

Distributed Virtual Networking Laboratory Environment for NetAcad



Petr Grygárek

VSB-Technical University of Ostrava
Faculty of Electrical Engineering and Computer Science
Department of Computer Science



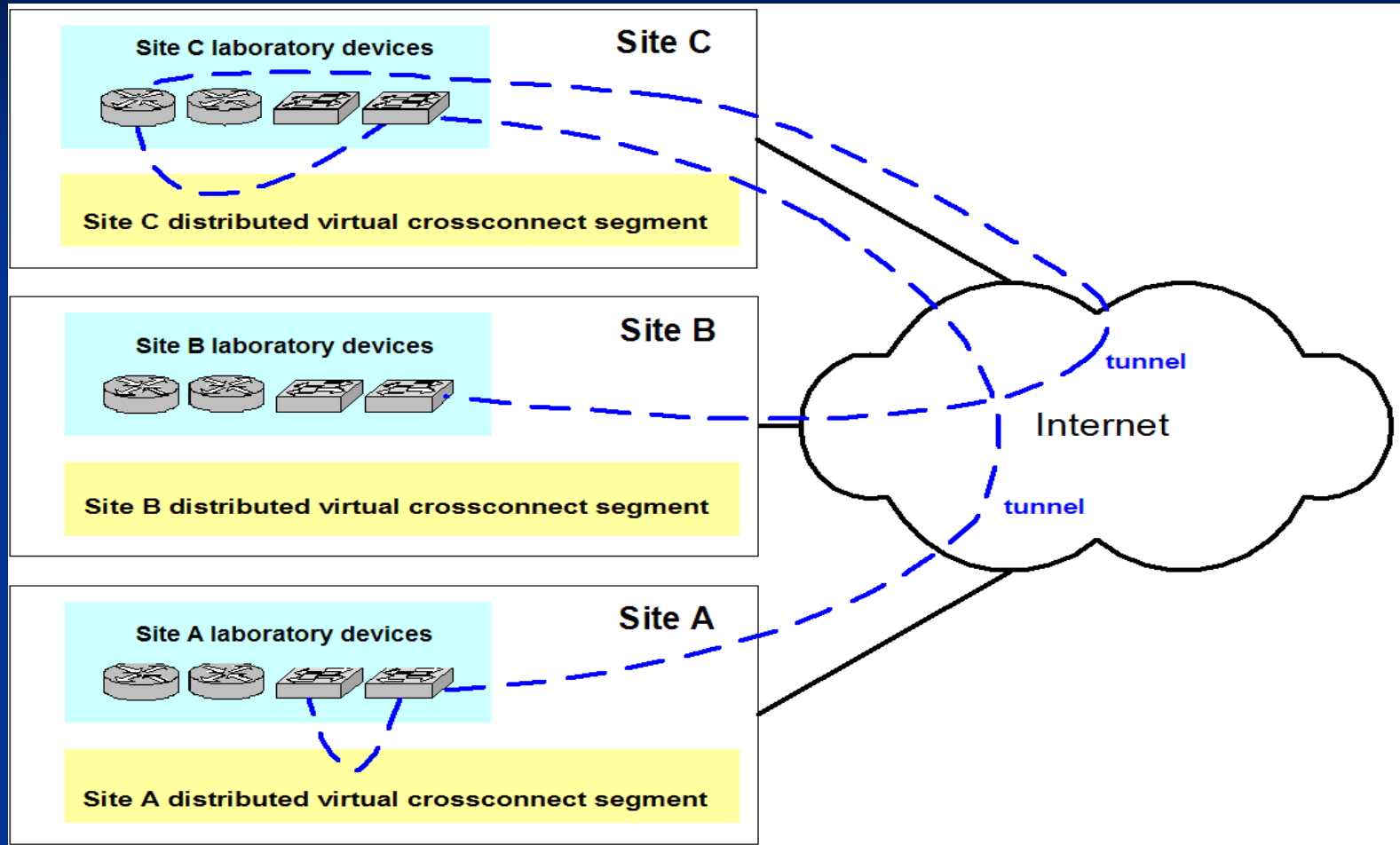
Regional Cisco Networking Academy



Distributed Virlab Project

- Started on 2006 and follows previous single-site remote access solution with support of automatic topology interconnection
- Distributed Virlab is not just another technology for remote access, but the complete open distributed architecture for automatic creation of distributed virtual topologies over Internet and sharing lab equipment between multiple lab sites.
- “Any Topology for Whoever at Any Time”
 - if there is enough lab devices to build it

