VITELS – An e-Learning Course on Computer Networks and Distributed Systems

*Prof. Dr. Torsten Braun, Dipl. phil. nat. Marc-Alain Steinemann, Dipl. phil. nat. Attila Weyland, University of Berne, [braun/steine/weyland]@iam.unibe.ch**

The Virtual Internet and Telecommunications Laboratory of Switzerland is an e-learning course based on a constructivist approach. Students learn and understand key Internet and distributed systems concepts by studying theory and assisting hands-on sessions on real network devices.

The Virtual Internet and Telecommunications Laboratory of Switzerland (VITELS) [6] is one of several projects within the Swiss Virtual Campus (SVC) [3] program funded by the Swiss Ministry of Education and Science. VITELS offers its students the same tools and methods they would find in a traditional university laboratory with the only difference that they can study at any place with Internet connectivity.

*** Torsten Braun** is Professor of Computer Science at University of Berne since 1998. He is head of the Computer Networks and Distributed Systems research group and project leader of VITELS. Since 2000, he has been member of the SWITCH Stiftungsratsausschuss.

Marc-Alain Steinemann is research assistant in the Computer Networks and Distributed Systems research group at University of Berne since 2000. He worked on module content, designed the VITELS architecture and is an author of the VITELS Didactics and Design Guide. He is a member of the SWITCH Projektausschuss "Authentication and Authorisation Infrastructure".

Attila Weyland is research assistant in the Computer Networks and Distributed Systems research group at University of Berne since 2002. He worked on module content, the overall design, a generic laboratory portal within the VITELS project and is an author of the VITELS Didactics and Design Guide.

VITELS partners include the Universities of Berne, Fribourg, Genève, Neuchâtel and the University of Applied Sciences Fribourg (see figure 1). All partners are connected to SWITCHlan [4] and operate their laboratory modules locally. The map displays the SWITCHlan and the VITELS locations. The clouds represent sites where modules are operated. The boxes represent the course and reservations system servers. Another SWITCHlan advantage is that the SWITCH video conferencing service (SWITCHvconf) allows the project partners to easily communicate by video conferencing. As one of the first user communities VITELS started using video conferencing for virtual project meetings in 2001 and could replace time and cost intensive travels throughout Switzerland.

Knowledge Bundling

The project's goal is to develop a course consisting of multiple independent but complementary modules developed under strict didactics and graphics guidelines. The motivation behind this activity bundling is to combine the limited available human and financial resources available to realize and maintain an attractive e-learning course. Each course module discusses a key concept in great detail with a strong emphasis on its hands-on session. This distributed activity management already resulted in a deployed VITELS curriculum consisting of five modules:

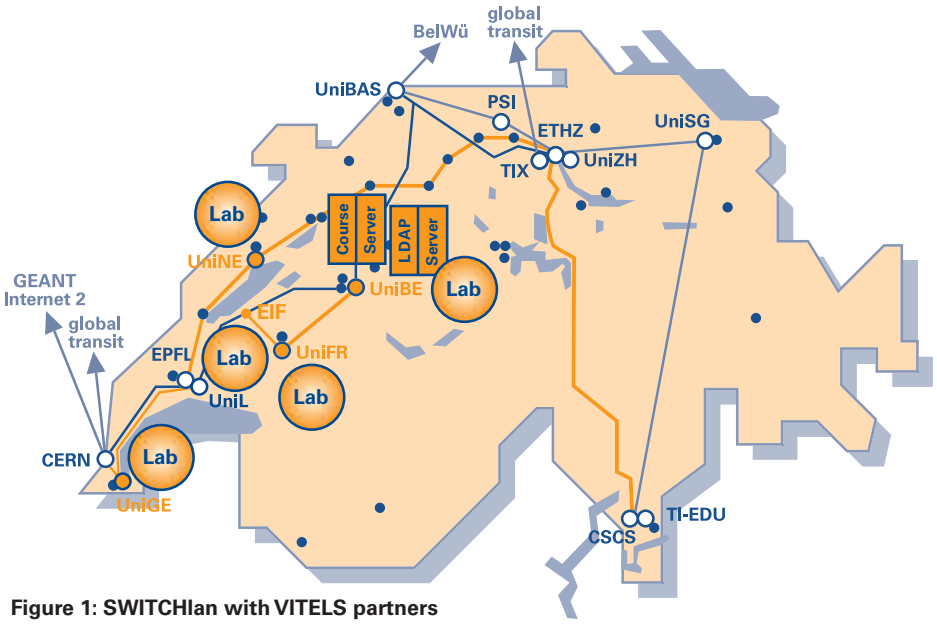
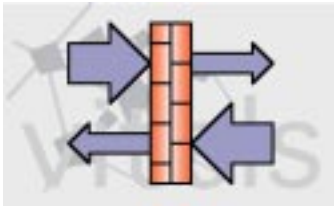


Figure 1: SWITCHlan with VITELS partners

Simulation of IP Network Configuration discusses theoretical and practical aspects of setting up Internet Protocol (IP) networks and covers a wide range of topics such as basic networking concepts, most widely used local area network technologies and the Internet Protocol. In the hands-on session students set up, configure and validate simulated and emulated IP networks.

