

# The iLab Experience

a blended learning hands-on course concept



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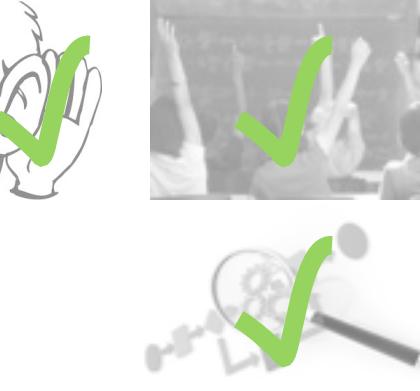


# facts

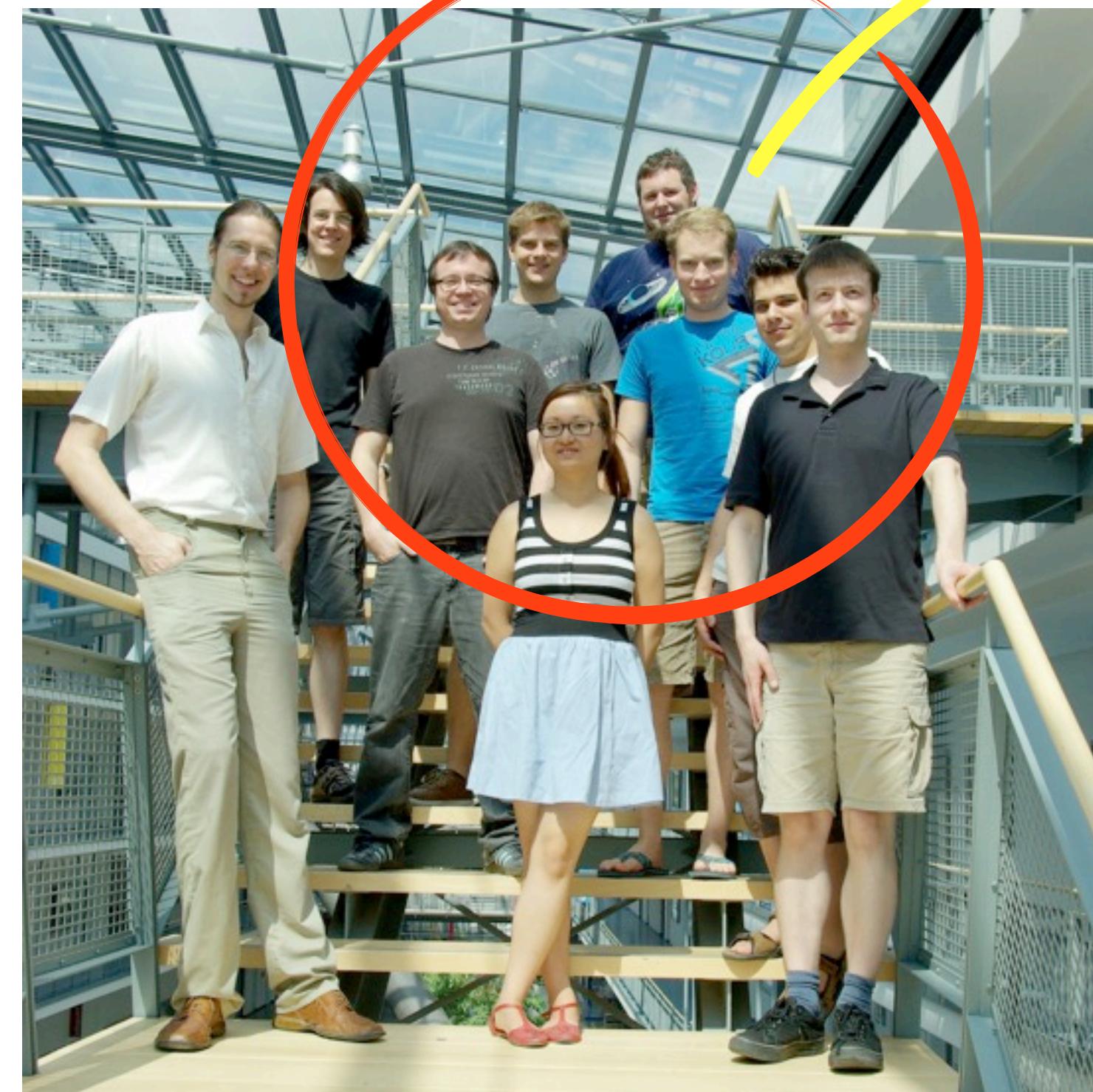


- **iLab** (=Internet) & **iLab<sup>2</sup>** (=selected network architectures and services)
- Bachelor and Master Level hands-on lab
- I semester / 10 ECTS (~300h)
- over 1000 participants so far
- over 80 registrations for next semester

only possible as working with the eLearning platform scales



# in short



listen



encourage

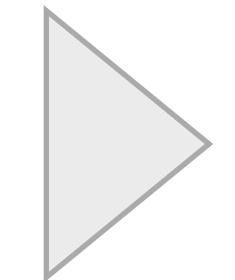
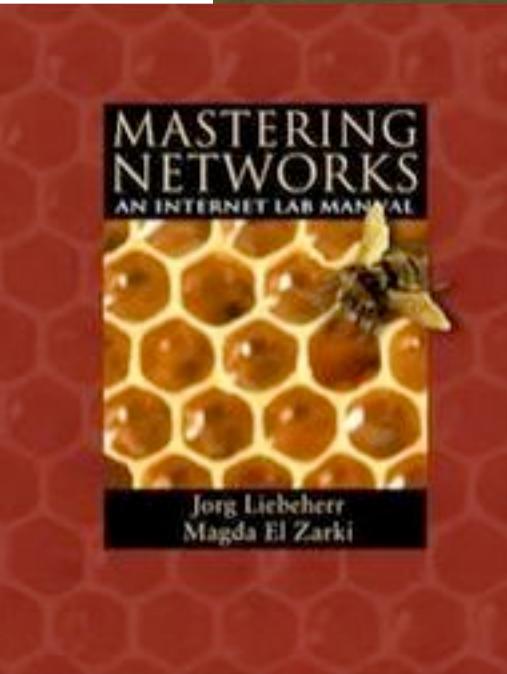


constantly improve

# background



# the beginning



The command to add a host route to IP address 10.0.2.31 with the next hop set to 10.0.1.21 is  
`PC1#route add -host 10.0.2.31 gw 10.0.1.21`

The command to add the IP address 10.0.4.4 as the default gateway is done with the command  
`PC1#route add default gw 10.0.4.4`

The commands to delete the entries created with the above commands are  
`PC1#route del -net 10.21.0.0 netmask 255.255.0.0`  
`PC1#route del -host 10.0.2.31`  
`PC1#route del default`

There is no simple way to delete all entries in the routing table. One method to flush the routing table is to disable the interface and then enable the interface, as in  
`PC1% ifconfig eth0 down up`

When the commands are issued interactively in a Linux Shell, the added entries are valid until Linux is rebooted. To make static routes permanent, the routes need to be entered in the configuration file `/etc/sysconfig/static-routes`, which is read each time Linux is started.

