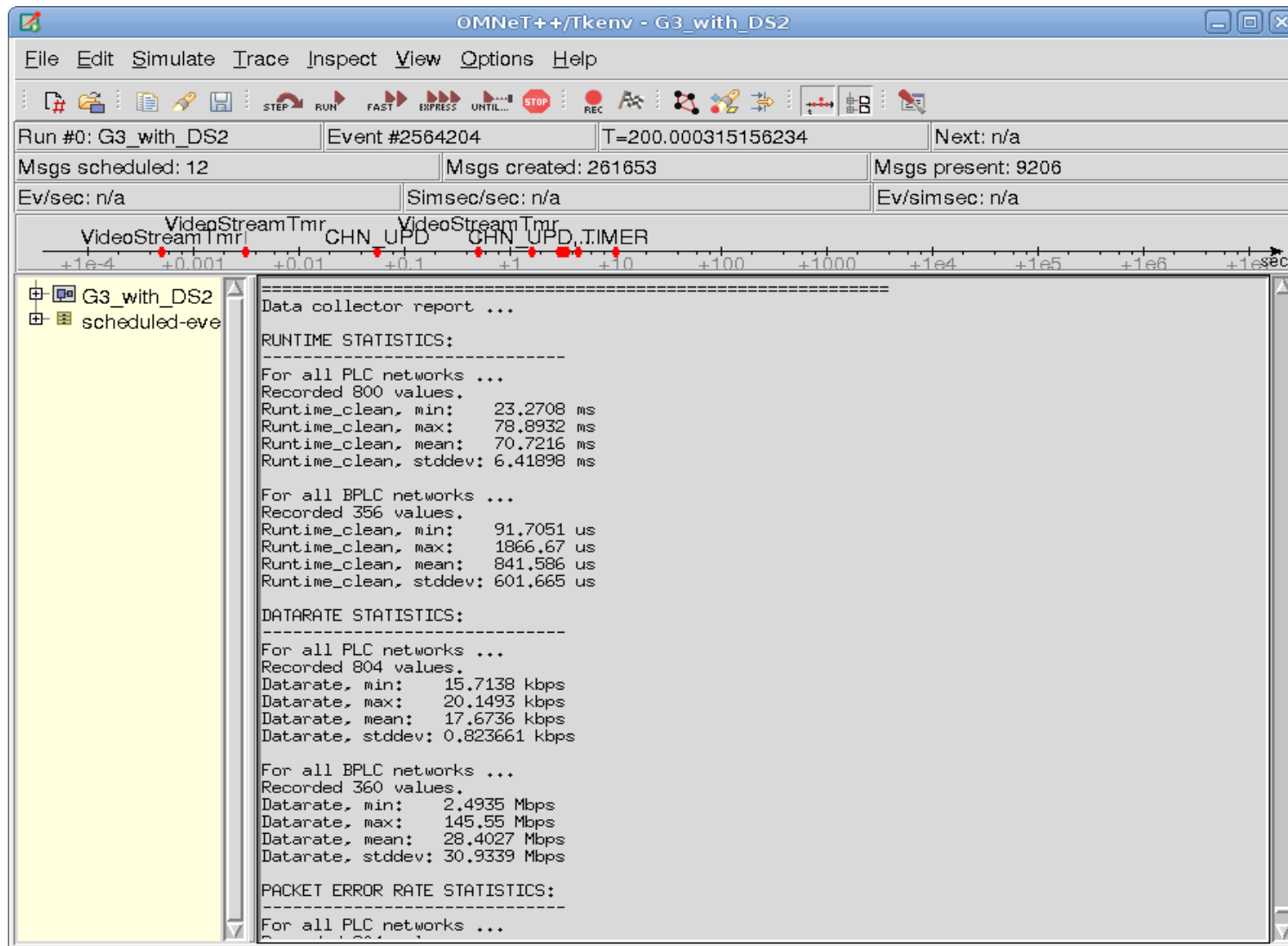
A Sample Network



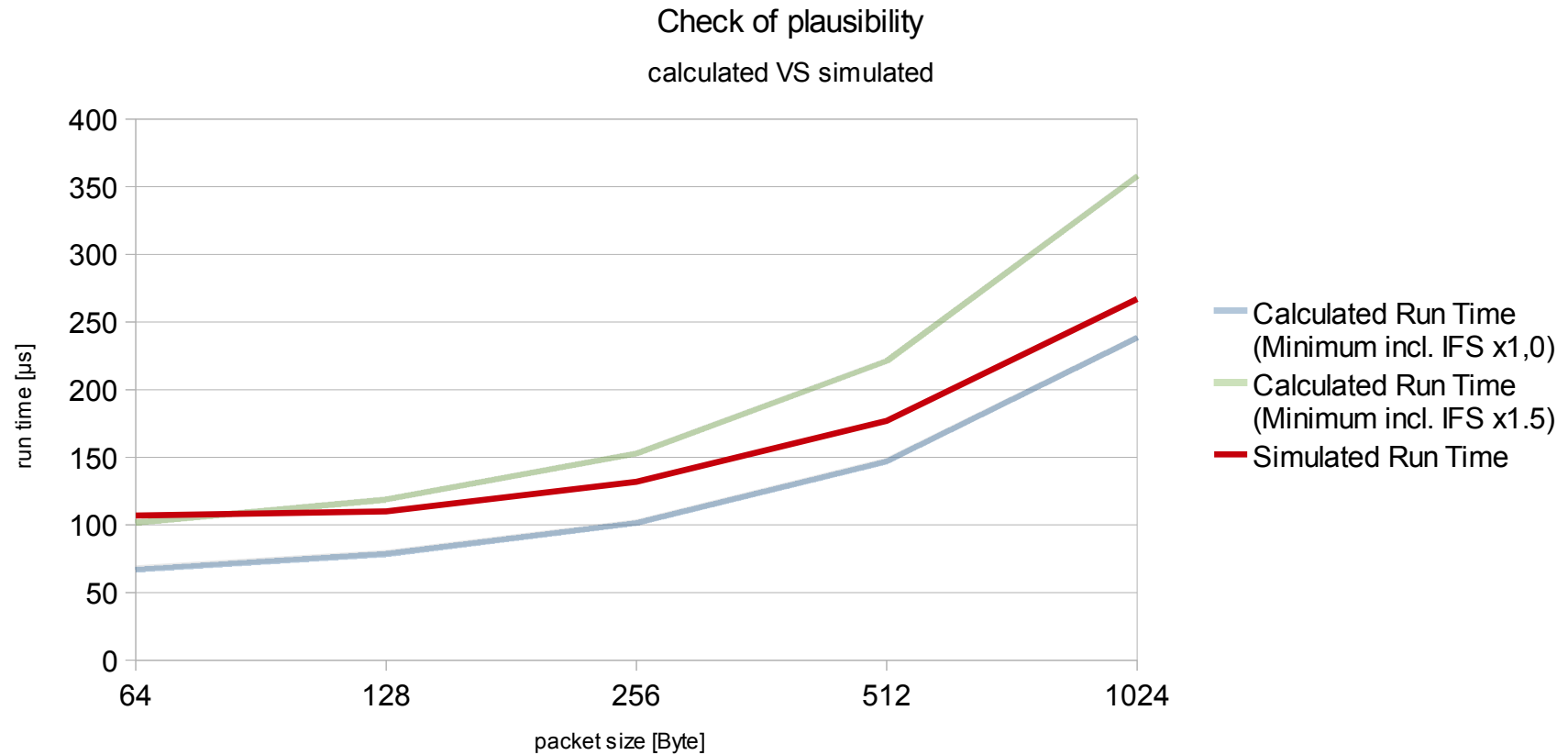
Verification of the overall Behavior



Sample Data Collector Output

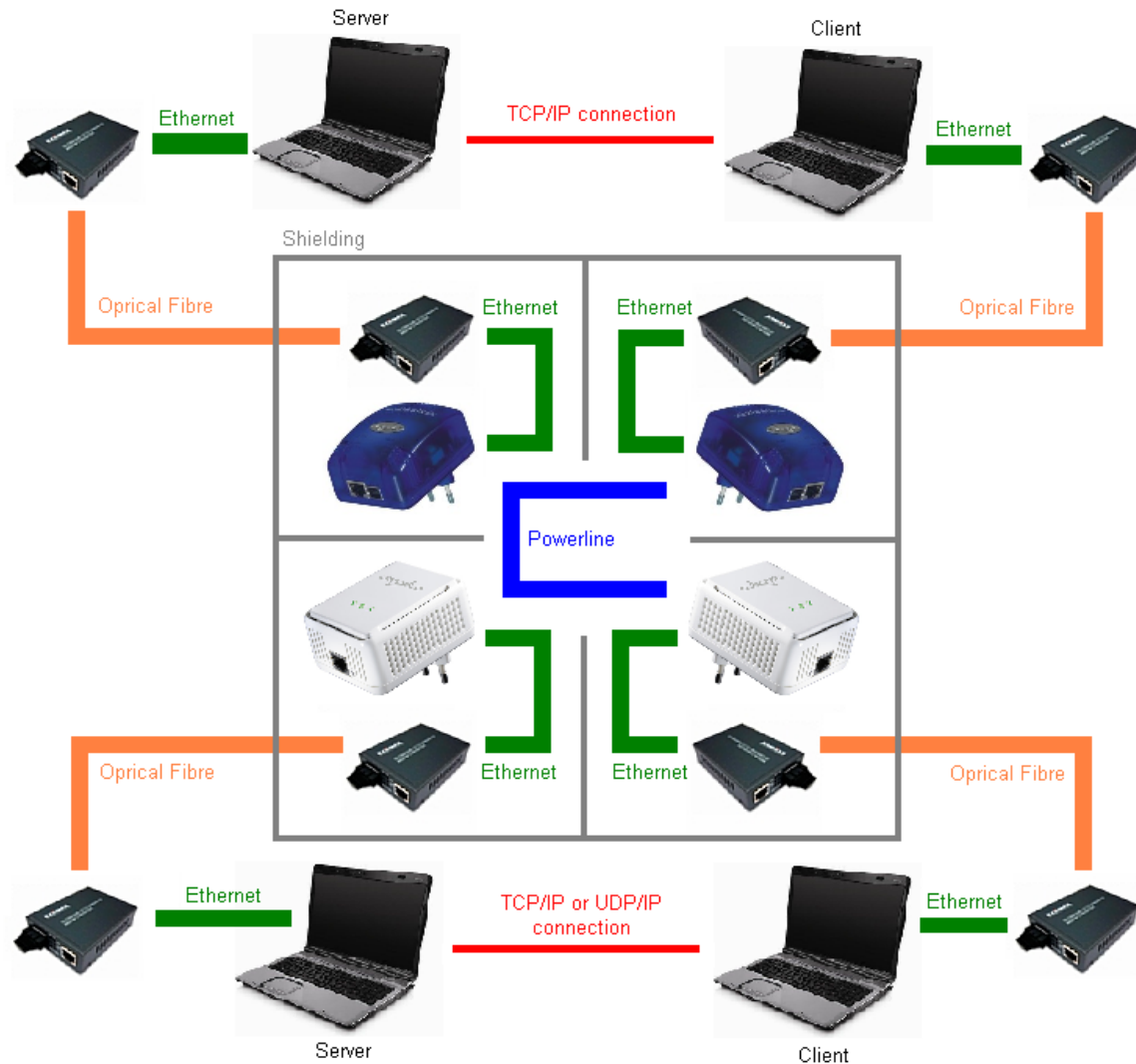


Verification of the Run Times

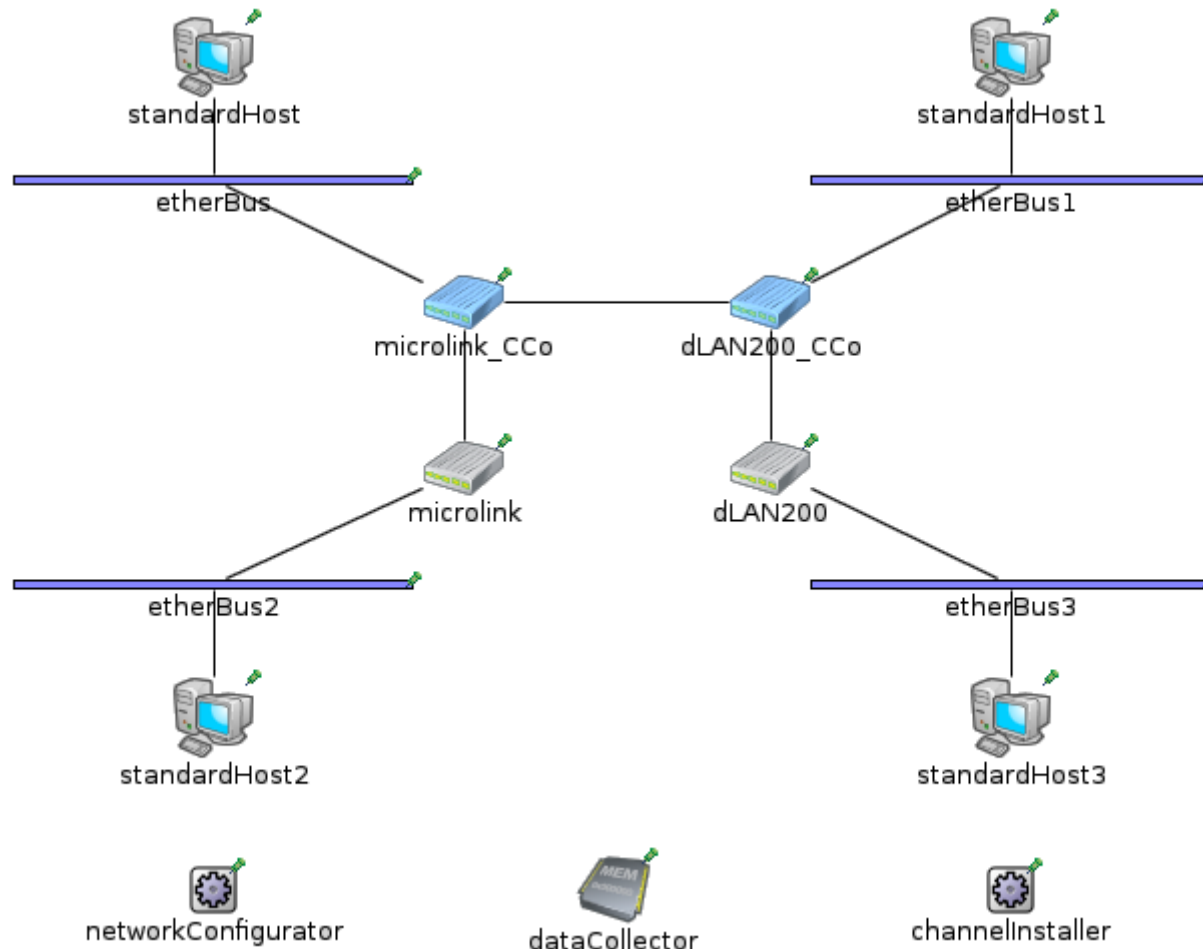


This result comes from a simple point-2-point connection network, which simulates devolo dLAN 200 modems.

A Real Testing Network



Simulated Network



Verification of ISP Behavior

The image displays six screenshots from the OMNeT++ simulation environment, arranged in a 2x3 grid. Each screenshot shows a different component of the simulation, with a focus on network performance metrics and event logs.

