



Cloud Networking (VITMMA02)

Data Center Bridging, Network virtualization technologies

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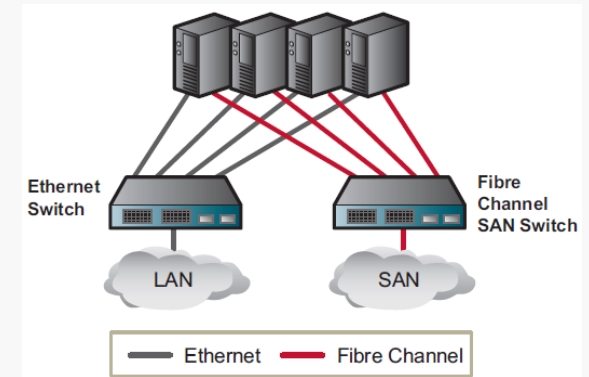
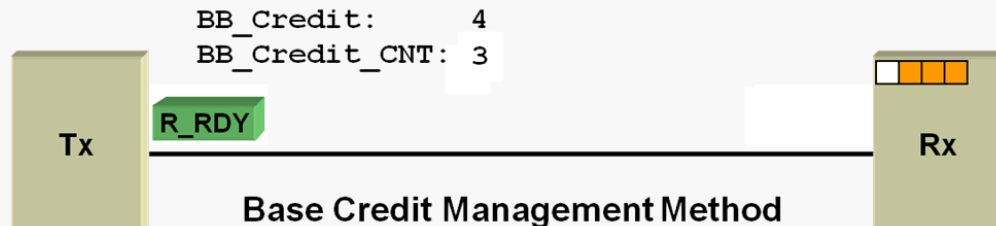


DATA CENTER BRIDGING

Storage traffic in the data center

» Earlier data centers

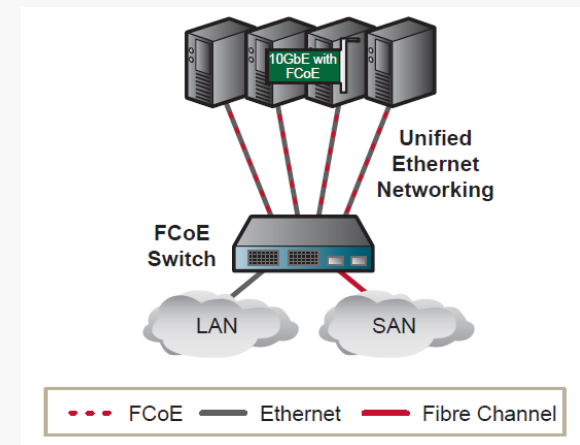
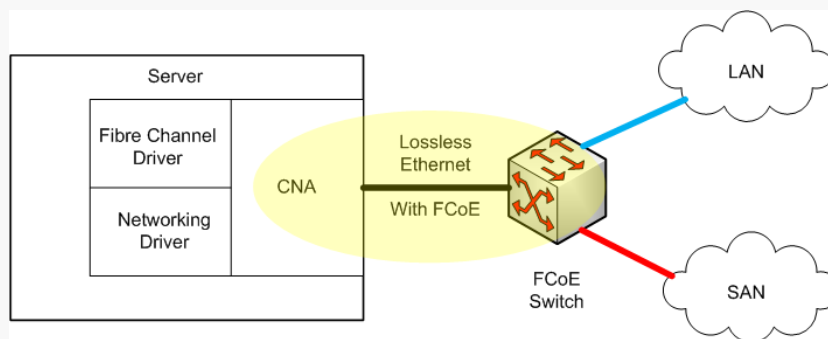
- » Ethernet for data traffic
- » Fibre Channel for storage traffic (SAN – Storage Area Network)
 - » different dedicated networks
 - » optical or electronic interface
 - » 2, 4, 8, 16 Gbps
 - » in case of congestion no packet drops
 - » buffer credit based flow control
 - » buffer to buffer credit



Fibre Channel over Ethernet (FCoE)