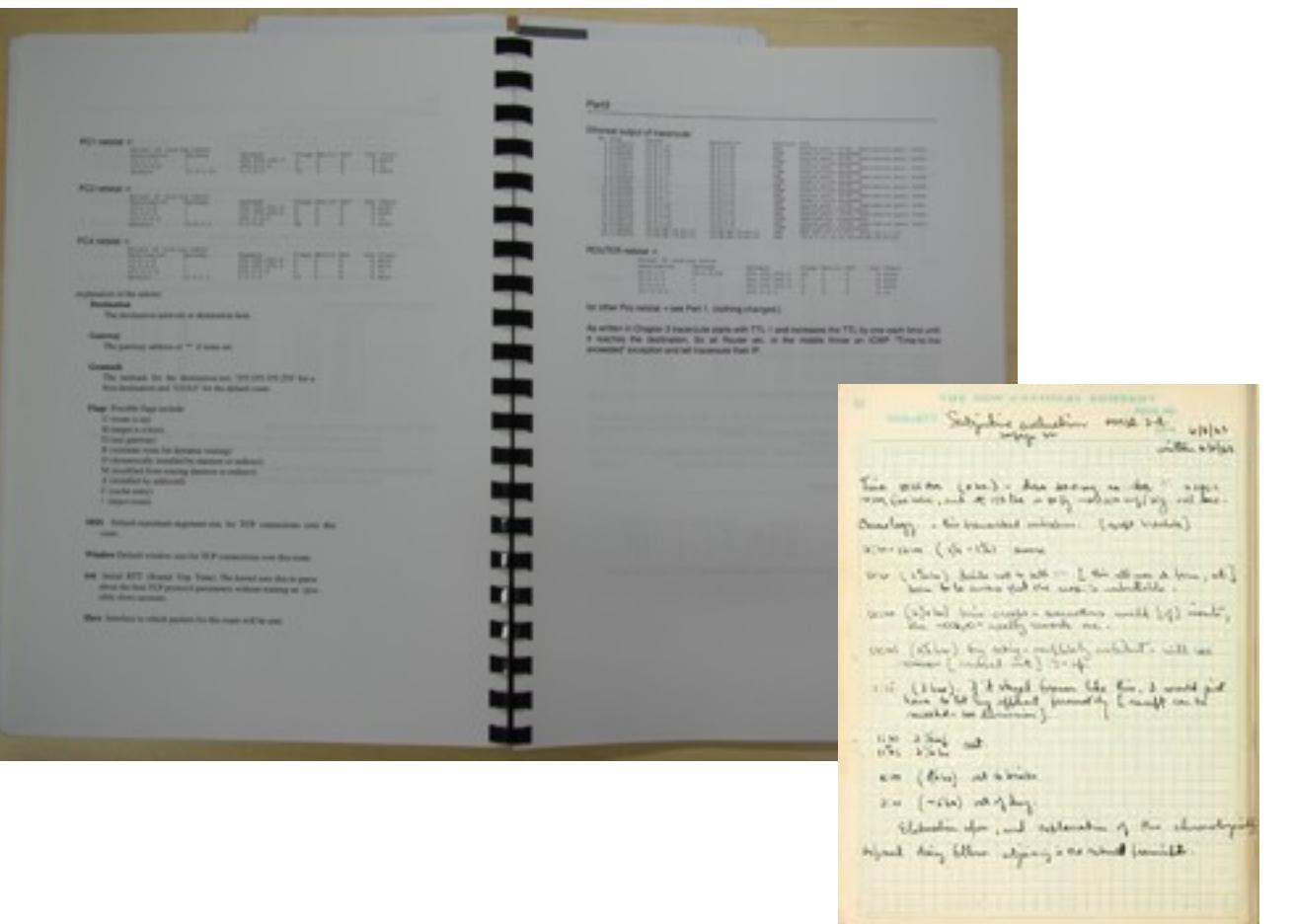
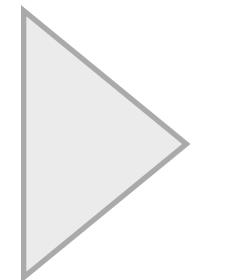
The following commands are helpful to get information on routing and to find mistakes in the routing setup:

**ping IPaddress** Tests if IPaddress can be reached.  
**traceroute IPaddress** Displays the route to the interface IPaddress.

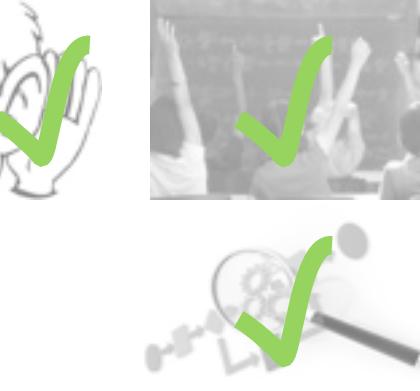
- Configure the routing table entries of PC1 and PC4. You can either specify a default route or you insert separate routing entries for each remote network. For this exercise, add a route for each individual remote network. As a hint, here is the configuration information for PC4:  
`PC4#route add -net 10.0.2.0 netmask 255.255.255.0 gw 10.0.3.1`  
`PC4#route add -net 10.0.1.0 netmask 255.255.255.0 gw 10.0.3.1`
- Configure the routing table entries of the IP router PC2. (The correctness of the routing entries will be tested after Router1 has been setup.)
- Display the routing table of PC1, PC2, and PC4 with `netstat -rn` and save the output.

**Lab Report:**  
Include the saved output of the routing table. Explain the entries in the routing table and discuss the values of the fields for each entry.

