

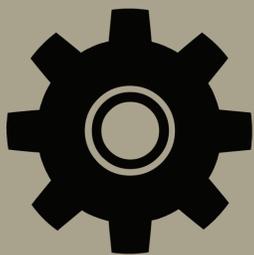
# Design and Implementation of the UULM Networking Lab

Michael Müller

Lectures regarding internet technologies aim to provide a theoretical background and try to further practical insights by offering accompanying assignments. However, these assignments often only cover a small part of the subject and usually do not provide hands-on experience with hardware which is actually used in existing working environments.

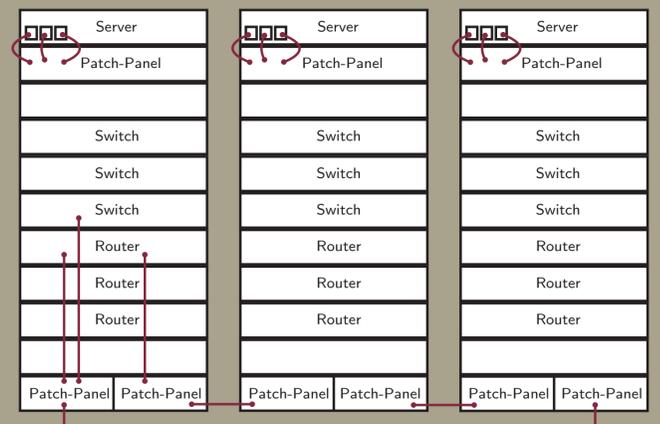
Students should be able to gather a better understanding of the concepts, technical challenges and design decisions behind the Internet. For this purpose we built the foundation for a network laboratory in which it is possible to set up and manage different network scenarios. The laboratory's purpose is to serve as an educational environment. Over the period of one semester, students set up core technologies within the laboratory, thus creating a macroscopic version of the Internet as part of a practical course.

## Architecture

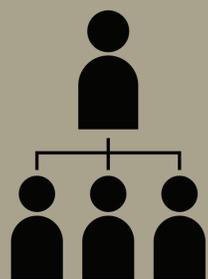


At least three racks are necessary to build interesting scenarios: for instance, failover problems only make sense with at least three different entities; if the direct route between two entities fails, the system should be able to adapt and use the third entity to balance the loss. Equipping the racks with identical equipment can be justified by an educational advantage; enabling three different groups to each work on a rack.

Similarly to the racks, at least three routers and switches for each rack are essential for interesting scenarios. Each rack is equipped with exactly three routers and switches in order to keep the laboratory simple whilst still having a broad variety of options for scenarios.



## Management system



### Out-of-Band Management

The network lab is set up in such a way that it is always possible to return to a working state. This is the single-most highest priority of the management system, as otherwise a multitude of problems could occur.



### Version control system

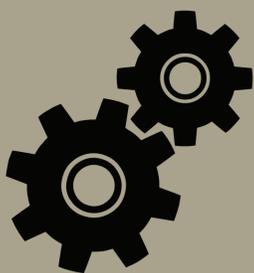
We provide a safe way of being able to work with the lab. Groups are able to save the state of their work at any time within a version control system. This provides a safe way of exploring the lab; by way of encouraging experimentation rather than constraining it.



### Access control

Students working on devices do not have the necessary privilege levels to permanently change the device configuration. As a consequence, the system must administrate the necessary privilege levels for different assignments.

## Implementation



Our implementation follows the Unix philosophy: *Do one thing and do it right*. We use different scripts for dedicated tasks, each fulfilling one function while remaining simple and small. A wrapper script is then used to compose the various scripts.

Our initial set-up does not need any kind of database system. Instead, data is stored within flat ASCII files; a simple solution which has many additional advantages. It enables the use of tools from the Unix toolchest to rapidly build up the system logic. The project can easily be understood, maintained and enhanced using standard Unix tools.

```
$ ls /mgmt/
./student-mgmt.sh

./devs/
./scripts/
./cisco1800/pull-config.sh
./cisco1800/push-config.sh
./cisco1800/prepare-assignment.sh
./assignments/
./groups/
```