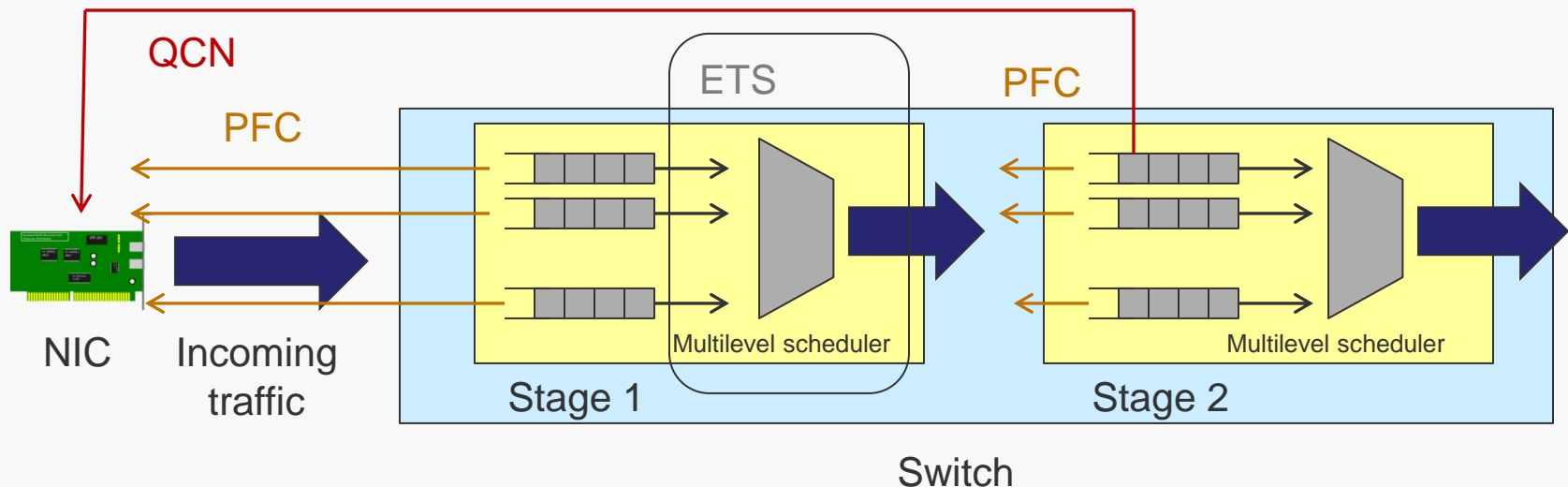
» Ethernet

- » in case of congestion packets might be dropped
- » TCP: reliable delivery (retransmission)
 - » delay jitter
 - » not ideal for video and storage traffic
- » required extensions: DCB