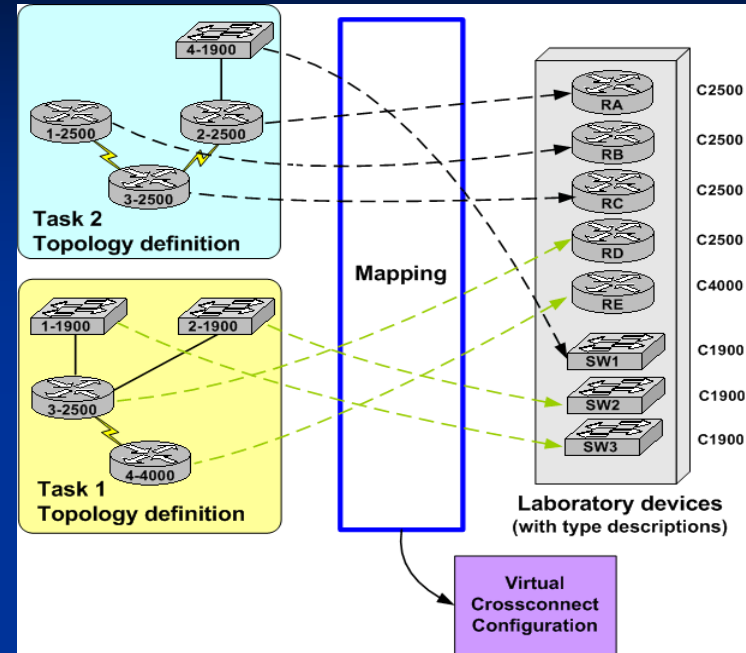
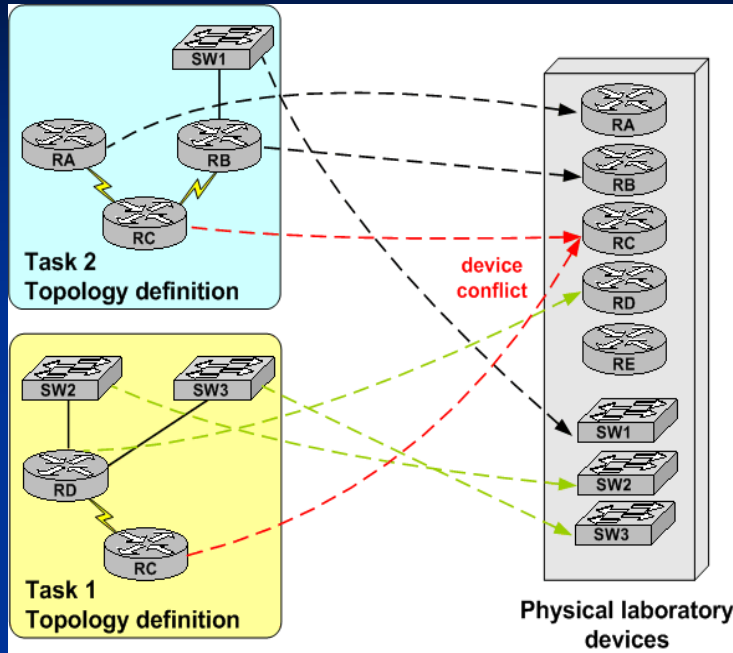
Basic Ideas (1)



Basic Ideas (2)