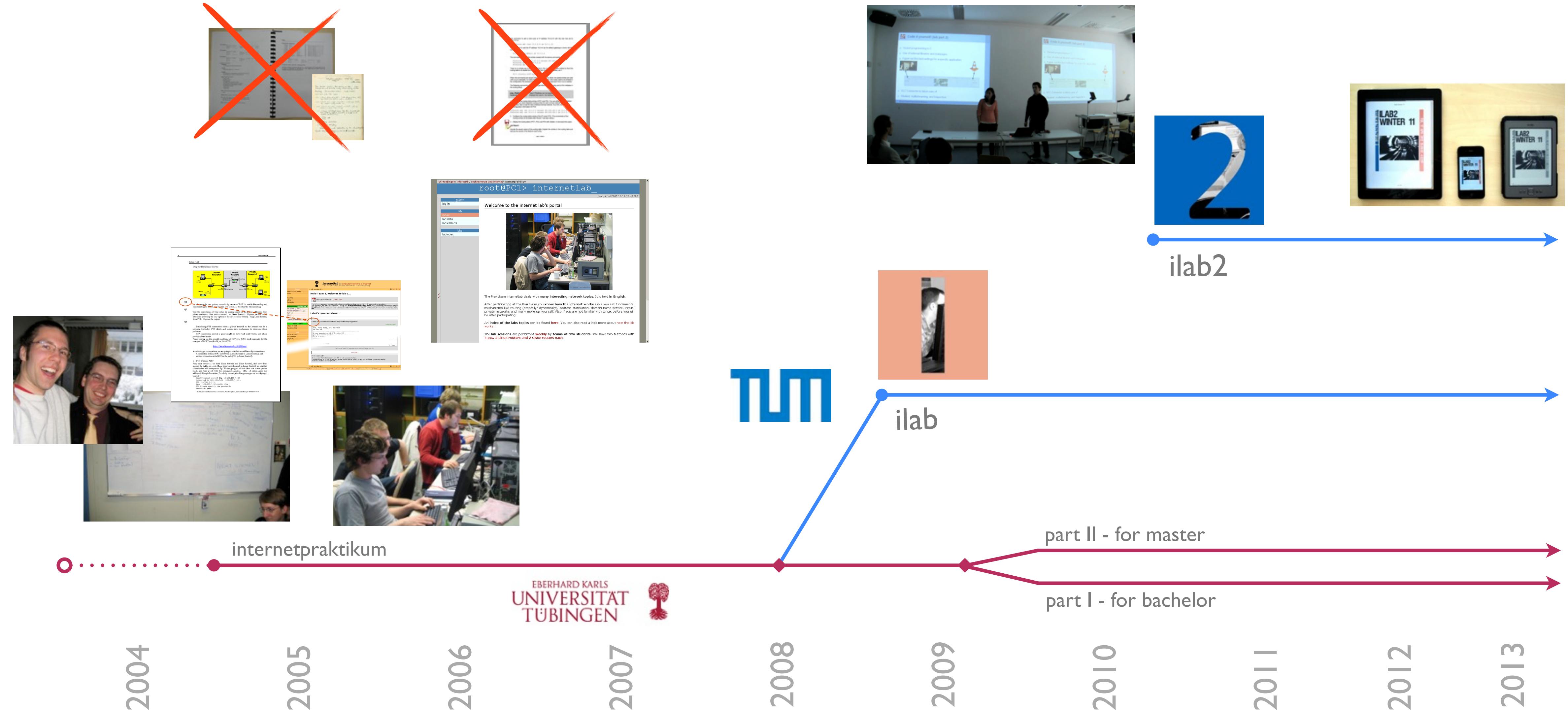
LAB 3 - PAGE 8



2003 Universität Tübingen: Internetpraktikum 2003

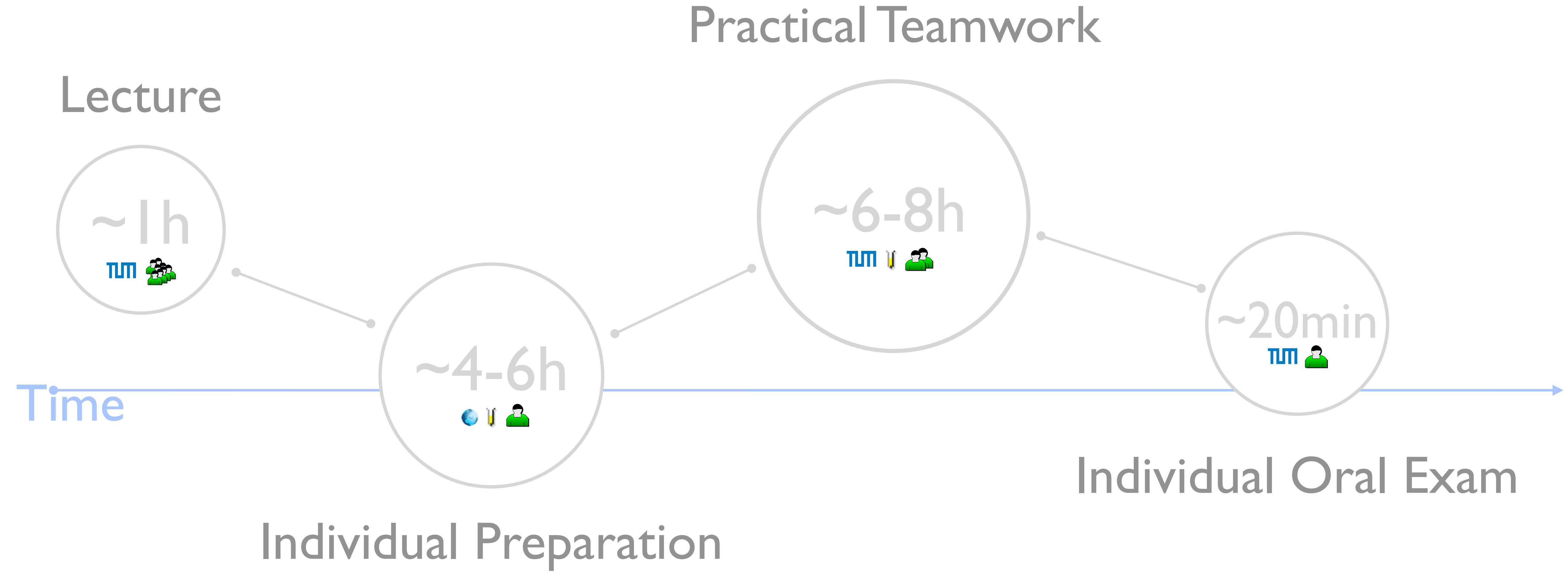


# constant improvement



didactic concept

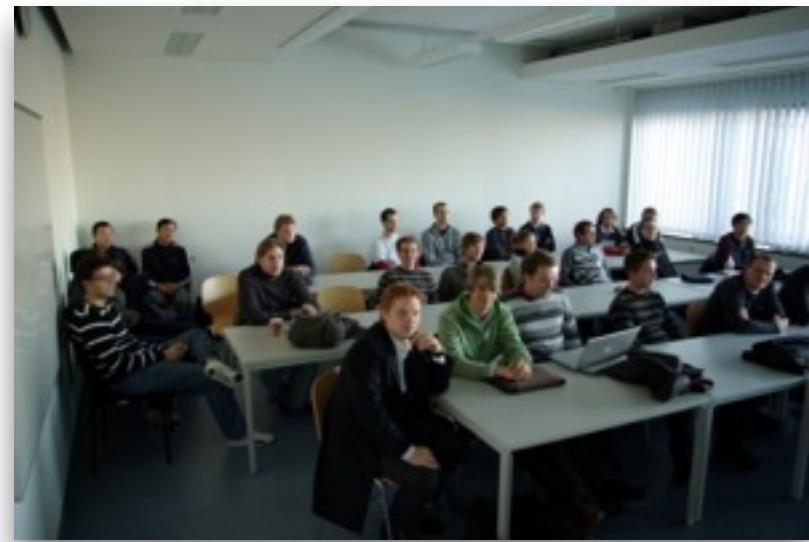
# blended learning concept





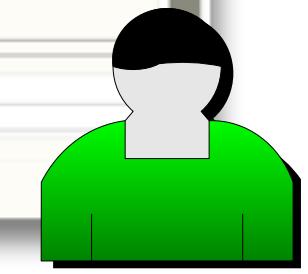
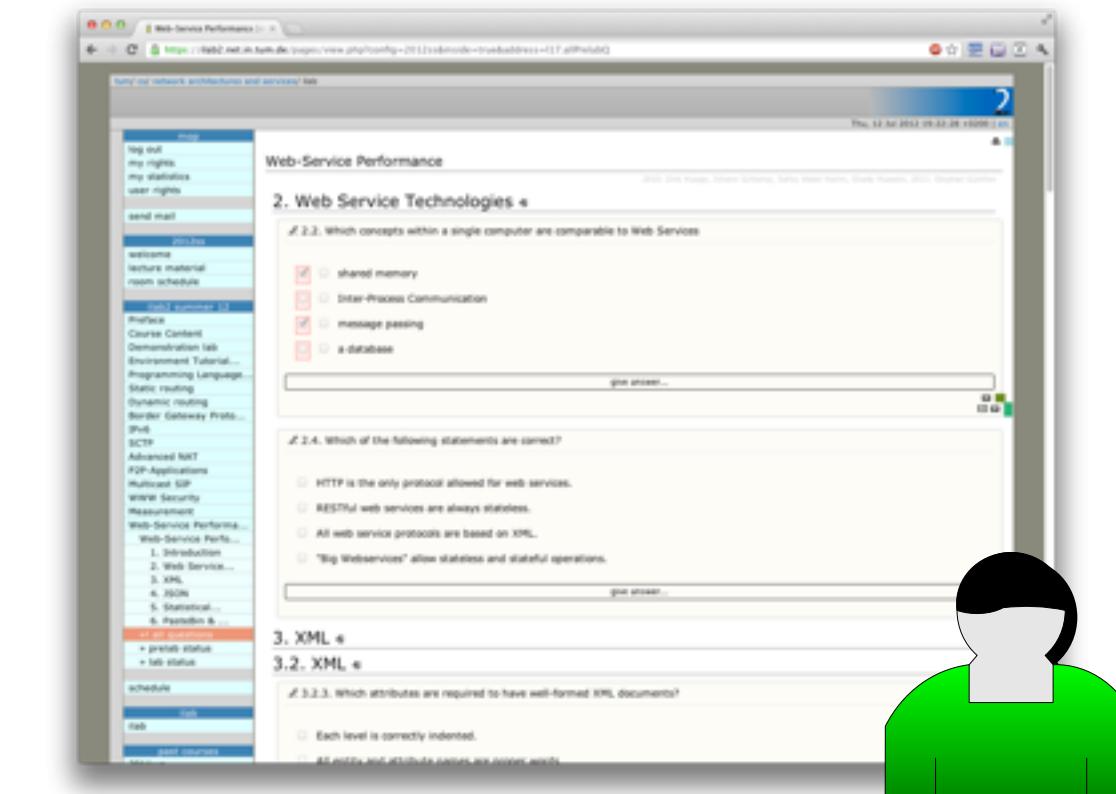
# eLearning support

