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FACULTY OF
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Communication Networks

Resilient Integration of Distributed High-Performance Zones into the BelWue Network Using OpenFlow

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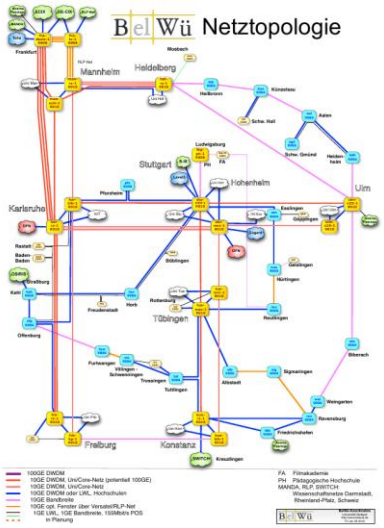
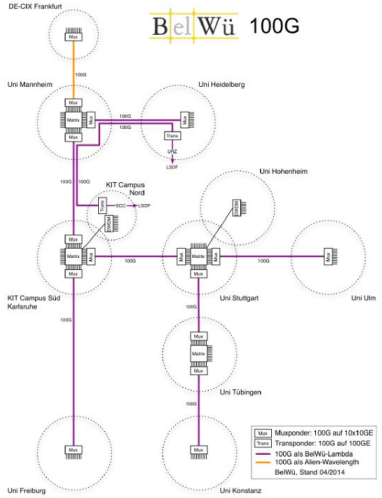
http://kn.inf.uni-tuebingen.de

Introduction

- BelWue ISP interconnects higher education and research facilities
  - 10 Gb/s core network

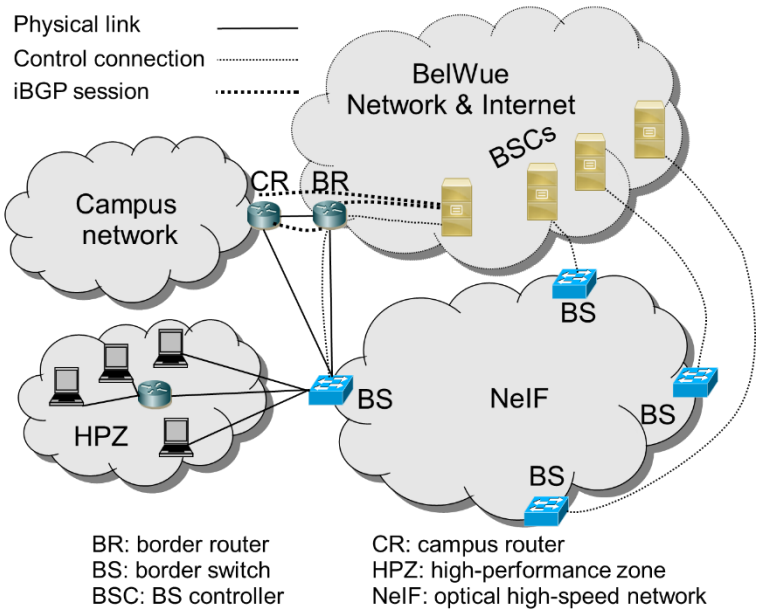


- BelWue core network is extended by highspeed network
  - Netzwerk für Innovation und Forschung – NeIF
  - Flexible optical platform
  - 100 Gb/s split up into 10x10 Gb/s
  - High-performance zones (HPZ)



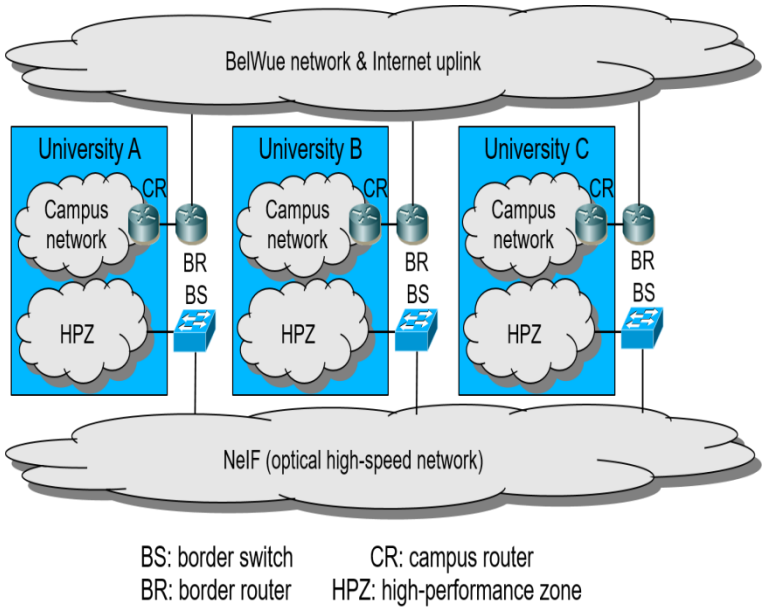
High-Performance Zones (HPZ)