IP Security introduces security concepts of today's Internet with theory about virtual private networks and security threats caused by hackers. In the hands-on part students set up security associations between two routers and perform bandwidth measurements across encrypted and unencrypted links.

Firewall Management explains actual firewall concepts, the mechanisms of packet filtering, network address translation and firewall architectures. In the hands-on session students configure a commercially available firewall device and protect a private network from attacks from the Internet.



Sockets and Remote Procedure Calls explains how to program applications on top of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) connections using the C programming language. In the hands-on session students program remote procedure calls client/server applications running Linux operating system and execute procedures on remote computers.

Remote Method Invocation explains how to program distributed applications composed of cooperating programs running in multiple processes that can reside on the same or on different computers. Students learn the concepts of Remote Method Invocation, an object-based programming model, which allows objects in different processes to communicate with each other. In the hands-on session students develop a client /server program.

Four further modules are currently under development:

– Linux Systems Installation and Configuration teaches the installation and configuration of Linux computers from scratch.

– Performance Evaluation in Real IP Networks explains theoretical and practical aspects of performance metrics in real IP Networks.

– Client/Server Programming discusses the theoretical and practical aspects of the client-server model by means of the Hypertext Transfer Protocol (HTTP).

– Protocol Analysis splits up the Internet into its layered protocol structure.

Didactics

Internet-based teaching is much more than making paper-scripts on-line available. It requires a well elaborated concept, for the didactics but as well as for the graphical layout. The resulting VITELS modules have the same graphical appearance and didactical structure and differ only in the content. The didactical concept has been developed in collaboration with Technologies de Formation et Apprentissage (TECFA) [5].

The constructivist approach on one side and the goal to produce an easy navigable and understandable course on the other side led to the development of the VITELS Didactics and Graphics Guide. The purpose of the guide is pretty clear: Experts of the respective module's topic must be enabled to produce valuable content without loosing time with didactical or layout problems. The guide is also adaptable to other courses with a constructivist approach.

A common introduction chapter exists for the whole course and it explains the course's global objectives, the pedagogical approach and the course structure to interested teachers and students. The introduction chapter's main task is to avoid reiterations in each of the VITELS modules.

All VITELS modules have exactly the same predefined structure and are split into four sections, as indicated in figure 2:

Chapter 1: Introduction
1 Welcome
2 The Goals and how to Reach Them
3 Module Vicinity
4 My Goals
5 Tips
6 FAQ

Chapter 2: Theory
1 Theoretical Basics
2 Readings
3 Personal Synthesis
4 Self Test
5 Quiz

Chapter 3: Knowledge Application/Exploration
1 Hands-on Session

Chapter 4: Prove Your Knowledge and Skills
1 Personal Synthesis
2 Final Quiz

Figure 2: VITELS module structure

Chapter 1 welcomes and introduces to the content. The module's goals and a storyboard where the module topic is put into context with related topics are followed by a graphical schedule that shows how much time a typical student should spend in each section. The schedule helps students to orientate themselves in the course. A Mind Map should activate students and encourage them to draw an own one (figure 3). Students get activated a second time when they have to actively formulate their expectations to the module after the initial information they got.

