Stacked-VLAN-Based Modeling of Hybrid ISP Traffic Control Schemes and Service Plans Exploiting Excess Bandwidth in Shared Access Networks

Dr Kyeong Soo (Joseph) Kim

Department of Electrical and Electronic Engineering
Xi'an Jiaotong-Liverpool University

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Outline

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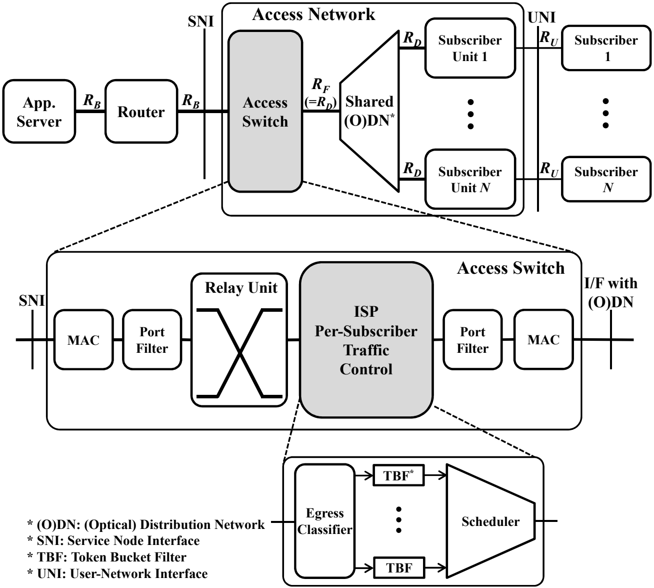
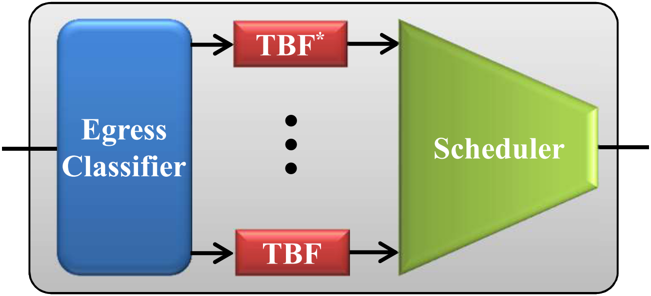
Current ISP Traffic Control Architecture



* (O)DN: (Optical) Distribution Network
* SNI: Service Node Interface
* TBF: Token Bucket Filter
* UNI: User-Network Interface

Issues with Current ISP Traffic Control

The arrangement of traffic shapers and a scheduler prevents subscribers from sharing available bandwidth.



Toward Fully-Shared Access

To implement fully-shared access networks for better resource utilization and higher energy efficiency, we have been studying the following:

- ISP traffic control schemes enabling excess bandwidth allocation [1,2].
- Hybrid ISP traffic control architecture and service plans exploiting excess bandwidth [3].
- **Implementation of simulation models** for the proposed traffic control architecture and service plans (*reported in this paper*).

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[1] K. S. Kim, *IEEE Commun. Lett.*, vol. 18, no. 4, Apr. 2014.
[2] K. S. Kim, *Proc. IEEE Sarnoff Symposium 2015*, Aug. 2015.
[3] K. S. Kim, *Proc. ICTC 2014*, Busan, Korea, Oct. 2014.

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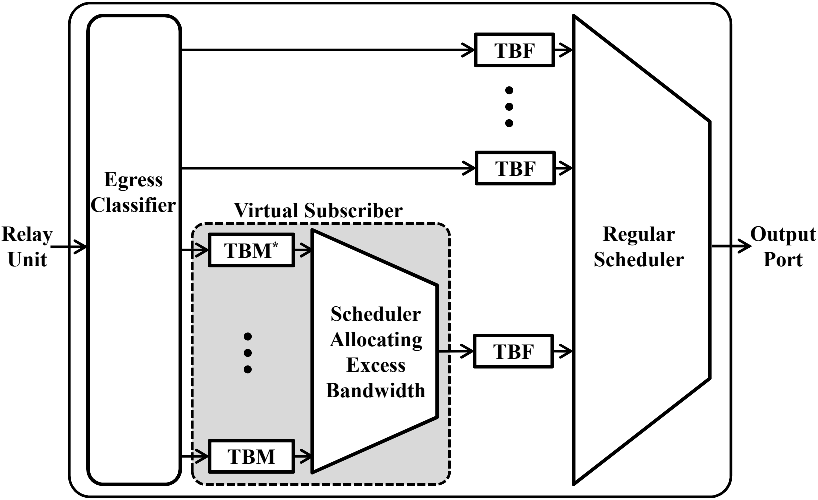
Hybrid ISP Traffic Control Architecture I



* TBM: Token Bucket Meter

Hybrid ISP Traffic Control Architecture II

- Backward compatibility
  - A group of new service plan subscribers are treated as one virtual subscriber under the existing flat-rate service plan.
- Better resource utilization
  - The new service plan subscribers can fully share the bandwidth within the group.
- Gradual introduction
  - Migration to a fully-shared access will be completed when all the subscribers of the existing service plan move to the new one.