- Each university consists of campus and HPZ
  - Connected by high-performance zone SDN switch (BS)
- HPZs
  - Form a separate network with its own IPv4 /22 address space
  - Dedicated /24 prefix per HPZ
- HPZ should communicate with
  - The legacy campus network
  - The Internet
  - HPZs at other campuses



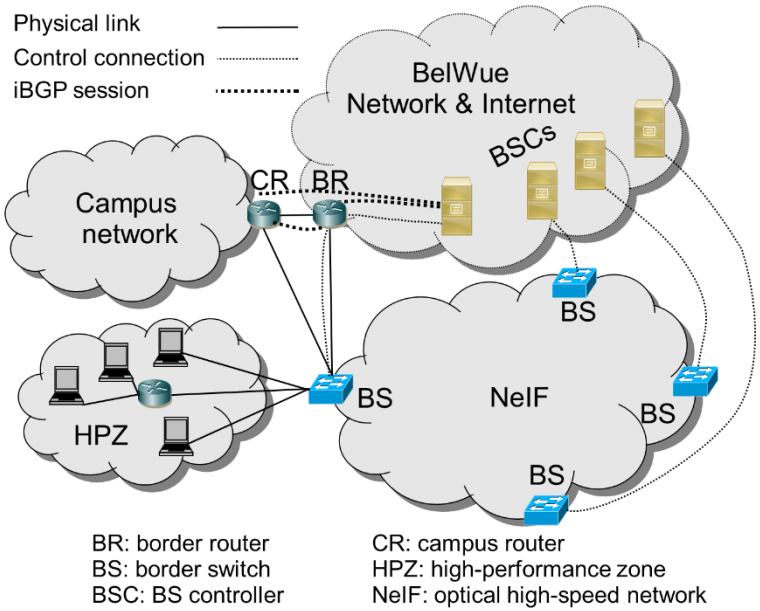
Motivation

- Forwarding or routing between the universities is necessary
  - A huge single LAN between all HPZs with classical switches
    - Only one large IP subnet
    - MAC-based forwarding also does not scale
    - Rather cheap
  - Forward traffic with the help of routers
    - Different IP subnets at each HPZ possible
    - Rather expensive
  - With SDN switches it is possible to develop a tailored solution for this problem



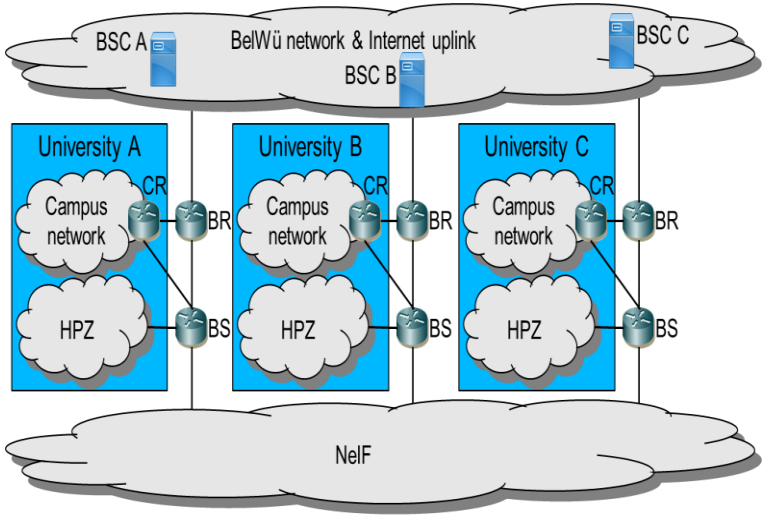
HPZ Integration into Campus and Belwue

- Communication to “legacy“ networks
  - BGP for signaling towards the legacy networks
    - BSCs act as proxy for BSs
  - Every BS announces entire /22 with low priority
    - Withdraw prefix on failure and possibly install rate limiter on remote BSs
  - Every BS announces local /24 with high priority