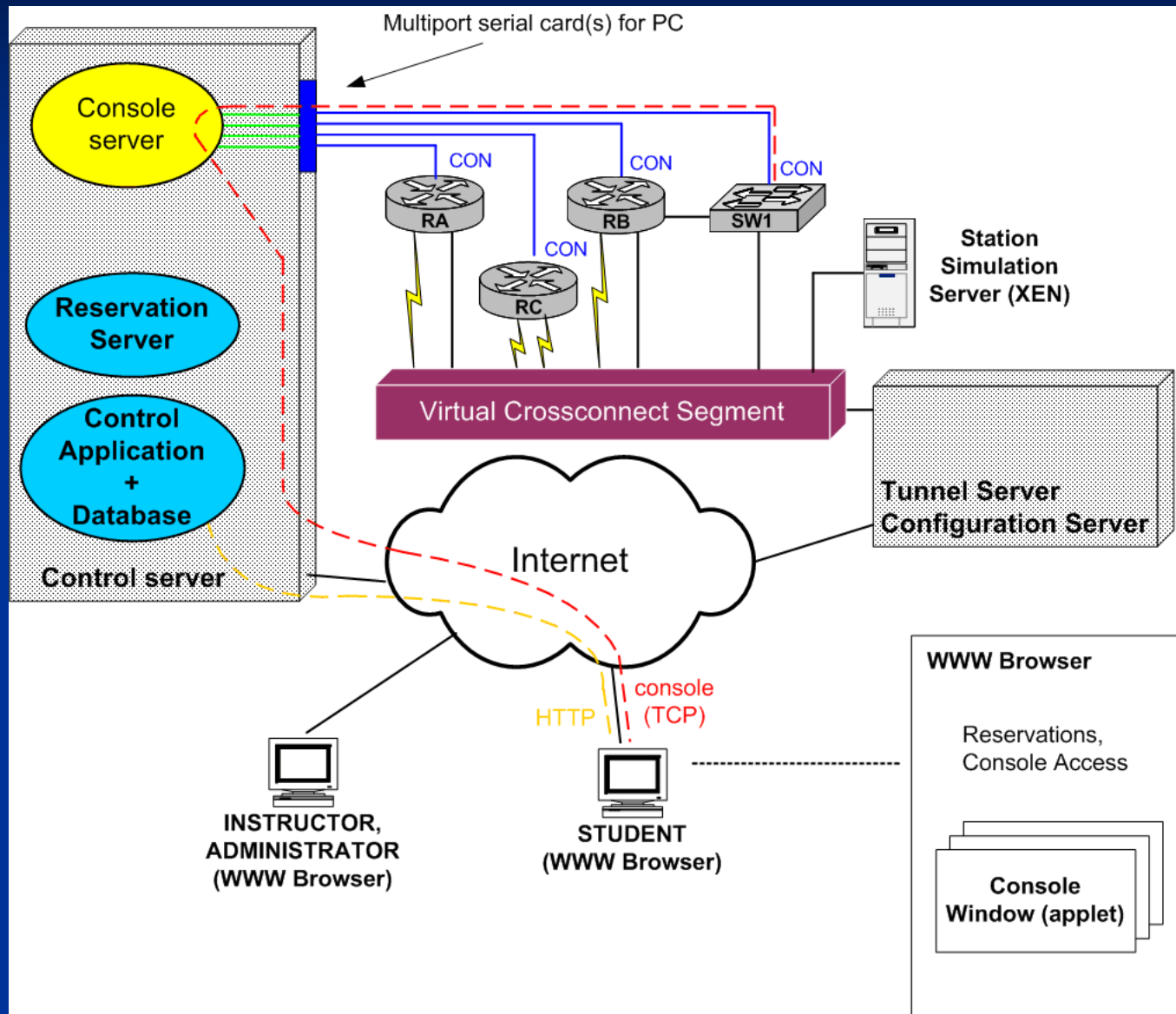
- Remote access to lab devices provided independently of their physical location
 - user previously reserves one of offered lab tasks or his/her own topology
- On-demand automatic creation of distributed virtual topologies using equipment from multiple sites
 - Transparent mutual sharing of lab equipment
 - Local lab admins may precisely control when their devices may be offered to partner sites
- Suitable physical devices actually used for virtual topology of particular lab task reservation are searched in participating sites dynamically
 - lot of various tasks may be reserved in parallel without fighting for particular device
- Distributed nature of the resulting topology is completely hidden to the user

Dynamic Device Mapping



- Description of task's topology is separated from specification of physical devices used for particular reservation of the task
- When student reserves a task, advanced mapping algorithm tries to find optimal mapping using a set of devices offered by individual sites for required time interval