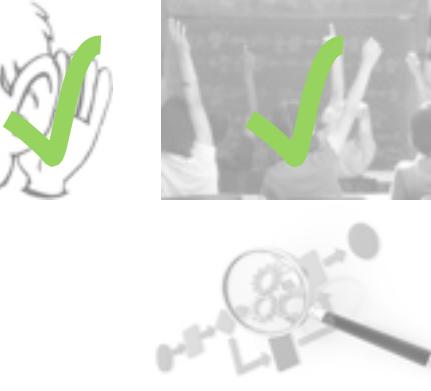
## Lecture



## Individual Preparation

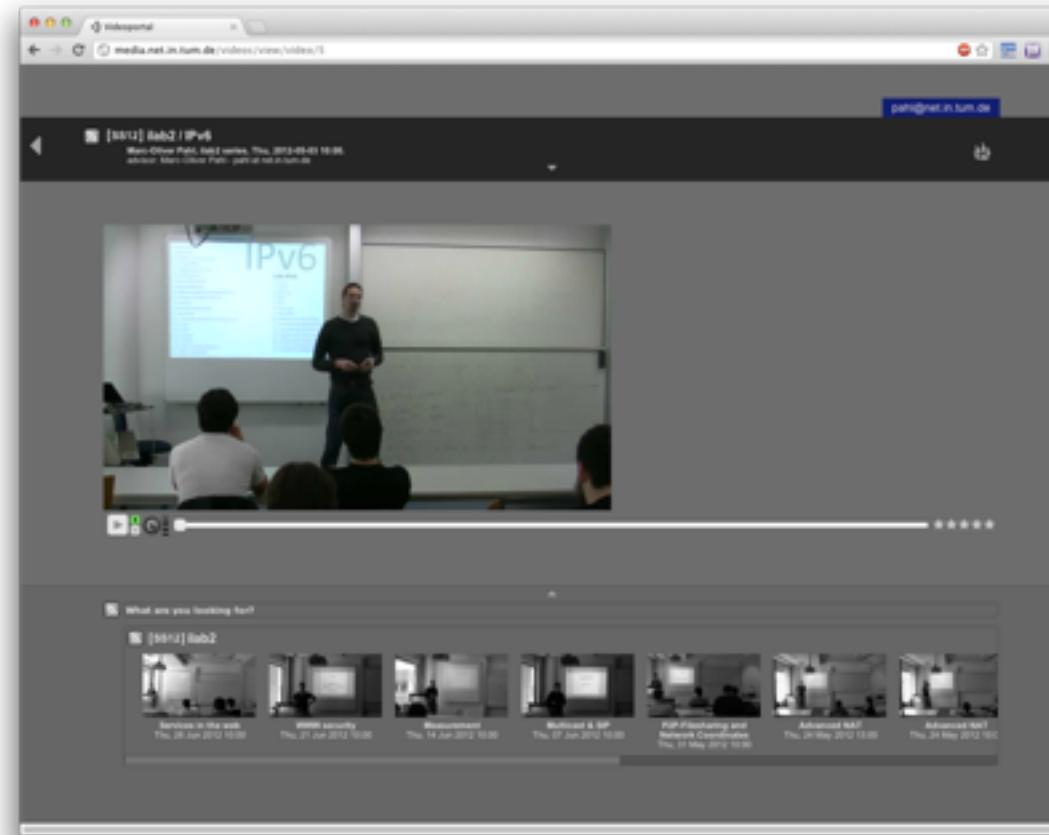
## Practical Teamwork





# eLearning prelab

not taken into account for grading  
(directly learn from errors)



The Motivation For Web Services

Web Services allow for the development of applications which are built around and accessible via web browsers. If designed with care, those applications are totally independent of a client's hardware, operating system, and even the web browser used to access the application. Furthermore, web services allow for well-defined interfaces between web servers and data stored on backends.

There are many examples for applications relying on web services. For instance, merchantile directory services might provide a simple web interface where a user can enter keywords characterizing a branch of trade and an approximate location. The web server passes the request to a backend which processes the request and returns the result.

More complex applications are social networks, e.g. Facebook. But also in companies web services are becoming more and more important. For instance, car repair shops commonly rely on parts catalog and repair instructions which are accessible through the web.

J2.2. Which concepts within a single computer are comparable to Web Services

shared memory  
 Inter-Process Communication  
 message passing  
 a database

give answer

2. Web Service Technologies

J2.2. Which concepts within a single computer are comparable to Web Services

shared memory  
 Inter-Process Communication  
 message passing  
 a database

J2.4. Which of the following statements are correct?

HTTP is the only protocol allowed for web services.  
 RESTful web services are always stateless.  
 All web service protocols are based on XML.  
 "Big Webservices" allow stateless and stateful operations.

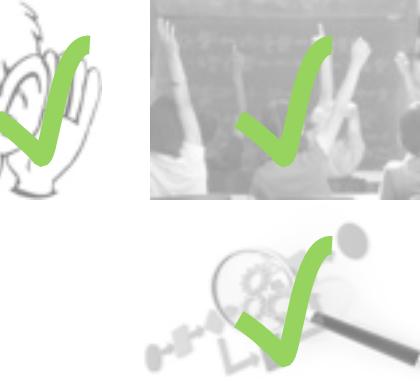
3. XML

J3.2.3. Which attributes are required to have well-formed XML documents?

Each level is correctly indented.  
All opening and attribute closures are proper, word

Order by: team

user	team	status
user1	team1	green
user2	team1	green
user3	team1	green
user4	team1	green
user5	team2	green
user6	team2	green
user7	team2	green
user8	team2	green
user9	team3	green
user10	team3	green
user11	team3	green
user12	team3	green
user13	team4	green
user14	team4	green
user15	team4	green
user16	team4	green
user17	team5	green
user18	team5	green
user19	team5	green
user20	team5	green
user21	team6	green
user22	team6	green
user23	team6	green
user24	team6	green
user25	team7	green
user26	team7	green
user27	team7	green
user28	team7	green
user29	team8	green
user30	team8	green
user31	team8	green
user32	team8	green
user33	team9	green
user34	team9	green
user35	team9	green
user36	team9	green
user37	team10	green
user38	team10	green
user39	team10	green
user40	team10	green
user41	team11	green
user42	team11	green
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user245	team62	green
user246	team62	green
user247	team62	green
user248	team62	green
user249	team63	green
user250	team63	green
user251	team63	green
user252	team63	green
user253	team64	green
user254	team64	green
user255	team64	green
user256	team64	green
user257	team65	green



# eLearning lab

credits for grading

The components of this lab will be configured step-by-step later. As first step we do the cabling here only.  
Please connect the devices as follows:

**Islet A**

PC1 (eth0), PC2 (eth0), PC3 (eth0), PC4 (eth0), and a central switch. PC1 and PC2 are connected to the central switch. PC3 and PC4 are also connected to the central switch.

**Islet B**

PC1 (eth0), PC2 (eth0), PC3 (eth0), PC4 (eth0), and a central switch. PC1 and PC2 are connected to the central switch. PC3 and PC4 are also connected to the central switch.

**This might save you some time...**

When you configured IPv6 addresses but cannot ping them it might have to do with the following:  
Make sure the interfaces are up before you configure their ipv6 addresses (`ifconfig -a`)  
Otherwise the ipv6 address will be added as `tentative` and not work properly (e.g. not answer to ping).

We will now test the setup again like we did on the previous page. We will again use netcat (most likely invoked by nc) the swiss army knife for networking.  
From the man page of netcat (man nc):

The nc (or ncrypt) utility is used for port scanning, anything under the sun involving TCP or UDP. It can be used for port scanning, remote logins,平凡的字节流 transfer, and more with both IPv4 and IPv6. Unlike telnet(1), nc accepts simply, and operates error messages onto standard error instead of sending them to standard output.

If you haven't already done so please make yourself familiar with netcat.  
Whenever you have questions consult the manpage on your hosts. Don't use man pages from the Internet as the implementations of netcat vary from operating system to operating system, (we even found two contradictory man pages on the net).

Now, please use netcat on PC1 or PC2 (one of the internal hosts) and access the apache webserver which is still running on PC4, port 80. Fire up tcpdump/wireshark on PC3 and capture the traffic on eth1. (Please mind that the file gets dumped to the directory where you started the netcat listener on the destination machine.)

Did it work?

2.6. As an alternative to SNAT we can also use Masquerading. Please explain the difference and the advantage of masquerading.

2.7. Now delete the SNAT rule and set up masquerading on PC3 (our Linux router). Which commands did you use?

2.10. Where can you change these values?

An accurate measure of the raw web service is the fastest: the Zabbix data server is placed second and the MySQL data server is the slowest. The difference between Zabbix and MySQL is not that much but the new service is a lot faster.

From the man page of netcat (man nc):

SCTP  
Advanced NAT  
P2P-Applications  
Multicast SIP  
WWW Security  
Measurement  
Web-Service Performance

+ all questions  
+ free-text  
1. Introduction  
2. Code Walkthrough  
3. Lab  
4. Please remember...  
5. Postlab & ...  
+ all questions  
+ lab status

**schedule**

**add course**

**MarkDown Demo**

**lab**

**good courses**

2013ws  
2013ss  
2013ws

**2.10. Where can you change these values?**

Order by: name

#	Team	Name	Score
1	1-B	Nagl, Timo	80%
2	1-B	Adam, Bernhard	80%
3	2-B	Gehrmann, Fabian	80%
4	2-B	Khemlaek, Hidet	80%
5	2-B	Klyuch, Oleg	80%
6	2-B	Ungurean, Mihai	80%
7	4-B	Mohr, Torsten	60%
8	4-B	Tran, Linh	80%
9	5-B	Krausz, Julian	80%
10	6-B	Pache, Christian	80%
11	6-B	Thielmann, Uwe	70%

Click here to see the statistics of all labs.