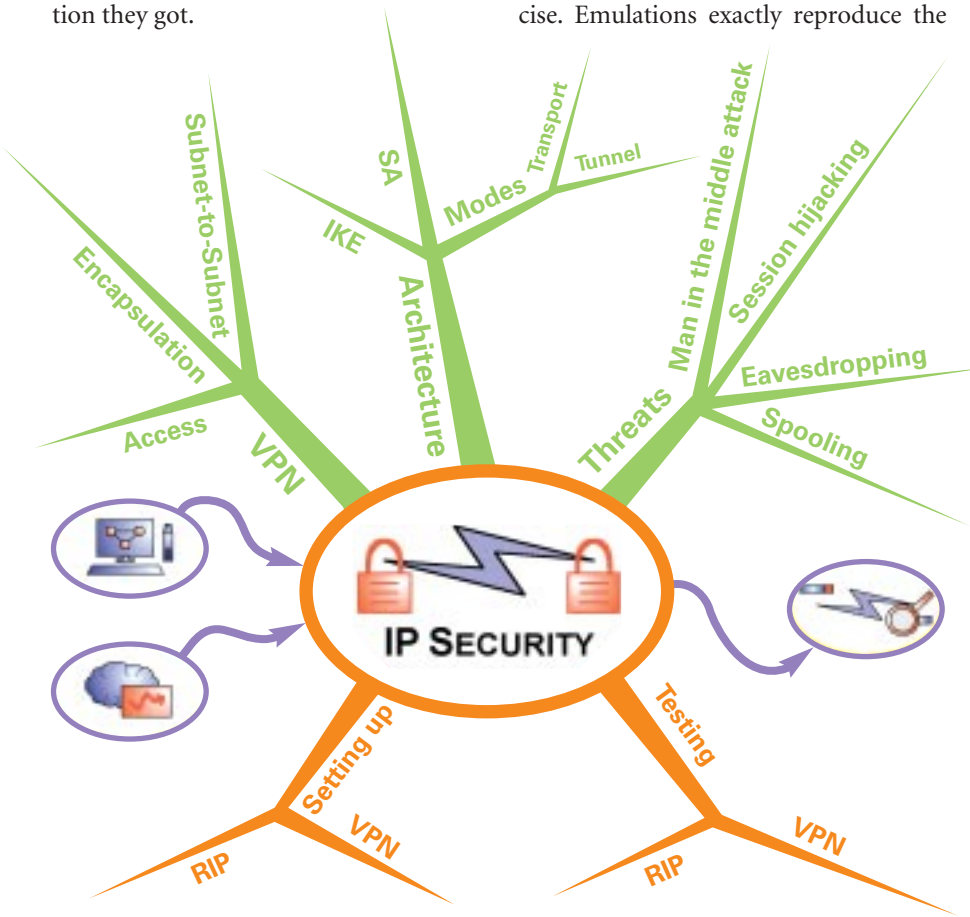


Figure 3: Mind Map activates existing knowledge

Chapter 2 introduces knowledge that is necessary for the hands-on session and includes text, graphics and interactive animations. The readings contain required and recommended readings. Each module must feature at least one required scientific reading to accustom students to scientific articles. When students finally write a personal synthesis they reactivate and recall what they have read and learned before. After that they proceed to check their knowledge in a self test until they feel ready for the quiz to proof their theoretical knowledge.

Chapter 3 only contains the hands-on session. Three different types of hands-on sessions are possible: simulations, emulations and experiments with real devices. Simulations are used where we cannot provide the number of needed devices for an exercise. In one exercise of the module Simulation of IP Network Configuration, students have to program routing tables of up to thirty devices. It would be too costly to buy so many devices. Another advantage simulations offer is that many students can work simultaneously at the same exercise. Emulations exactly reproduce the behavior and look of real existing devices and are much closer to reality than simulations. Emulations are more difficult to implement. An emulation is used to set up network interfaces and routing tables and to connect a bigger sized network in the before mentioned module. Most VITELS modules let students work on real devices but from remote computers. Even if students would work locally they would not have different screens and keyboards than at home. In the module IP Security, students work with two Cisco routers and are able to perform all possible commands, even locking themselves out. But they do not get lost since all devices can be reset upon demand.

Chapter 4 concludes each module. It starts with a personal synthesis covering the whole module but especially focusing on the hands-on session. The module ends with a quiz, which is graded and contains questions about the theory and the hands-on session.