Internal Architecture of Virlab Site

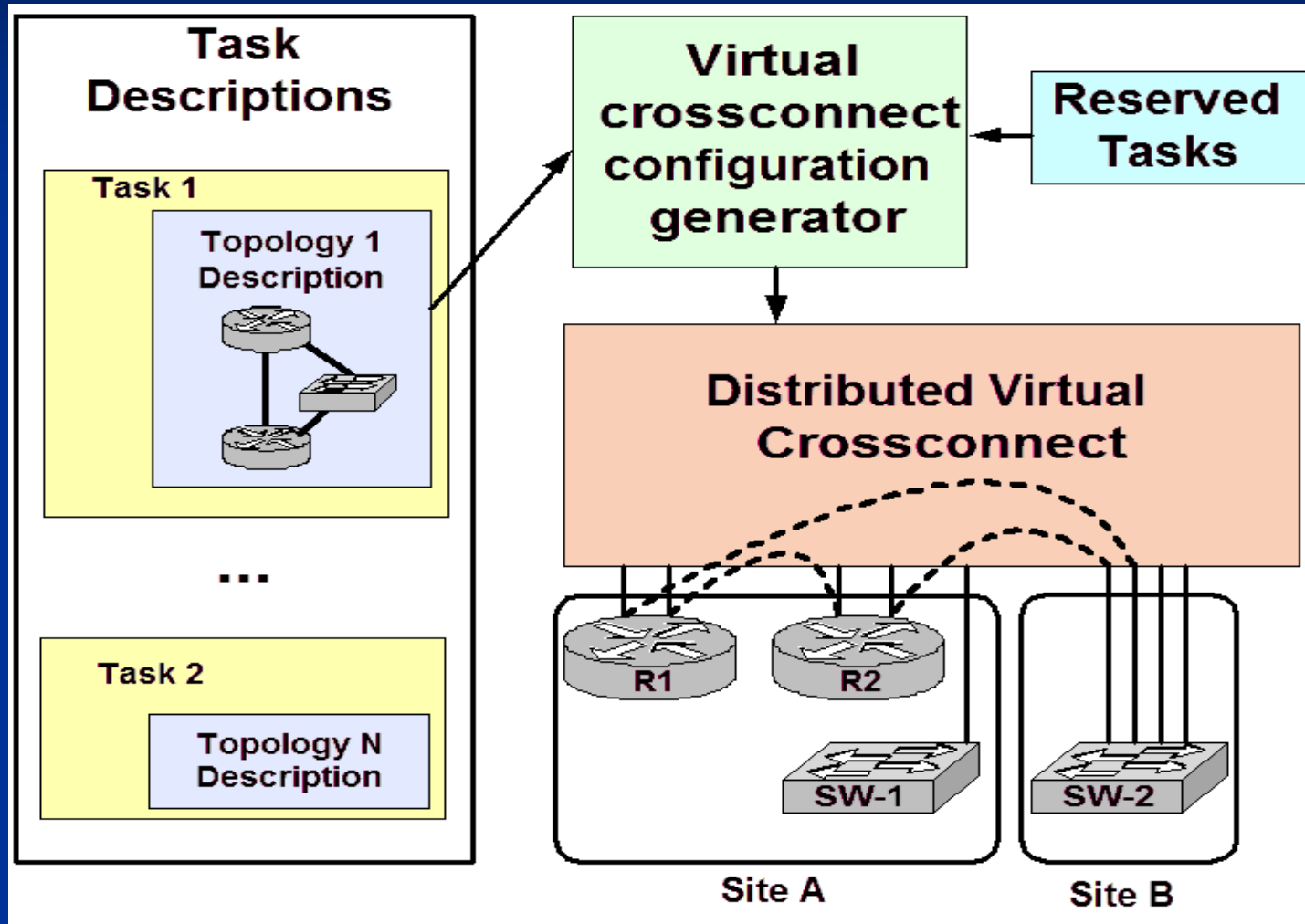


Distributed Virtual Crossconnect

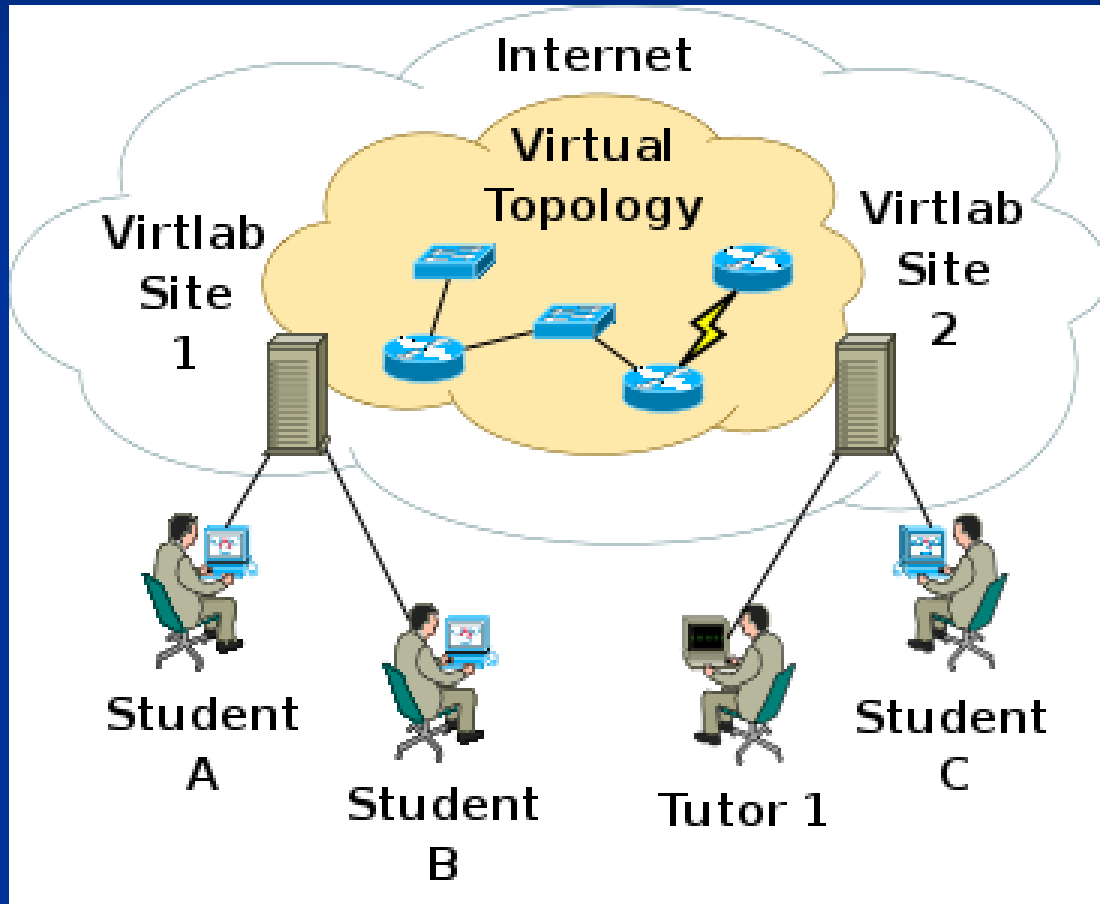
- Allows to create distributed virtual LAN/WAN topologies automatically
 - either locally or using virtual links over Internet
- Implemented using various switching elements hidden behind tunnel servers of individual sites and configured uniformly by a simple tunnel server's CLI
 - Uses commercially available LAN switches with QinQ support and our own switching element prototypes
 - Serial ports can be automatically interconnected locally now, solution for tunnelling over Internet is just being developed
- Modular well-extensible tunnelling architecture allows to add new interface types and switching technologies easily
- Support for inspection of traffic passing any line (virtual network probes)



How Distributed Virtual Crossconnect Works



Resulting Semi-virtual Environment



Important Features of the Implementation

- Fully distributed
 - no single point of failure
 - allows independent operation of individual sites even in case when other site(s) becomes unavailable
 - local administrators have full control of sharing of their lab devices
- International operational context taken into account
 - per-user GUI language setting
 - support for timezones
 - ...

Benefits of Lab Remote Access

- More opportunities for individual students' practicing
- Increases lab utilization and makes investments into lab equipment more efficient
- May be also used in ordinary lab exercises
 - saves time to connect required topology

Current Virlab utilization

- regular Bc/MSc-level university courses
 - particularly for distant-learning students
 - mandatory, currently approx. 40 students
- CNAP courses (RCNA Ostrava, LCNA Karviná)
 - for individual remote practicing (more than 100 students)
 - set of tasks for advanced Routing&Switching and NS2