Stop seeing someone's data.

update status

If you click on 'x' this icon the respective user will be mapped to his current team answers. (Don't forget to update the status after remapping!)

all instructions  
online

free text inputs  
inline

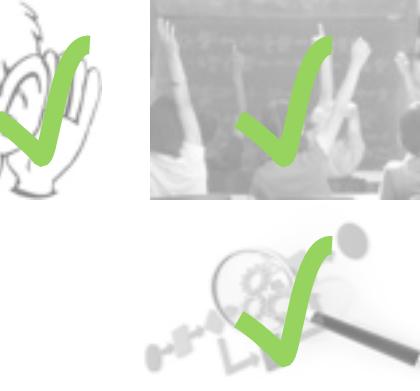
cross correction

course management

no additional reports

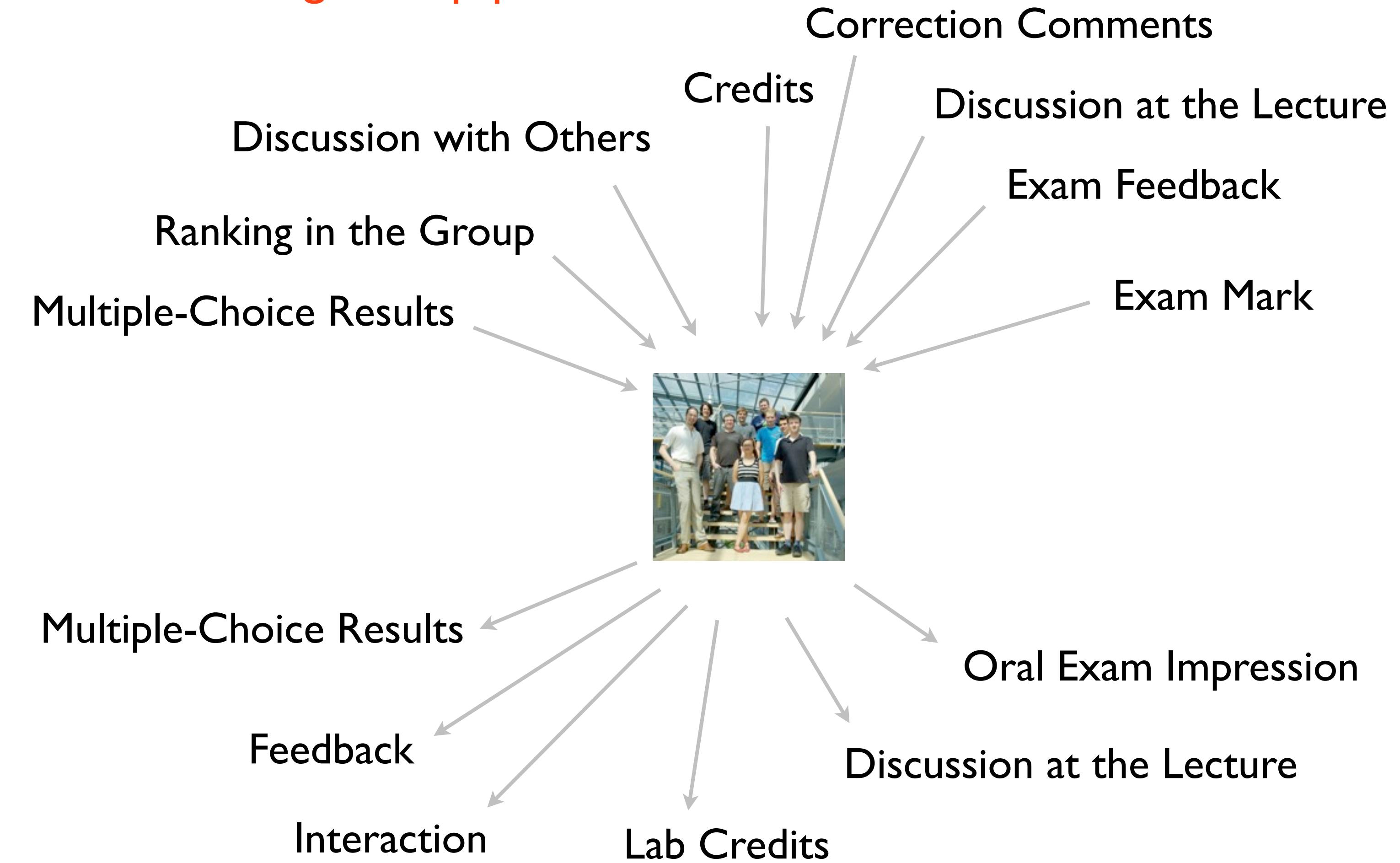
fast feedback

important **success factors**



# interactivity

## Self-Learning Support



Feedback to the Teachers

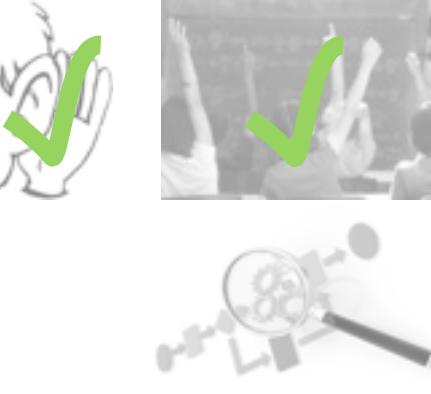
Feedback is important to encourage the learners to continue learning. It is a main mean for motivation. Feedback is important for the teachers as well as it helps them to adapt to the needs of the current student group. The student feedback is continuously used to improve the exercises.



# frequent change

## variation

in learning methods and modes

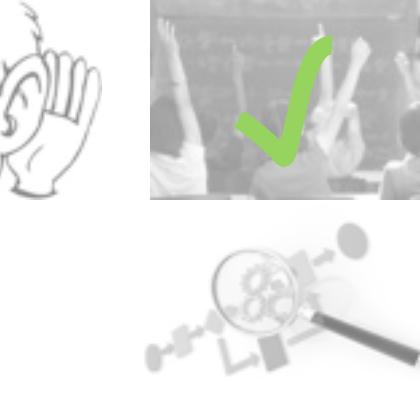


# iLab

= online + live

instructions, self-  
correcting multiple-  
choice questions, free  
text inputs, course  
management, mail  
support, chat