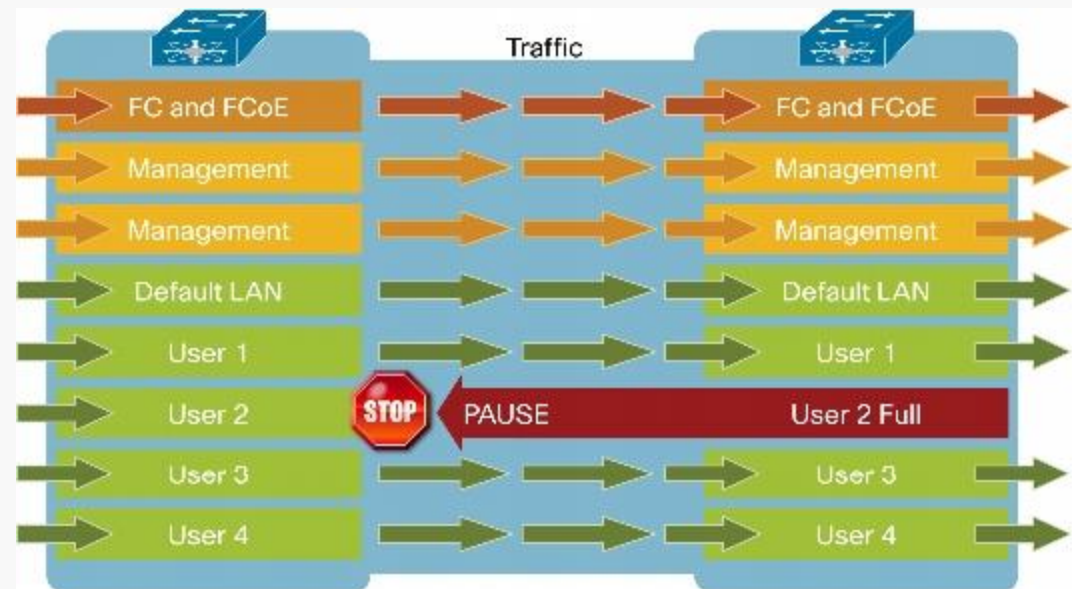
Data Center Bridging

- » Ethernet extensions: (more) reliable delivery without the complexity of TCP
 - » Priority based Flow Control (PFC)
 - » Enhanced Transmission Selection (ETS)
 - » Quantized Congestion Notification (QCN)
 - » Data Center Bridging exchange (DCBx) protocol



Priority based Flow Control

- » To provide lossless operation
- » IEEE 802.1Qbb
 - » link level
 - » between switches or switch stages
- » 8 priority class (802.1p): virtual lanes
- » inside switch: allocated memory partitions
 - » check if watermark is crossed
- » pause message includes a duration



Source: Cisco

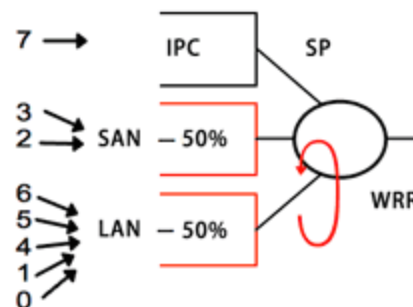
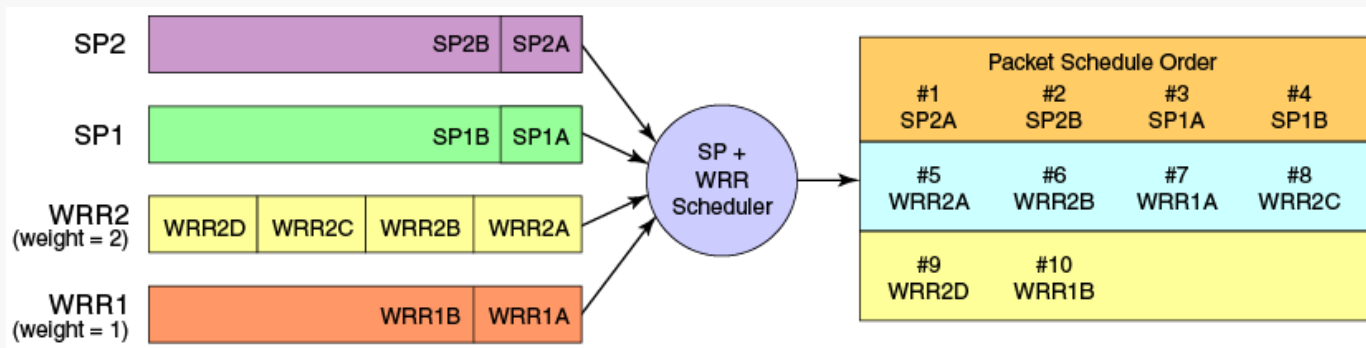
Enhanced Transmission Selection

- » IEEE 802.1Qaz
- » Traffic classes
 - » classification
 - » rule based header matching: Access Control List (ACL)
 - » 3-bit priority filed in VLAN tag
 - » scheduling may be applied to Traffic Class Groups (TCG)
 - » an ETS capable switch is required to support for at least three traffic classes