Benefits of Cooperation between Lab Sites

- Sites may specialize on particular (potentially expensive) special technology and share devices with others
 - Increases devices' utilization and makes investments into lab devices much more efficient
 - VŠB-TU Ostrava: Security, OPF-SLU Karviná: VoIP
- Easy replacing of failed devices
- Allows to create large-scale topologies or multiple topologies in parallel by integrating equipment from multiple sites
 - useful for final exams or large-scale case studies (topologies may be established for couple of days if necessary)
 - simulates real-world network environment
 - we work on integration of traffic generators and honeypots to simulate real traffic and end systems
 - long-term large-scale topology setups accessible by group of users may exist concurrently with short-term individual reservations

Daily operation of the virtual laboratory environment

- Important to maintain the system running 24h/7days per week
- Continuous monitoring of inter-site connectivity and functionality of individual components is inevitable
- Extensive logging of system operation, critical errors reported via e-mail
- Further enhancements and automation are planned
- Filtering of dangerous configuration commands on lab devices

Current Status

Piloting implementation of distributed Virlab was installed between VSB-Technical University of Ostrava and Silesian University at Karvina on autumn 2007.

http://www.cs.vsb.cz/vl-wiki/index.php/Pilotn%C3%AD_konfigurace

About 30 Cisco devices (routers, switches, ASA)

About 20 simulated Linux instances

Set of lab tasks with unified structure was prepared
(in Czech and English language)

- IGP route optimization + advanced BGP
- Network Security 2
- Routing & Switching, Frame Relay (CCNA) - 31.8.08
- Network Security 1 - 31.8.08

Virtlab and Packet Tracer Comparison

(Packet Tracer version < 5.0)

Packet Tracer Advantages

- No necessary investment into physical lab devices, zero cost of lab environment operation and maintenance
- Checking of correct completion of tasks required by particular scenario
- Simulation mode allows to trace packets and inspect their contents

Virtlab Advantages

- Students work with real lab devices
 - Support of all IOS commands (including debugging commands)
 - IOS with special feature set may be uploaded into lab devices if needed, so that various special technologies may be taught (security, MPLS, ...)
 - Special networking technologies (like ISDN PRI., ADSL etc.) may be incorporated
- Any networking device may be incorporated (even non-Cisco equipment, which allows us to simulate real-world heterogenous network environments)
 - Instances of full Linux OS virtualized using XEN proved very useful to host various network services and testing tools
 - Text-based (CLI/Telnet/SSH) management of lab devices is required now
 - GUI-based management interfaces (WWW, proprietary GUI-based applications) will be supported in near future by integrating user's PC to the lab topology using VPN
- A group of students can remotely cooperate on solving a lab task
- Tutor may access device consoles when necessary
 - multiple shared access modes - demonstration, examination, cooperation mode
- No license limitation to CNAP students only

Comparison

- Packet Tracer is an excellent zero-cost tool for CCNA1 and CCNA2 and partially for CCNA3 and CCNA4
 - focus to basic (+intermediate) routing & switching
 - it is still necessary to stimulate students to work with real devices to get real experience, since PT is only a simulator
- Virlab is much more suitable for CCNP, CCNA4, NS and other specialized courses (including non-Cisco)
 - allows to incorporate various kinds of physical lab devices and any networking technologies (including non-Cisco)
 - supports collaboration of students, possibly under tutor guidance
 - requires expenses to real lab equipment and distributed environment maintenance

Virtlab Enhancements: Current Work

- Implementation of virtual network analyzer probes into production environment
- Integration of honeypots and traffic generators to simulate real Internet traffic
- Virtual interconnection of WAN ports between sites
- Integration of user's PC into lab topology - allows to use all software preinstalled on user's PC to test behaviour of the lab configuration
 - Hacking tools, network management tools, ...
 - Management of lab devices using WWW and proprietary management tools

Future Plans

- Support for evaluation of students' work
 - automatic checking of completed configurations
 - behavioral approach
- Further automation of Virlab distributed environment monitoring and configuration
- Enhancements of GUI
- Incorporation of another sites
- Partial integration with Edinet EU LLP Project
 - federation approach

Conclusion

Using our distributed virtual networking laboratory architecture, multiple cooperating teaching/research institutions are able to

- implement large WAN topologies using devices of multiple participant sites
 - behavior of real-world topologies may be studied
- seamlessly substitute a failed device with other, possibly from a friend institution
- specialize to buy expensive special devices and share them with others

See <http://www.cs.vsb.cz/vl-wiki> for more information

Questions ?