lecture,  
hands-on,  
discussion



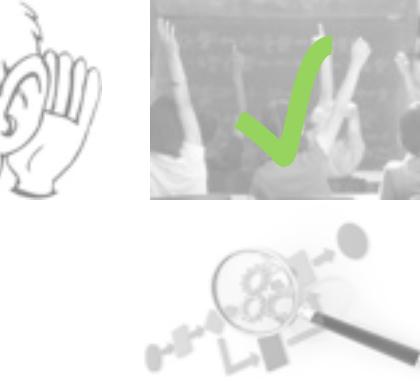
# iLab

= group + individual + team

lecture

self-preparation

hands-on

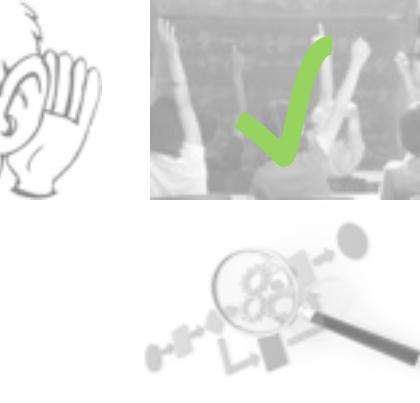


# teamwork

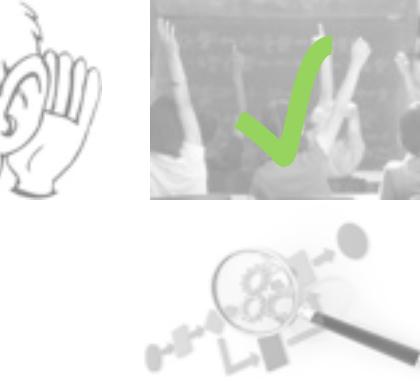
## you are not alone

learning from and supporting the team mate





# further encouragement

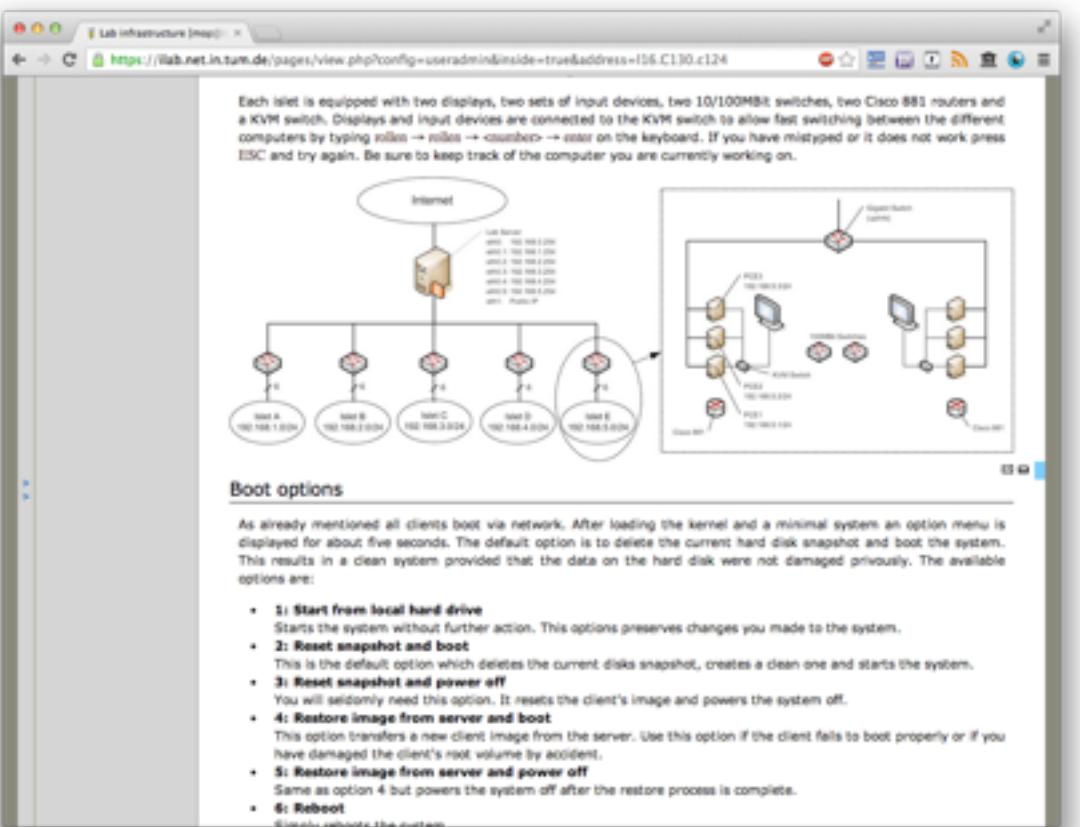


# eLearning registration

The screenshot shows a registration form for a practical exercise. It includes fields for 'surname', 'forename', 'eMail', 'currentSemester', 'desiredTeamPartner', and a 'register' button. A note at the top says: "How can I apply? You find the registration form below. As the practical exercises are performed in teams of two students, it is a good idea to already search a team partner right now. You can give the name of your designated team partner in the application form. As the places are usually in great demand you should register early. The amount of free places is shown below the form. Please continue registering even if no places are left as usually not all students really participate at the end (+ teams can use weekend slots on the testbed). If you register now and decide not to participate later please withdraw the course as described in the email to free your place for students on the waiting list. Thank you." Below the form, a progress bar shows 100 places left out of 240.

The screenshot shows a preface page for the Internet Lab. It features a welcome message to the user: "Hello Marc-Oliver Pahl, welcome to the lab!". Below this is a "Short introduction to the didactical concept with some historical remarks". The text discusses the history of the lab, mentioning Prof. Dr.-Ing. Georg Carle and his chair for "Rechnernetze und Protokolle". It also notes the involvement of Uwe Bilger and Magda El Zarki. The page includes a small portrait of Uwe Bilger and a "check prelab" button.

The screenshot shows a demonstration prelab page. It provides instructions for using the lab module, mentioning "prelab" and "real lab". It also describes the "prefile" which contains theoretical background and practical sections. A "multiple choice question" is displayed: "What is a magician but a practicing theorist? --- Uwe-Marc Kessell, 'Return of the Jedi'". The answer is "This is a multiple choice question. Click on 'give answers' to set the check marks. Don't forget to 'save'...". The page also includes a "boot options" section with various system recovery and restore options.



## registration

## immediate access

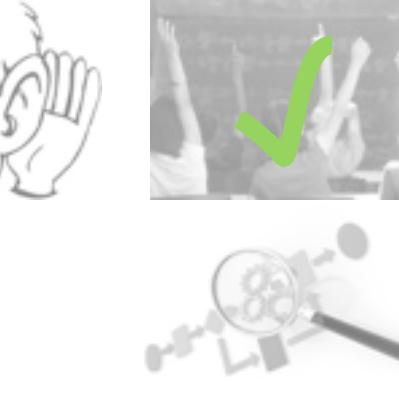
## tutorials web-based labsystem

## tutorials environment / basic tools



# feel at home





# topics



- a **Demonstration lab** - This lab module makes you familiar with the web-based learning system and the didactical principles behind the course.
- b **Cisco IOS Tutorials** - This tutorial give an introduction into the programming languages used in iLab2 (C, Java, Python). It also introduces the basics of Cisco IOS.
- c **Environment Tutorial Lab Room** - This tutorial introduces the lab room environment.
- 0 **The basics** - Our main concern in the first lab exercise is to get familiar with the basic tools we are using. You'll have a look at Linux' network capabilities experimenting on Layer 2 and 3 of the ISO-model.
- 1 **Static routing** - Continuing on Layer 3 we have a deeper look into IP-Routing.
- 2 **Dynamic routing** - On our journey towards the "real Internet" we learn how automatic routing works inside the different domains of the net.
- 3 **TCP/ UDP** - After looking at IP fragmentation, we climb up one Layer to Layer 4: The end-to-end-communication is of our interest now.
- 4 **DNS** - Most of the time we address machines using names instead of (IP-)numbers... but how does the Domain Name System work? After this lab you should know exactly what happens, when you type <http://ilab.net.in.tum.de> into your browsers url-field...
- 5 **NAT/ DHCP/ IPv6** - Coming closer to our home setup we look inside Network Address Translation as technique to use one external address to allow multiple intern machines to access the Internet. NAT is especially important today since we are getting out of Ipv4 addresses. Besides its usefulness NAT causes some trouble as we will see. Another important mechanism is Dynamic Host Control Protocol allowing computers to be partly automatically configured. As the migration towards Ipv6 is ongoing and since the new protocol provides interesting mechanisms we have a look at it here.
- 6 **Security I** - In this lab we get to know how Firewalls help to secure our network-nodes. As example we use a webserver using TLS.
- 7 **Security II** - How can we establish secure connections over insecure networks?
- 8 **Wireless LAN** - Often used but how is it really working? We address physical aspects as well as protocol aspects before we come to security. We will explore how fast we can crack a WEP-Key and more important why. We will look at WPA and Radius for a more secure wireless infrastructure.