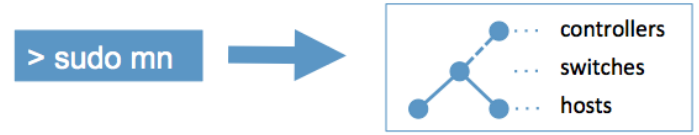
Inter-HPZ Communication

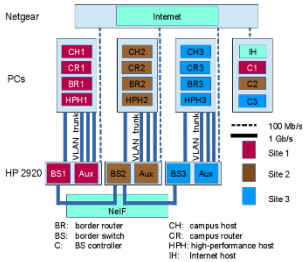
- Communication among HPZs
  - Forward packet among HPZs with the help of SDN
  - Default: Destination IP prefix matching at HPZ
    - Special rules, e.g. based on destination port, supported
  - Forward action to local HPZ or to next hop HPZ
- Control path between BSC and BS
  - Out-of-band signaling
  - “Legacy” BelWue
    - No additional cables
    - Redundancy mechanisms
    - Rerouting

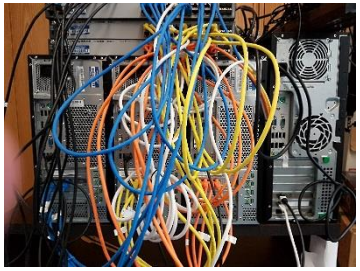


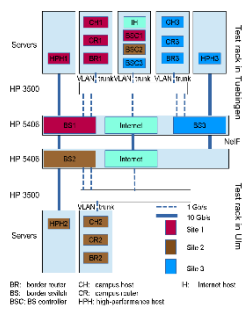
Implementation

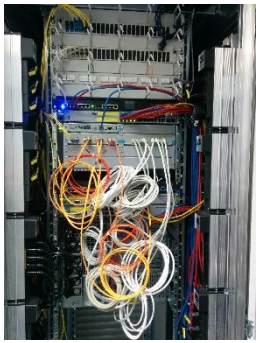
- SDN controller based on Ryu
  - Rapid prototyping
  - Lightweight
- Three testbeds
  - Mininet based emulation
    - Basic proof of concept
  - Local testbed
    - Based on 4 PC and 3 SDN-capable switches
    - Virtual machines for different components
  - Distributed NeIF prototype
    - 3 university locations and BelWue location