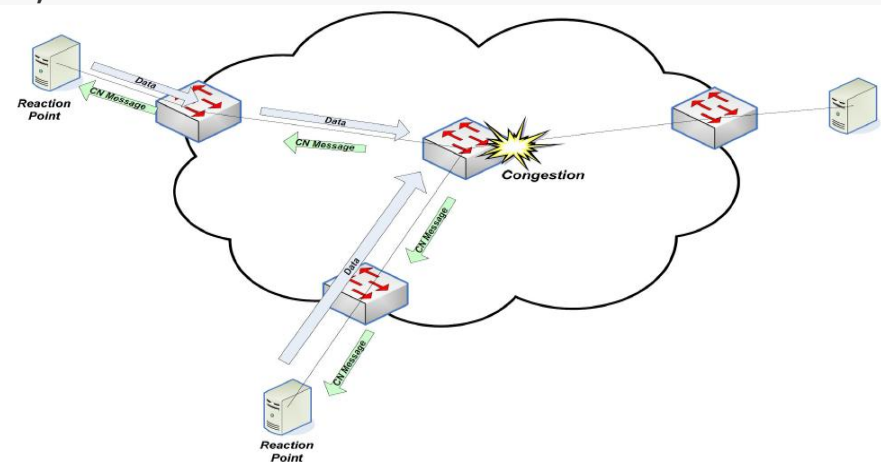
Enhanced Transmission Selection

- » Bandwidth allocation
 - » bandwidth to be configured for each traffic class (max. 8)
 - » with a granularity of 1% with allowed deviation of +/-10%
 - » any unused bandwidth is available to other traffic classes
- » Implementation: scheduling and rate limiting, shaping



Quantized Congestion Notification

- » PFC + ETS
 - » lossless transmission and bandwidth guarantees
 - » quick reaction time
 - » however: many hops through switches and multi-stage switches inside the data center
- » QCN (802.1Qau): for minimizing transient congestions
 - » feedback to the source ("end"-to-end / middle-to-end)
 - » larger time-scale
 - » congestion point
 - » reads the queue length from the switch, random sampling (depending on queue fill level)
 - » calculates a feedback value based on the queue fill level info (quantized to 6 bits)
 - » sends back to source MAC address (reaction point)
 - » with probability of 1-10%
 - » updates the queue sampling rate
 - » reaction point
 - » rate limiting traffic based on the feedback value
 - » then slowly increased again





Quantized Congestion Notification

- » Rarely implemented in data centers
 - » the control loop is highly dependent on factors such as
 - » congestion point reaction time, time to send the QCN frame back through the network, and the reaction point queue throttling time
 - » requires a lot of fine tuning
 - » ideal for long lived flows
 - » uncertainty: frames are randomly sampled
 - » at the source one queue should be allocated for each potential congestion point
 - » operates inside L2 subnets
 - » traffic crossing a router lands in another QCN domain
 - » for high traffic rates the proper implementation is by hardware
 - » replacement of all NICs and switches



Data Center Bridging exchange (DCBx)

- » Coordination between neighboring devices
 - » PFC
 - » number of priorities or traffic classes
 - » ETS
 - » allocated bandwidth units
- » Link Level Discovery Protocol (LLDP) messages
 - » Type-Length-Value structure
- » Operation
 - » sending side
 - » *suggests* parameter settings to the remote end
 - » sent at a periodic rate
 - » receiving side
 - » setting up parameters taking into consideration of the configuration received from the other side
 - » database update based on received data
 - » does not expect, process, or generate acknowledgements
 - » does not care what the remote side does