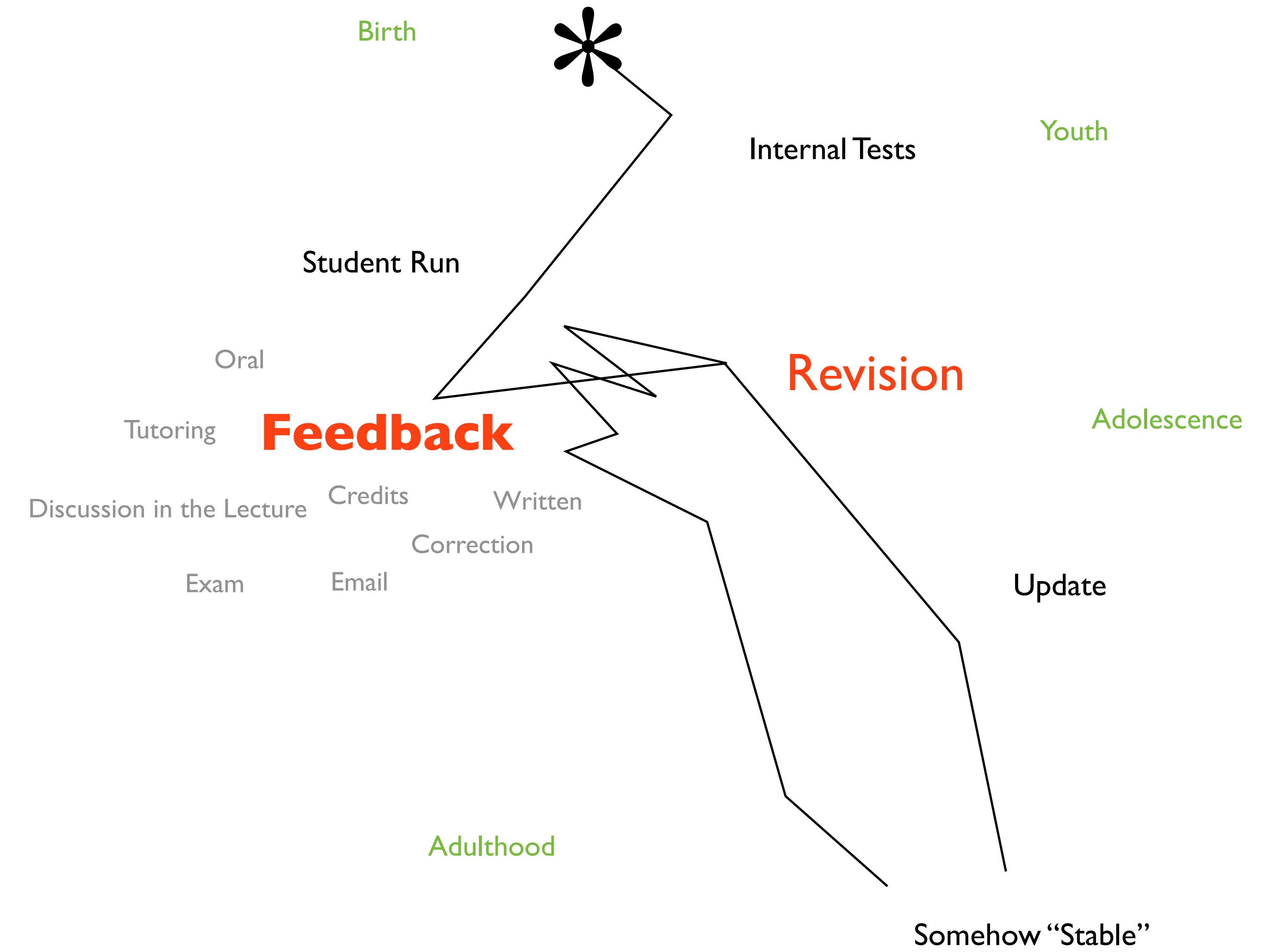


- a **Environment Tutorial Lab Room** - This tutorial introduces the lab room environment.
- b **Programming Language and Cisco IOS Tutorials** - This tutorial give an introduction into the programming languages used in iLab2 (C, Java, Python). It also introduces the basics of Cisco IOS.
- c **Demonstration lab** - This lab module makes you familiar with the web-based learning system and the didactical principles behind the course.
- d **Static routing** - Continuing on Layer 3 we have a deeper look into IP-Routing.
- 0 **Dynamic routing** - On our journey towards the "real Internet" we learn how automatic routing works inside the different domains of the net.
- 1 **Border Gateway Protocol** - This lab is about the Border Gateway Protocol (BGP) that is used for routing between Autonomous Systems (AS). You will learn about the power of the system and the risks of configuration errors...
- 2 **IPv6** - In this lab different features of IPv6 are examined: Autoconfiguration, DHCPv6, NAT64, Fragmentation, and Dual Stack implementation. Additionally a DNS Server running with IPv6 and IPv4 addresses and automatic Zone transfer is configured.
- 3 **SCTP** - You will get to know the features of SCTP realizing a video streaming example.
- 4 **Advanced NAT** - You will explore advanced NAT traversal techniques in this exercise.
- 5 **WWW Security** - In this lab, you are going to investigate some of the most important security challenges on the WWW. You will hack a Web server using a number of attack techniques, working your way through SQL Injection, Cross-Site Scripting and Remote Code Execution until you gain shell access to the server and can manipulate the file system.
- 6 **Multicast SIP** - In the first part of this PreLab you will learn about IP Multicast and the protocols used by it, IGMP and PIM. The second part is about SIP, the Session Initialisation Protocol, and how it is used, both in voice over IP and other applications.
- 7 **Measurement** - This lab is about passive traffic measurements and the export of measurement data from a monitoring probe to a remote traffic analyzer using the IPFIX protocol.
- 8 **Advanced Wireless LAN** - Defend my wireless territory - Do you have problems with overcrowded frequency bands for WLAN? The ilab2 can help you! This lab will address multiple aspects of WLAN, focusing on the protocol, especially on management and its flaws.
- 9 **Smart Space Orchestration** - Physical spaces that are enriched with networked sensors and actuators are called smart spaces. In this exercise you will build your own smart device, write a protocol for communicating with it, write a driver that connects your device with the ds2os middleware, and create user application services that orchestrate your space using your device.



# continuous evolution

iLab exercises grow from continuous exchange. Exchange within the group of learners and between the students and the professors. The iLab encourages to exchange wherever possible. It is an important element of the success of the concept.



# outlook

# context related chat

The screenshot shows a web browser window with a sidebar on the left containing a navigation menu and a list of past courses. The main content area displays a series of numbered questions. A yellow callout bubble from a user named 'mop' points to the text about netcat, suggesting to look at the routing table of PC4. Another callout from 'u>' says 'good point :)'.

**2. iptables' NAT basics and trial**

We will now test the setup again like we did on the previous page. We will again use netcat (most likely invoked by nc) the swiss army knife for networking.  
From the man page of netcat (man nc):

The nc (or netcat) utility is used for just about anything under the sun involving TCP or UDP. It can open TCP connections, send UDP packets, listen on arbitrary TCP and UDP ports, do port scanning, and deal with both IPv4 and IPv6. Unlike telnet(1), nc scripts nicely, and separates error messages onto standard error instead of sending them to standard output, as telnet(1) does with some.

If you haven't already done so please make yourself familiar with netcat.  
Whenever you have questions consult the manpage on your hosts. Don't use man pages from the Internet as the implementations of netcat vary from operating system to operating system. (we even found two contradictory man pages on the net).

Now, please use netcat on PC1 or PC2 (one of the internal hosts) and access the apache webserver which is still running on PC4, port 80. Fire up tcpdump/wireshark on PC3 and capture the traffic on eth1. (Please mind that the file gets dumped to the directory where you started the netcat listener on the destination machine.)

Did it work?

2.6. As an alternative to SNAT we can also use Masquerading. Please explain the difference and the advantage of masquerading [2 credits]

2.7. Now delete the SNAT rule and set up masquerading on PC3 (our Linux router). Which commands did you use? [2 credits]

Now we have a working NAT environment. You should be able to ping PC4 from PC1 and PC2. Furthermore, PC1 and PC2 should be able to access the webserver running on PC4 (please verify using netcat or curl (ilab@PC1:~\$ curl 10.1.1.254)).

Now we want to take a closer look on the actual NAT mapping table and how Linux/iptables manages the nat table. Therefore, please start iptstate on PC3 to see all current connections.  
Establish a new connection from PC1 to the webserver on PC4 and watch the newly established connection.

2.9. On the lab machines, what is the default TTL value of a **TCP connection** (not TTL of an IP-packet) and what is the default value for the **TIME\_WAIT**? [1 credits]

2.10. Where can you change these values?

**mop>** do not forget to look at the routing table of PC4 here!  
**u>** good point :)

**jan>** Did anyone get this running?  
**silvie>** sure.Though we had to resetup.Probably we had a bug.Maybe you have a similar problem.