Architecture

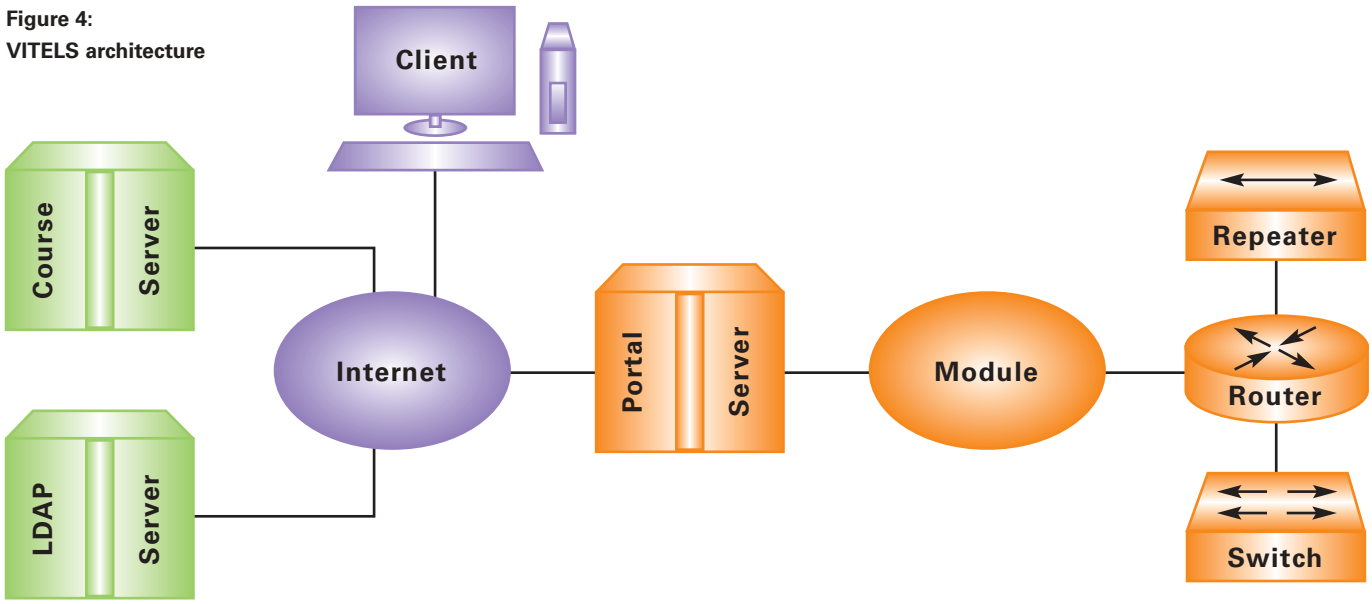
VITELS is based on a specially developed architecture to satisfy the requirements of distributed content providers and the possibility to reserve expensive laboratory devices that are available in a limited number only. Each participating university develops and maintains its modules within its own laboratory environment, but allows VITELS students to access and use the laboratory infrastructure.

The current architecture is based on a Lightweight Directory Access Protocol (LDAP) directory server for user and module data management as well as for scheduling functions (figure 4). Students must reserve time slots for hands-on sessions by a web interface.

Each module's hands-on session with emulations or real devices can be accessed via a portal server. Portal servers perform gateway functions but also act as firewalls. There is one portal server per module. Portal servers do not contain any student data but they are connected to the central LDAP directory server, where they get authentication and authorisation information. Students and teachers connect with secure socket layer (SSL) through the portal to the laboratory equipment. The architecture allows connecting all kind of laboratory modules to the portals.

For the proper function of the hands-on exercises, error recovery mechanisms had to be implemented. Students, with or without bad intentions, can crash hardware or lock out themselves from the laboratory infrastructure. A part of

Figure 4:
VITELS architecture



the recovery functions is a virtual "emergency button" that is placed on the course pages, allowing a restart with the original settings at any time. After a student has finished an exercise, the hardware has to be re-initialized and set to the original settings for the next student. Automatic reset is performed between the time slots of two users.

A commercial web-learning platform (WebCT) is used for the typical course management and content provision. Commercial web-learning platforms offer many useful functions for student management and especially for creating and automatically grading exercises. Although those platforms offer news boards, chat, student mail, white boards and more – they are restricted in terms of designing web pages. As a consequence, the portal servers run their own web servers and provide parts of the course module's content directly to the students. The result is that the web pages on the course server lead through the entire course, such as a red thread, but is supplemented with content from external sources such as from the portal servers.

Conclusions and Next Steps

About fifty students attended the course in its current form. Students appreciated the clear concept behind VITELS and the uniform appearance. After overcoming a first distrust caused by unfamiliar didactical elements, students confirmed that they have learned a lot. This shows that university education could be enriched by elements such as writing syntheses or formulating own learning goals. After collecting further feedback the VITELS guide will be improved to even better satisfy students' and teachers' expectations.

Our contacts to other SVC projects such as Nano-World [2] helped improving our project in technical as well as in didactical issues.

VITELS is open to new partners not only as students' providers but especially as module providers. There are many topics in the area of Internet and telecommunications that could be covered by more modules.

VITELS has been a pilot project in many areas such as didactics, authentication and authorization, video conferencing and constructivist e-learning. Currently, VITELS intends to be one of the first projects that moves to the future SWITCH WebCT server. VITELS is also one of the AAI pilot projects [1] and will be integrated into the Swiss-wide Authentication and Authorisation Infrastructure whose deployment is lead by SWITCH.

References

[1] AAI-Portal Project (VITELS), http://aaitest1.unibe.ch
[2] Nano-World, http://www.nano-world.org
[3] SVC, http://www.virtualcampus.ch
[4] SWITCH, http://www.switch.ch
[5] TECFA, http://tecfa.unige.ch
[6] VITELS, http://www.vitels.ch