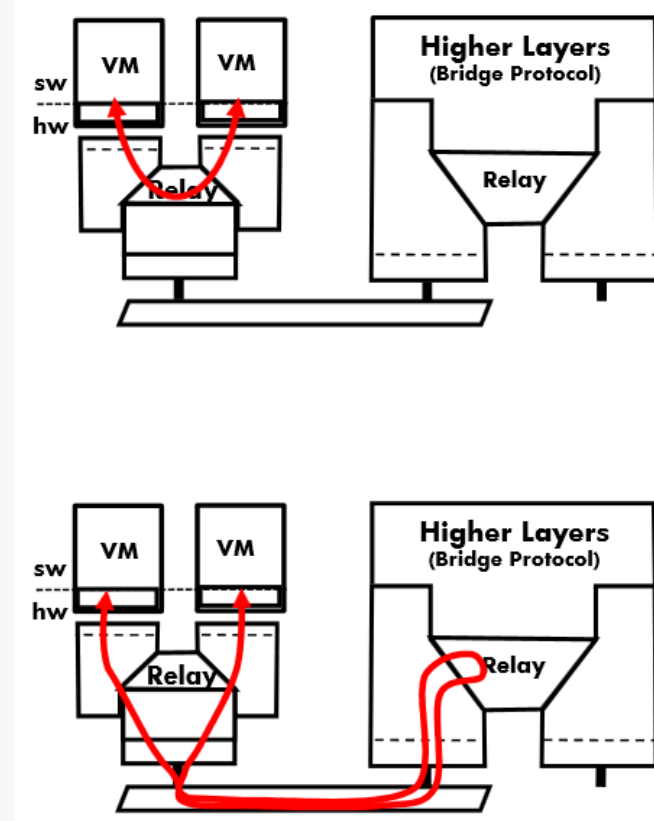
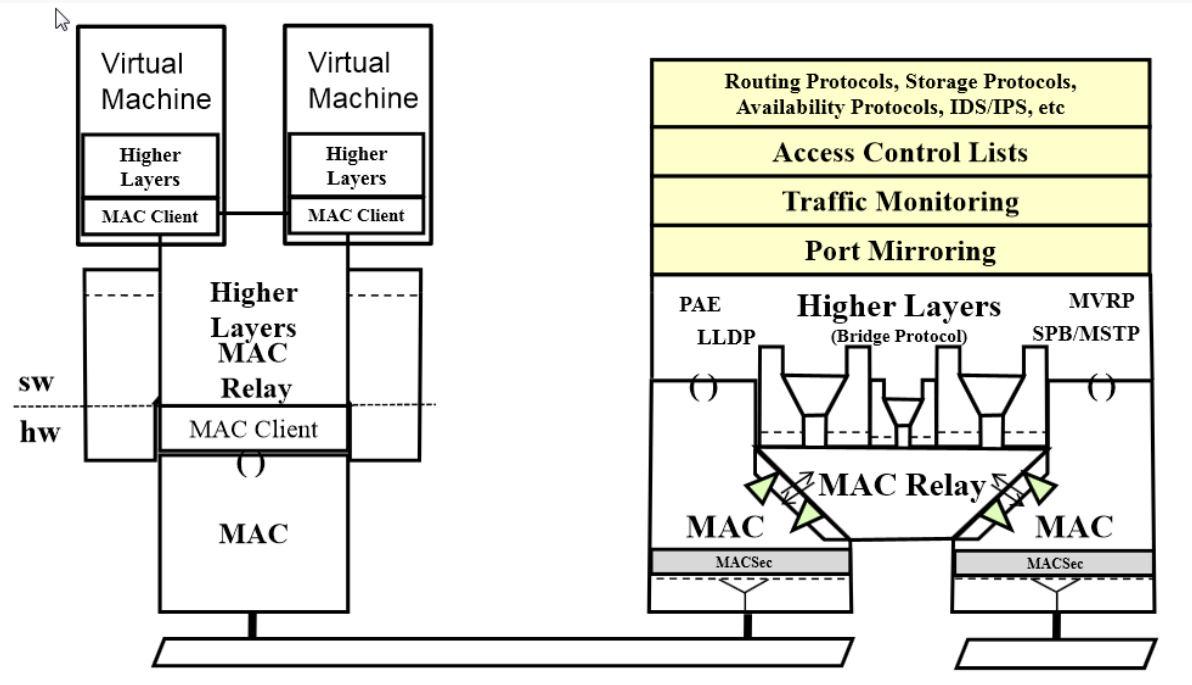


NETWORK VIRTUALIZATION TECHNOLOGIES



Edge Virtual Bridging

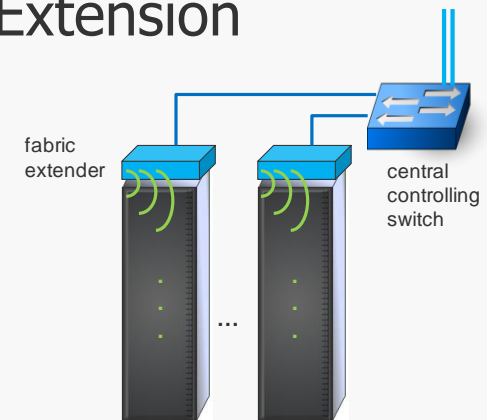
- » ToR physical switch \leftrightarrow virtual switch (Virtual Ethernet Bridge – VEB) capabilities
 - » filtering, security, monitoring, etc.