# automatic diffs in correction

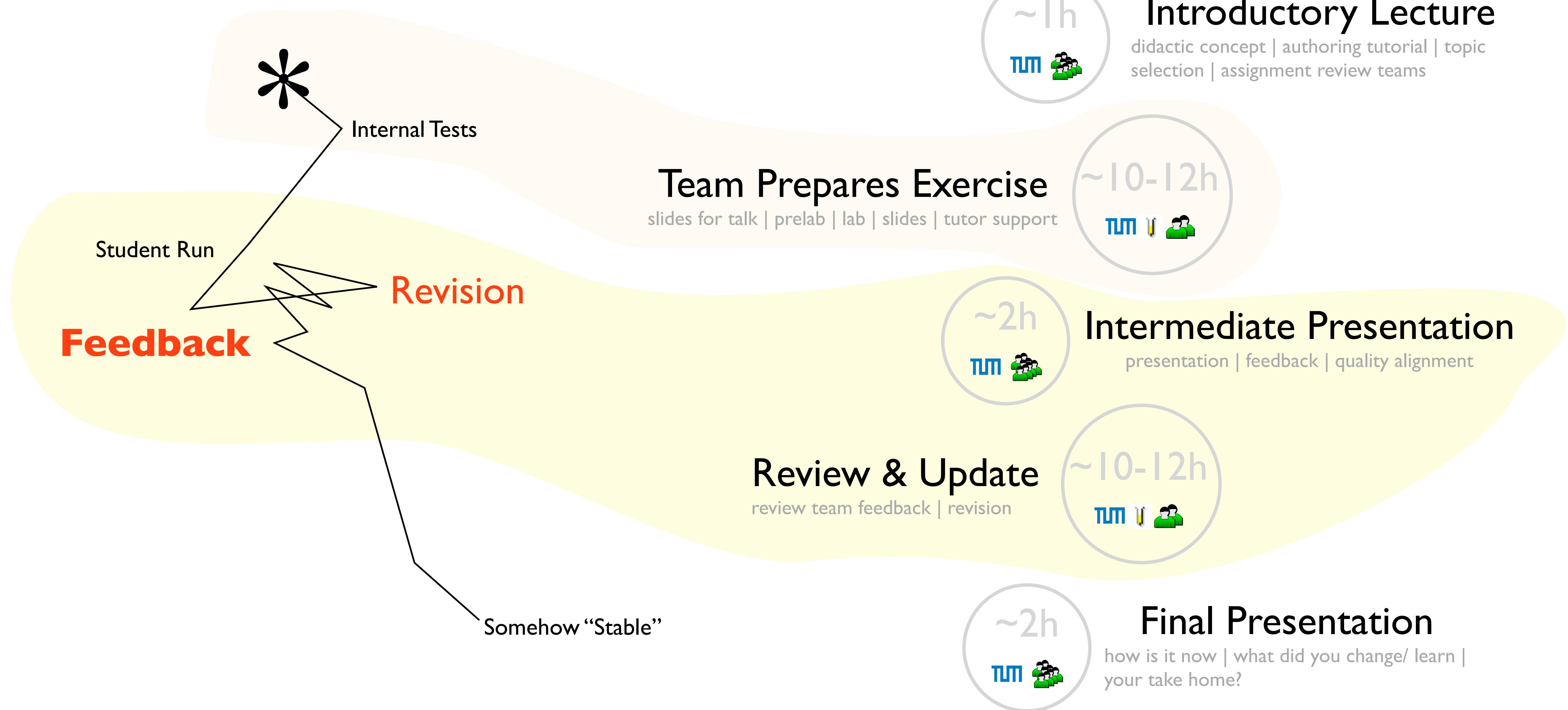
The screenshot shows a web browser window titled "Local setup [mop@ilab2 sun]" displaying a page from <https://ilab2.net.in.tum.de/pages/view.php?config=2012ss&inside=true&address=l17.C287.C306.c307>. The left sidebar contains a navigation menu with sections like SCTP, Advanced NAT, P2P-Applications, Multicast SIP, WWW Security, Measurement, Web-Service Performance, and a schedule section with "edit menu", "MarkDown Demo", "ilab", and past courses from 2011ws to 2010ss.

The main content area displays several student answers under "team 5". The first answer is marked as "correct". The second answer, from "team 2", includes a table comparing XML, binary, and JSON performance metrics:

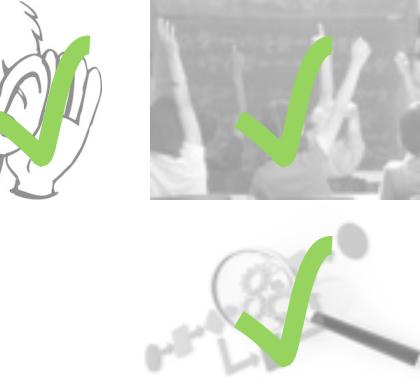
	xml	binary	json
1	1.09861588478	0.129147052765	0.63597990823
2	1.23830294609	0.160252094269	0.71970486409
3	1.41623497009	0.164623975754	0.774814844131
4	1.47846794128	0.169669866562	0.912448167801
5	1.86631283569	0.20542883873	1.10420203209

The third answer, from "team 3", states: "The binary performance is the better than the others. Even the maximum time of the binary NFC is less than the minimum time of the other methods. Among JSON and XML, we can see that JSON is much faster and its median is almost half of the median of the XML." The fourth answer, from "team 6", lists the technologies in order of performance: "fastest to slowest: Binary, JSON, XML". The fifth answer, from "team 4", states: "XML is (with a large gap) the slowest technology, JSON and binary seem to deliver almost the same performance."

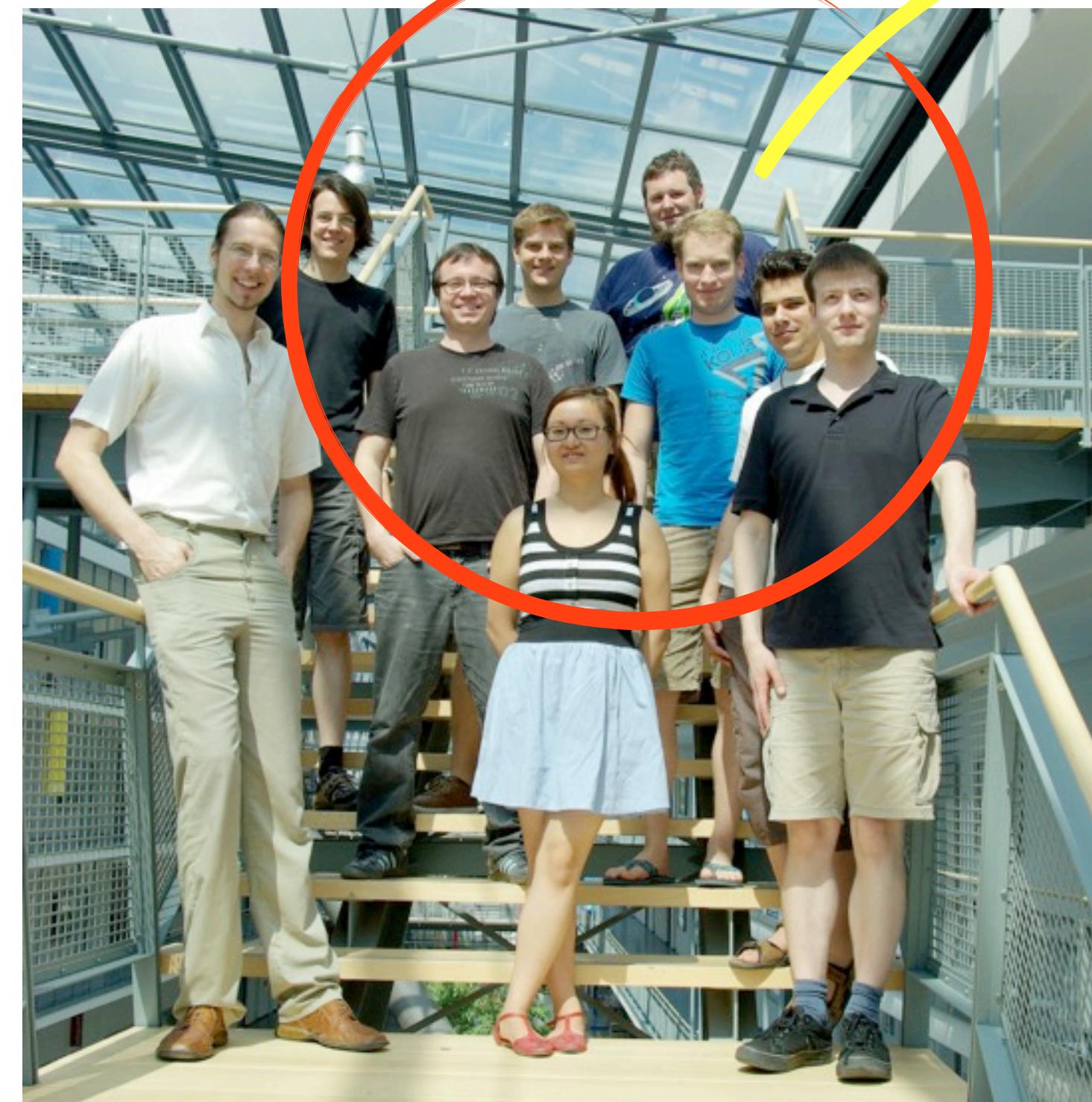
# create your own exercise



# summary



# in short



listen



encourage



constantly improve

variation: online + live  
team work + individual  
+ group  
feedback  
encouraging  
environment

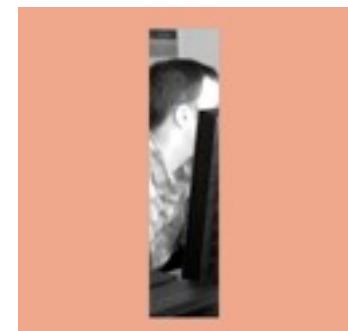
# lots of happy faces



# The iLab Experience

- <http://ilab.net.in.tum.de/>

Bachelor/ Master course



- <http://ilab2.net.in.tum.de/>

Master/ Bachelor course



- <http://labsystem.sf.net/>

eLearning environment ([open source](#))



- [Marc-Oliver Pahl](#) | pahl@net.in.tum.de

<http://pahl.de/>