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Modeling of Hybrid Traffic Control I

Major requirements:

- *Backward compatibility* with the existing VLAN implementations in INET-HNRL, including
  - EthernetFrameWithVLAN message format
  - MACRelayUnitNPWithVLAN and VLANTagger modules
- *Expandability* to stack more than two VLAN tags

Modeling of Hybrid Traffic Control II

Two possible approaches:

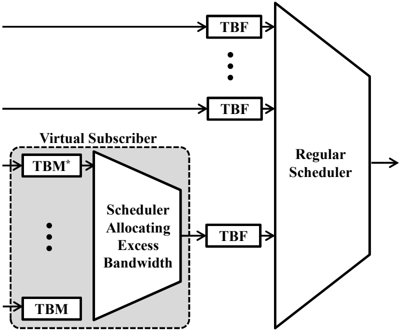
- Integrated approach
  - The whole scheduling is implemented as one integrated scheduler like the hierarchical token bucket (HTB) scheduler [4].
- Modular approach
  - Separate schedulers (e.g., a scheduler based on TBF shaping and a DRR-based scheduler enabling excess bandwidth allocation [5]) are combined into one.

[4] M. Devera. Linux HTB home page.

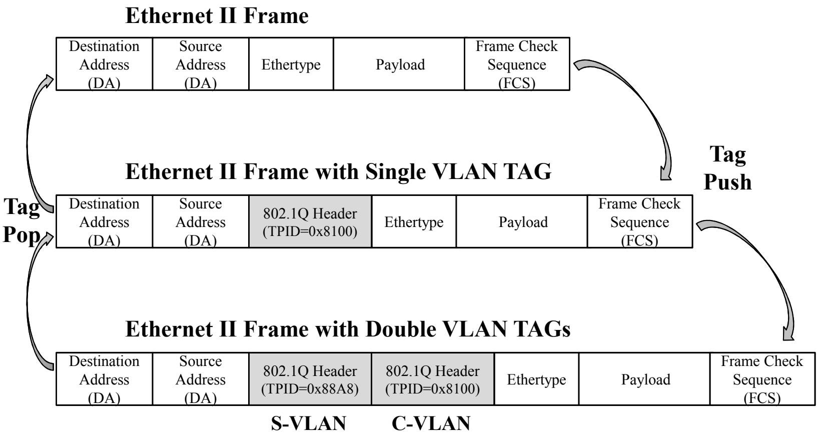
[5] K. S. Kim, *Proc. IEEE Sarnoff Symposium 2015*, Aug. 2015.

Identification of Subscriber Frames I

- For the existing traffic control scheme, the whole frames from the subscribers of the hybrid scheme are identified and treated as a group (i.e., *one virtual subscriber*).
- For the new excess-bandwidth-allocating traffic control scheme, the frames from each subscriber are identified and treated as a separate flow.
- This can be done by IEEE 802.1Q *stacked VLANs* (also called *provider bridging* and *Q-in-Q*).



Frame Formats for VLAN Stacking



Ethernet II Frame Message Definitions

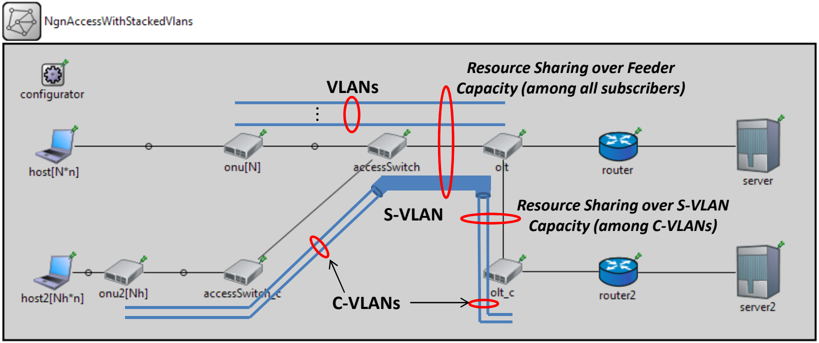
Without VLAN stacking:

```
packet EthernetIIFrameWithVLAN extends EthernetIIFrame
{
    uint16_t tpid = 0x8100; // tag protocol identifier (16 bits; set to 0x8100)
    uint8_t pcp; // priority code point for IEEE 802.1p class of service (3 bits; 0 (lowest) to 7 (highest)
    bool dei; // drop eligible indicator (1 bit)
    uint16_t vid; // VLAN identifier (12 bits; 0x000 and 0xFFF are reserved, which allows up to 4094 VLANs)
}
```