Forrás: Pat Thaler et al., IEEE 802 Tutorial: Edge Virtual Bridging, 2009.

Edge Virtual Bridging

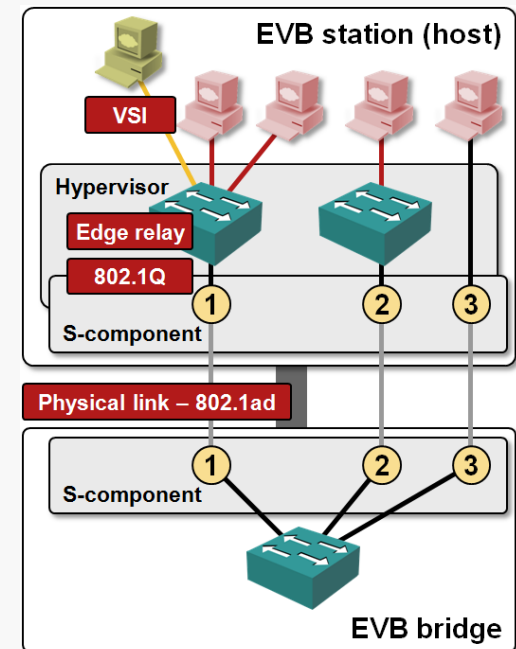
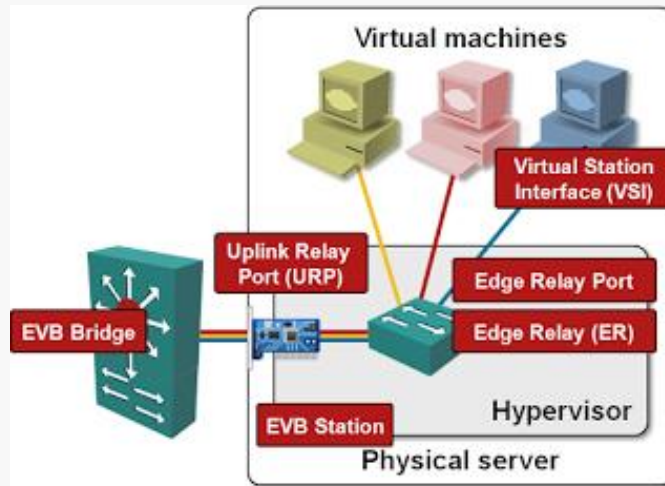
- » EVB: IEEE standard
 - » interaction between the physical and virtual switches
 - » capability of the physical switch
 - » goal: handle all traffic uniformly
 - » Virtual Ethernet Port Aggregation (VEPA) 802.1Qbg
 - » server side capability
 - » all traffic is forwarded to the neighboring physical switch
 - » multi-channel: S-Tag (Q-in-Q)
- » Identifying virtual interfaces on a physical port
 - » Virtual Network Tag (VN-Tag), Bridge Port Extension 802.1Qbh, 802.1BR (E-Tag)
 - » ports configured by central controlling switch
 - » on fabric extender (S-Tag)
 - » on NIC of server (VN-Tag)
 - » for each vNIC a separate VN-Tag
 - » extra header containing Virtual Interface (VIF)