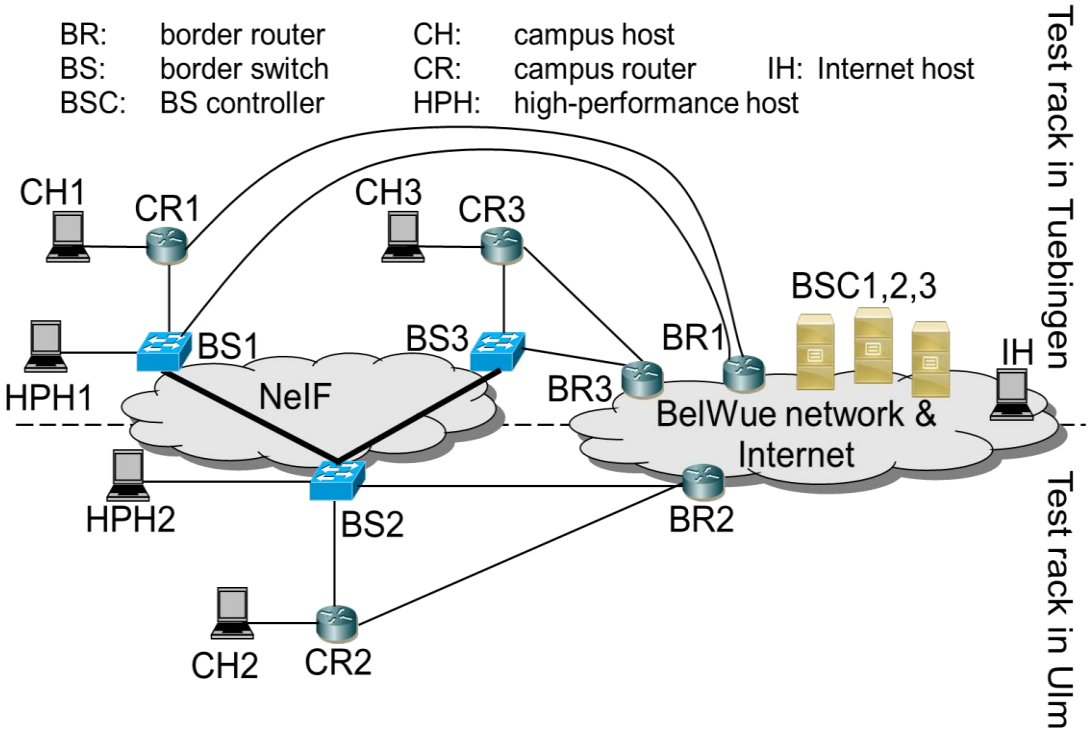
Advanced Features

- Goal: integrate the NeIF network more in the (simulated) daily operation

- Automatic rerouting in failure cases
  - On NeIF failure use legacy access
  - On legacy failure use NeIF access
- Relieve legacy uplink
  - University to university communication through NeIF
- Traffic engineering with help of SDN
  - SDN can consider more parameters for routing decision
  - Treat certain flows special
- Step-by-step integration

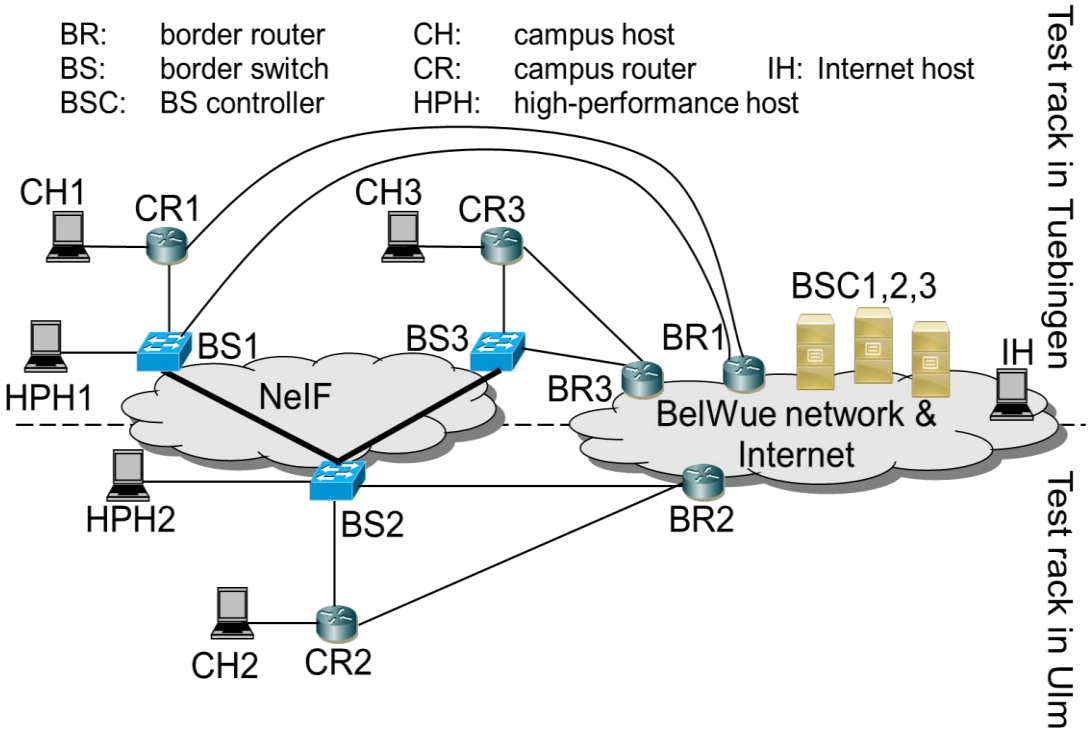
Tests

- Basic connectivity test
  - Ensure all hosts can reach each other
  - Ensure traffic is sent through desired paths
  - Tools: ping and tcpdump
- Fail-over test
  - Disable link on NeIF
  - Ensure traffic is sent through desired paths
  - Measure time to recover
  - Tools: ping and tcpdump



Tests

- Performance test
  - TCP throughput
    - HPZ to HPZ
    - HPZ to campus
    - Campus to campus
  - Tools:
    - iperf, netperf
    - http download
  - Result:
    - 9,4 Gb/s on 10 Gb/s links
    - 960 Mb/s on 1 Gb/s links
    - 480 Mb/s on 500 Mb/s links



Conclusion

- Integration HPZs into university campuses and BelWue network
  - Based on iBGP towards “legacy” network
  - Based on OpenFlow in NeIF
- Implemented in 3 testbeds
  - Emulation, local testbed and real distributed prototype
- We performed several tests
  - Connectivity, performance, fail-over
  - Provided bandwidth for the HPZs and campuses is close to the theoretical optimum.

