Interactions Between TCP/IP Protocol Stack and Long-Reach PON

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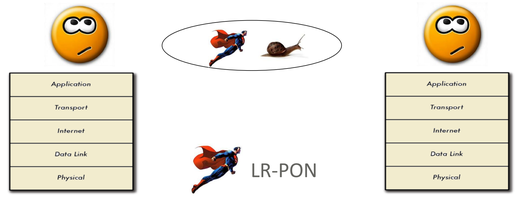


Motivations

- ❑ LR-PON has the potential of providing abundant bandwidth to large number of users with low cost.
- ❑ However, the users care about the Quality of Service experienced by network applications.
- ❑ Thus, it is worthwhile to study the interactions among LR-PON and the protocols / algorithms used by TCP/IP protocol stack

Analysis vs. Testbed vs. Simulation

Analysis

- ❑ Too complex to model LR-PON and TCP/IP protocol stack together
- ❑ Analysis with some over-simplified model is questionable

Testbed

- ❑LR-PON hardware components are still under development.
- ❑ Too expensive to build one LR-PON with one thousand ONUs.

Simulation

- ❑ The credibility is lower than testbed
- ❑ Simulation speed might be too slow for a 10Gbps LR-PON with 1000 ONUs.

Our Choice

- ❑ Simulation is selected since it is the only feasible choice in current phase
- ❑ Improving simulation speed through the justified simplifications in physical layer and the heavily hacked code.

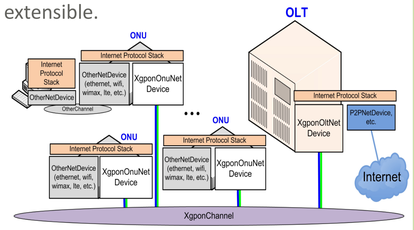
Simulator Features and The Reference Simulation

Simulator Features

- ❑ This simulator is developed based on NS-3, the state of the art network simulator.
- ❑ It follows the standard of XG-PON (G.987 Recommendations).
- ❑ Encryption is not implemented although key management is supported.
- ❑ Physical layer issues (FEC, Line coding, etc.) are simplified for saving CPU.
- ❑The scheduling and DBA algorithms are extensible.

Reference Simulation

❑ Through changing the network used to connect the client computer and the ONU, we can study various scenarios of the integration between optical and wireless networks.



Transport Protocols on LR-PON

TCP on LR-PON

- ❑ Due to the large number of ONUs and QoS support, Internet traffic tends to experience dynamic bandwidth, long delay, and large jitter.
- ❑ It is worthwhile to study TCP performance on LR-PON, especially the interactions between TCP and DBA/scheduling algorithms of LR-PON.
- ❑Due to high bandwidth provided by LR-PON, it is worthwhile to study high-speed TCP variants on LR-PON, such as Cubic-TCP distributed with Linux and Compound-TCP proposed by Microsoft

Multipath TCP on LR-PON + Wireless Networks

- ❑MP-TCP is proposed to improve the performance of mobile devices through multiple wireless networks.
- ❑ Since various wireless networks will be attached to the same LR-PONs, it is valuable to study MP-TCP under this scenario.

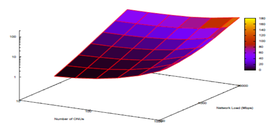
Performance of LR-PON Simulator

Computer Configuration

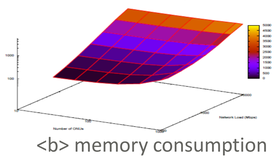
- ❑ CPU: Intel(R) Xeon(R) CPU E5-1410 0 @ 2.80GHz (4 cores). Cache: 10240 KB; Note that just one core is used in the simulations.
- ❑ Memory: 48GB

Simulation Setup

- ❑ XG-PON1 is simulated (DS: 10G; US: 2.5G).
- ❑ UDP traffics are simulated for both directions (the upstream load is 1/4 of the downstream).
- ❑ Downstream load varies from 150M to 10G.
- ❑ The number of ONUs varies from 25 to 1000.



<a> simulation speed



<b> memory consumption

Key Messages

- ❑ It takes less than 200s to simulate one second even when there are 1000 ONUs and the network load is 10Gbps.
- ❑ Under the hardest scenario, the amount of consumed memory is just slightly higher than 5GBytes

Progress and Future Work

Progress

- ❑ Developed jointly by researchers from both UCC and TCD.
- ❑ Source code is available (contact with the authors)
- ❑ One paper has been published.
  - ❖ X. Wu, K.N. Brown, C.J. Sreenan, P. Alvarez, M. Ruffini, N. Marchetti, D. Payne, and L. Doyle, "An XG-PON Module for the NS-3 Network Simulator", Workshop on NS-3, 2013

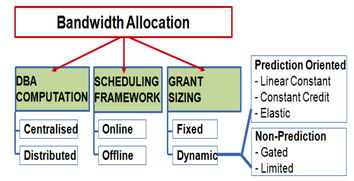
Future Work

- ❑ code refactoring to improve performance, especially simulation speed.
- ❑ simulating LR-PON as backhaul for WiFi, LTE, etc. to study integration between optical and wireless networks.
- ❑ distributed simulation.
- ❑ future research, using the simulator, as described in the next panels

Bandwidth Allocation and Quality of Service

Why Bandwidth Allocation?

❑ Bandwidth Allocation is essential, for the point-to-multipoint LR-PON network which shares the same bandwidth among several users and services (Wi-Fi, Wi-MAX, Mobile Network, Home users, Enterprise, IPTV, VoIP, etc.)



Research Challenges

❑However, the challenge of high-speed (10Gbps/2.5Gbps) and long-reaching (100Km) PON is to support different QoS associated with a variety of end-user services through a proper BW allocation mechanism, so that,

❑ While the different type of services share the same bandwidth through the LR-PON MAC layer (using TDM)

❑ QoS in each service is not compromised in the layers above MAC layer, especially before OLT and after ONU, where the Core and end users are, respectively.

QoS in Different Standards	
EPON	IEEE 802.1p (Priority 0 - 7)
GPON	TCONT1 - Fixed BW TCONT2 - Assured BW TCONT3 - Non-Assured BW TCONT4 - Best Effort BW
LTE	GBR (2,4,3,5) Non-GBR (1,6,7,8,9)
Wi-Fi	Wi-Fi Multimedia Extensions Wi-Fi Scheduled Multimedia

A LR-PON simulator, that can simulate a 1000-ONUs 10-Gbps network with reasonable speed, has been developed as a platform for future network research.

CTVR Communications Showcase 2013