Traffic Analysis of Broadband over Power Line (BPL) over Power Line Communication (PLC) Medium

URL: http://www.sfu.ca/~gba2/

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Introduction to BPL and PLC

- Broadband over Power Line (BPL) runs over Power Line Communication (PLC) medium (medium-voltage lines)
- PLC network allows efficient deployment of a control network, taking advantage of the existing electrical infrastructure
- The use of BPL using PLC allows medium-voltage supply networks to deliver various communication services
- Internet access, voice over IP (VoIP), automatic meter reading (AMR), and home and building automation
- Services possible are highly dependant on data throughput, reactance to noise and background traffic, and “burstiness” of transmission
- BPL over PLC provides 200 Mbps (up + down)
Introduction – Project Idea

- Idea: Analyze data throughput, utilization, delay, collisions, and burstiness (throughput fluctuation) of varying traffic
- Goals:
  - Use OPNET 14.0
  - Create a basic BPL network running over PLC nodes and medium
  - Model different traffic generation schemes
  - Simulate the network operation
  - Analyze and compare results
- Desired Scope:
  - BPL Head-End Unit
  - BPL End-Point Units
  - Various traffic generators (constant size and arrive, exponential size and arrival)
  - PLC medium links
Introduction – The Technology

- Adapters at centralized locations carry broadband internet traffic
- Adapters convert data to special frequencies that can be combined with electricity
- End point BPL modems to separate data from electricity, data sent to Ethernet port
Introduction – The Technology cont’d

- BiPAC 2300 BPL Access Head-End Unit
- BiPAC 2103 BPL Access End-Point Unit
- PLC Medium Voltage Aluminum Power Line
- 100BaseT Duplex Ethernet Link
Introduction – Why BPL/PLC?

• Reduced power costs and pollution

• Increased reliability and security

• Electrical Infrastructure already exists

• No need for additional modems or routers besides head-end/end-point units

• AMR/SmartGrid overlay capability – effective control over the power transmission grid to increase efficiency and transmission while reducing costs
Implementation Details – Overall Design

- Network diagram:
Implementation Details – Overall Design cont’d

- Model diagram:
Implementation Details – System Schematic
Implementation Details – Node Models

- **BPL Access Head-End Unit**
Implementation Details – Node Models cont’d

- BPL Access End-Point Unit
Implementation Details – Node Models cont’d

• Constant Traffic Source
Implementation Details – Node Models cont’d

- Exponential Traffic Source
Implementation Details – Process Models

- Hub_Tx in BPL Head-End Unit
  - Receives data from subnet
  - Emulates physical medium
  - Sends results to switch process

- Hub_Rx in BPL Head-End Unit
  - Receives data from head-end unit
  - Converts electrical signal to ethernet
  - Sends results to workstation
Implementation Details – Traffic Generators

- **Constant Traffic Subnet**
  - Generates self-similar packets
  - Interarrival time is constant

- **Exponential Traffic Subnet**
  - Generates exponential distribution of packets
  - Interarrival time follows exponential distribution
Implementation Details – OPNET Configuration

- **OPNET 14.0 Configuration File**
  
  #number of logical channels
  log_channels: 1

  #tells what type of protocol exists in each logical channel
  log_channel_0 : BPL_PLC
  #log_channel_1 : BPL_alt
  #log_channel_2 : BPL_alt

  #tells the number of slave nodes
  slave_nodes : 2

  #initial repeater level
  repeat_downlink : 1
  repeat_uplink : 1

  #number of retries
  number_retries : 2

  #timeslot for start of collecting statistics
  start_timeslot : 0
Discussion – Some Results

- Data throughput between traffic generator and head-end unit
- Down and up traffic

- Result summary: Exponential traffic shows less burstiness, delay, and collisions. See project report for full results.
Discussion – Challenges

- OPNET crashes, library errors, login issues, remote access problems
- OPNET provides no native support for PLC medium
- Lack of relevant models available on OPNET online library
- BPL and PLC relatively new technology
- Lack for relevant documentation available
Discussion – Possible Improvements and Future Work

- Increase scope by adding workstation nodes and end-point units
- Create a node that better emulates the PLC link medium
- Implement Remote Energy Management over Power Lines and Internet (REMPI) Project libraries for more robust simulation
- Incorporate iAd Physical Layer Emulator (C++) interface into OPNET to achieve greater model accuracy
- Add more types of traffic to be transmitted over PLC link – voice, AMR
- Obtain more metrics (jitter, packet loss, latency)
- Introduce background load and noise into PLC network
Discussion – Lessons Learned

- Potential of BPL over PLC as a robust communication medium
- Using OPNET to effectively model a network
- Modifying existing models to suit our design
- Creating a process model from scratch using Proto-C
- Reading and analyzing simulation results
- Managing time and resources to complete project
References


Thank You!