L2 configuration automation

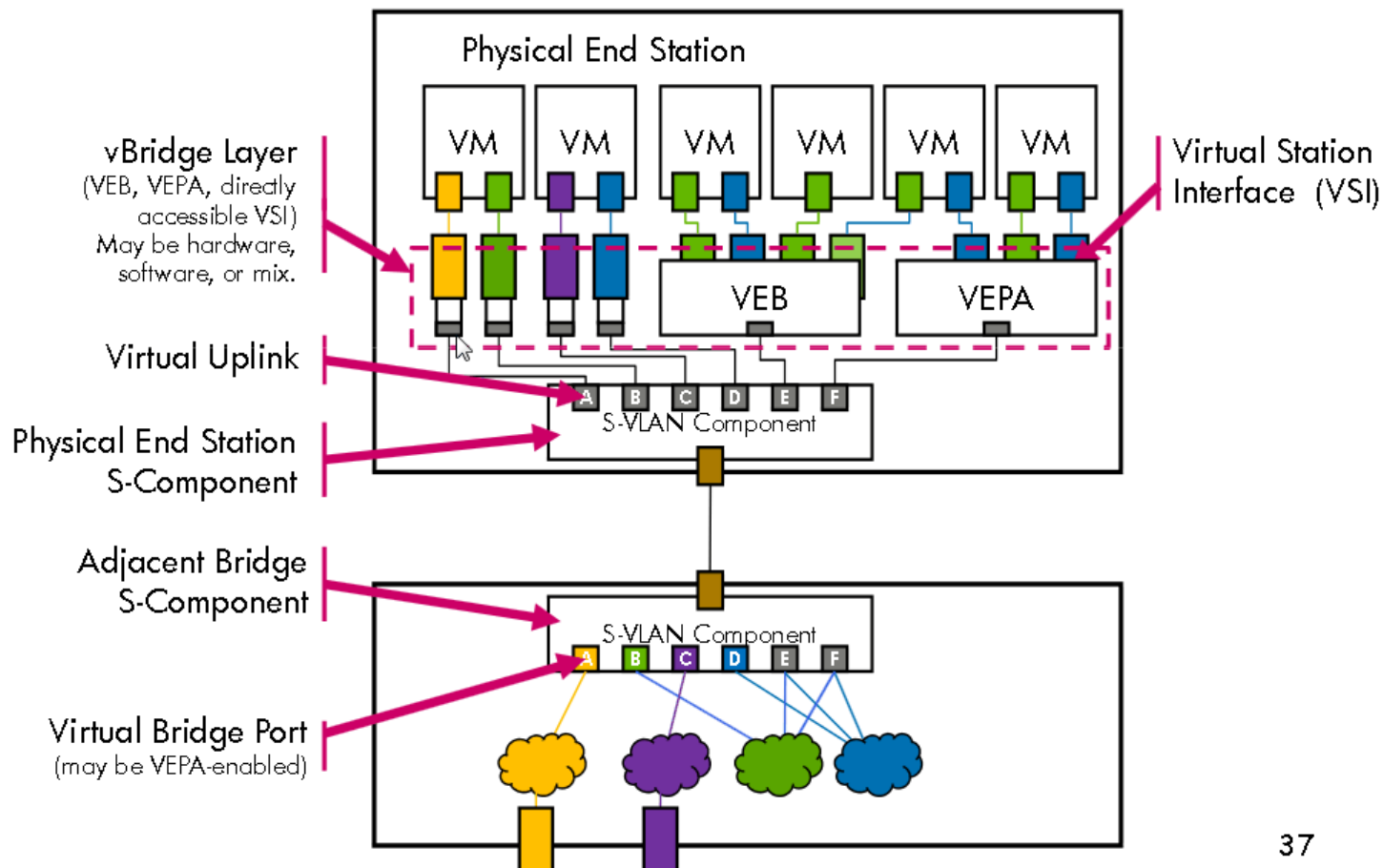
» Edge Virtual Bridging

- » Virtual Station Interface (VSI): VM NIC
- » VSI Discovery and Configuration Protocol (VDP)
 - » EVB bridge receives info from the hypervisor before starting the VM
- » VN-Tag: extra header for identifying vNIC (Cisco)
 - » local tag between the controlling switch and the fabric extender
- » S-component
 - » multiplication of logical 802.1Q links over a physical link (Q-in-Q)



Edge Virtual Bridging

» Combining different technologies



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Forrás: Pat Thaler et al., IEEE 802 Tutorial: Edge Virtual Bridging, 2009.