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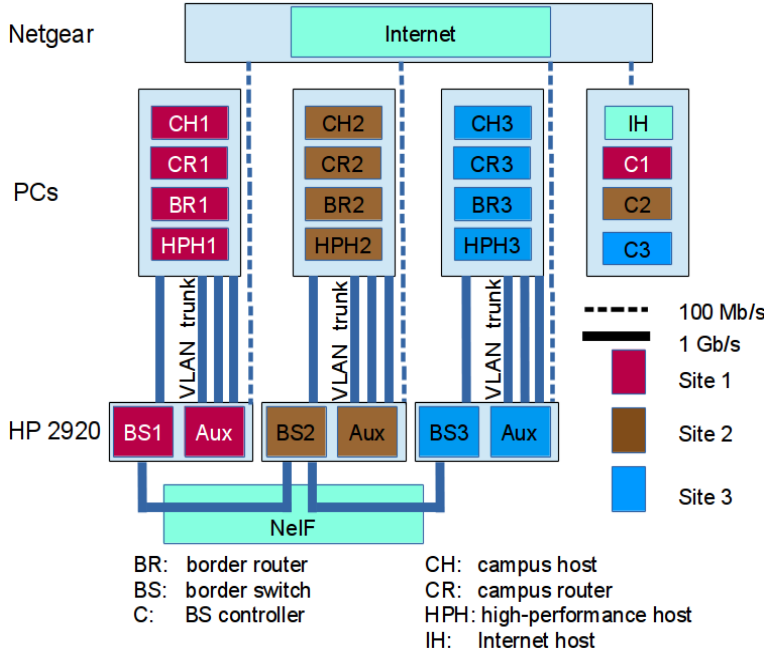
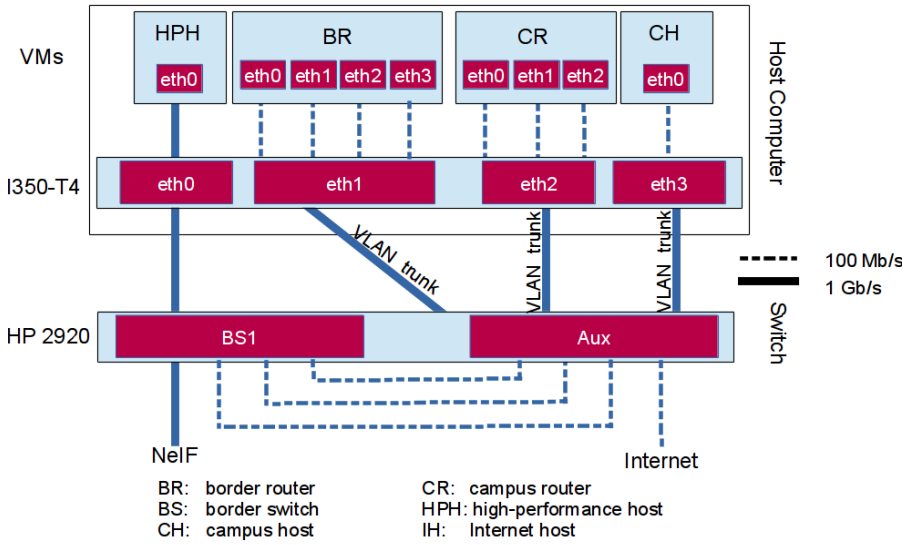
Implementation: Local Testbed

- Local testbed
  - Virtualized CH, CR, BR, HPH per location on single PC
  - Switches partitioned
    - SDN enabled
    - Conventional part, used to e.g. (de)multiplex VLANs
  - BelWue and Internet location based on Linux containers (LXC)





Implementation: NeIF Prototype

- Setup changes for NeIF prototype
  - Use of bwNET test racks
    - Servers instead of PCs
  - Distributed on 2 locations
    - Tuebingen and Ulm
  - Use NeIF for high-speed links between locations
  - HPH on dedicated machine
    - Utilize high bandwidth