- Top Left:** Shows the main simulation window for 'LaboratorySetup_2'. The status bar indicates 'Run #0: LaboratorySetl, Event #61', 'T=0.500009614999', and 'Next: LaboratorySetup_2.eth'. The console shows event logs for ARP resolution and packet transmission.
- Top Middle:** Shows a detailed view of the 'LaboratorySetup_2.dLAN200_CCo' component. A red circle highlights the 'Current datarate: 84.500000 Mbit/s Mode: CSMA'.
- Top Right:** Shows a detailed view of the 'LaboratorySetup_2.microlink_CCo' component. A red circle highlights the 'Current datarate: 4.790000 Mbit/s Mode: CSMA'.
- Bottom Left:** Shows the main simulation window for 'LaboratorySetup_2' at a later time, 'Event #102', 'T=0.500233317079'. The console shows event logs for message handling and packet transmission.
- Bottom Middle:** Shows a detailed view of the 'LaboratorySetup_2.dLAN200_CCo' component. A red circle highlights the 'Current datarate: 82.895000 Mbit/s Mode: CSMA'.
- Bottom Right:** Shows a detailed view of the 'LaboratorySetup_2.microlink_CCo' component. A red circle highlights the 'Current datarate: 2.442900 Mbit/s Mode: CSMA'.

Results from the Simulation

TABLE II. CONFIGURATION FOR THE SIMULATION

Parameter	Max.	Average	Min.
Fast PLC data rate	200 MBit/s	64.5 MBit/s	6 MBit/s
Slow PLC data rate	14 MBit/s	4.79 MBit/s	1.2 MBit/s

TABLE III. SAMPLE RESULTS FOR THE SIMULATION

Parameter	Measured	Simulated	Accuracy
Fast PLC data rate	31.1 MBit/s	31.18 MBit/s	99.7 %
Slow PLC data rate	2.33 MBit/s	2.48 MBit/s	93.9 %

Conclusion

- The toolkit provides a good base for the simulation of various existing PLC variants in a (rather static) smart grid environment.
- The more is known about the timing constants of a system, the more accurate is the simulation.
- Through the variation of parameters, the benefit of improvements can be estimated in advance.