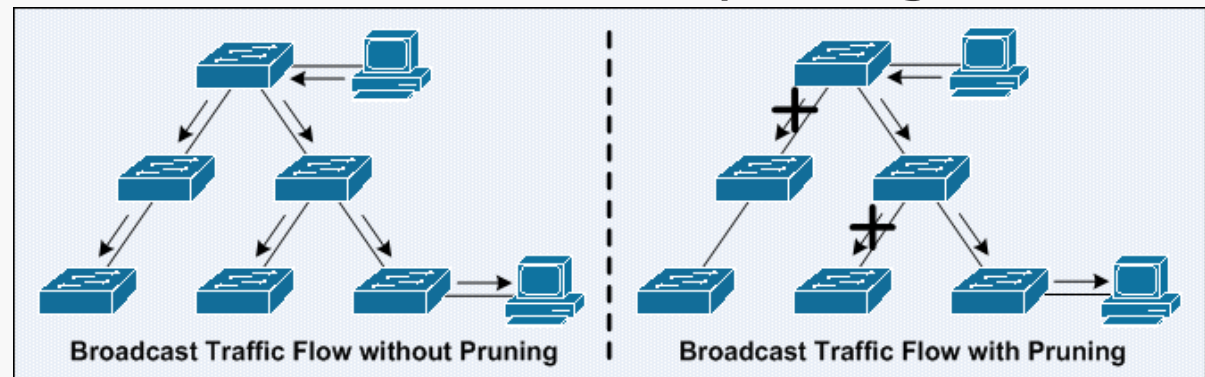


Evaluation

- » Virtual switch (VEB)
 - » forwarding by MAC + VID
 - » not needed
 - » MAC address learning, because VM addresses can be preconfigured
 - » STP, because located at the edge of the network
 - » traffic kept inside the server
 - » not visible, analyzable, filterable from outside
 - » better performance for VMs residing on the same server
 - » no common management with the physical switched
 - » CPU and RAM usage on the server
- » EVB
 - » all traffic crossing the physical switches (more advanced features)
 - » less network configuration task
 - » more traffic and delay in the network
 - » VEPA
 - » forwarding by MAC + VID
 - » function of virtual switch is kept
 - » Ethernet frames
 - » capability for sending the traffic back on the input port (hairpin)
 - » VN-Tag
 - » forwarding by tags
 - » new frame format
- » Applicability of technologies
 - » VEPA: hypervisor support required
 - » VN-Tag: special NIC required
 - » other directions
 - » physical switch features integrated into virtual switches
 - » other network virtualization and tunneling technologies (VXLAN, NVGRE, etc.)

Network virtualization technologies

- » STP problems: routing (e.g. IS-IS) with MAC addresses
 - » Shortest Path Bridging MAC (SPBM)
- » limited number of VLANs: add another VLAN tag
 - » Q-in-Q, provider bridging, (IEEE 802.1ad)
- » MAC address limit: add another MAC address header
 - » Provider Backbone Bridges (PBB), 802.1ah
 - » Transparent Interconnection of Lots of Links (TRILL)
 - » bridging + routing
- » to avoid hypervisor flooding: consider VMs
 - » VLAN pruning: elimination of unnecessary traffic
- » to avoid flooding the core network: VLAN pruning in the core network





Network virtualization

- » VN-Tag identifies the VM, but not the tenant
- » Support for tenant separation
 - » Virtual Extensible LAN (VXLAN) – RFC 7348
 - » Cisco, VMware
 - » transport of virtual L2 traffic over physical L3 network
 - » Network Virtualization using Generic Routing Encapsulation (NVGRE)
 - » Microsoft, Intel, HP, Dell
 - » Generic Network Virtualization Encapsulation (GENEVE)
 - » superset of VXLAN and NVGRE
 - » Stateless Transport Tunneling (STT)
 - » Nicira ⇔ VMware



Sources

- » Pat Thaler et al., IEEE 802 Tutorial: Edge Virtual Bridging, 2009.
- » Overlay Virtual Networking Explained, Ivan Pepelnjak, NIL Data Communications, 2011.
- » Shortest Path Bridging, IEEE 802.1aq, Tutorial and Demo, NANOG 50 Oct 2010, Peter Ashwood-Smith, Huawei
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