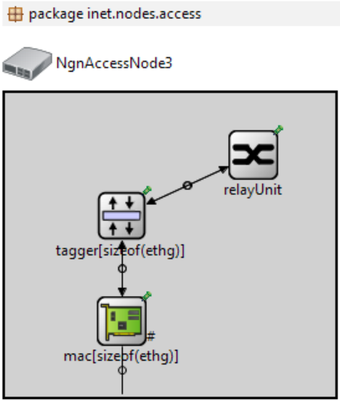
With VLAN stacking:

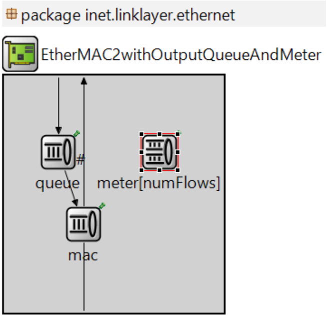
```
cplusplus {{
#include <stack>
#include "VLAN.h" // define VLANTag struct
typedef std::stack<VLANTag> VLANTagStack;
}}

class noncobject VLANTagStack;

packet EthernetIIFrameWithVLAN extends EthernetIIFrame
{
    uint16_t tpid; // tag protocol identifier (16 bits; set to 0x8100 for C-TAG & 0x88A8 for S-TAG)
    uint8_t pcp; // priority code point for IEEE 802.1p class of service (3 bits; 0 (lowest) to 7 (highest)
    bool dei; // drop eligible indicator (1 bit)
    uint16_t vid; // VLAN identifier (12 bits; 0x000 and 0xFFF are reserved, which allows up to 4094 VLANs)

    // optional; IEEE 802.1Q-in-Q stacked VLANs.
    VLANTagStack innerTags; // based on std::stack
}
```

Stacked-VLAN-Based Modeling of An Access Network with Hybrid ISP Traffic Control



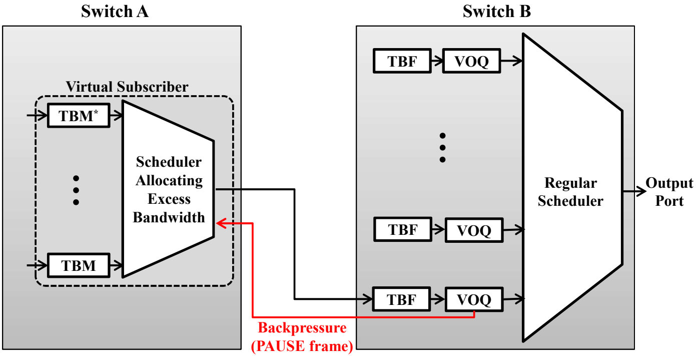
Modules with VLAN Support



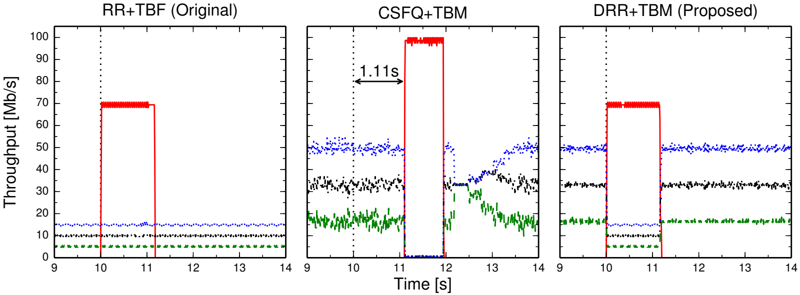


Backpressure between Schedulers

- Two schedulers are currently connected based on Ethernet flow control, which halts the transmission of the whole frames.
- For better control, we need an extension (like IEEE 802.1Qbb) to halt the transmission of *non-conformant frames only*.



Throughput Example



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Summary

- Discussed the issues in current practice of ISP traffic shaping and related flat-rate service plans in shared access networks.
- Reviewed alternative service plans based on new hybrid ISP traffic control schemes exploiting excess bandwidth.
- Reported the current status of our modeling of the hybrid ISP traffic control schemes and service plans with OMNeT++/INET-HNRL based on stacked VLANs.