Chair of Network Architectures and Services
Department of Informatics
Technical University of Munich

Seminar: Innovative Internet Technologies and Mobile Communications (IITM)

Topic Presentation

Prof. Dr.-Ing. Georg Carle,
Dr.-Ing. Stephan Günther, Benedikt Jaeger

Friday 21st October, 2022

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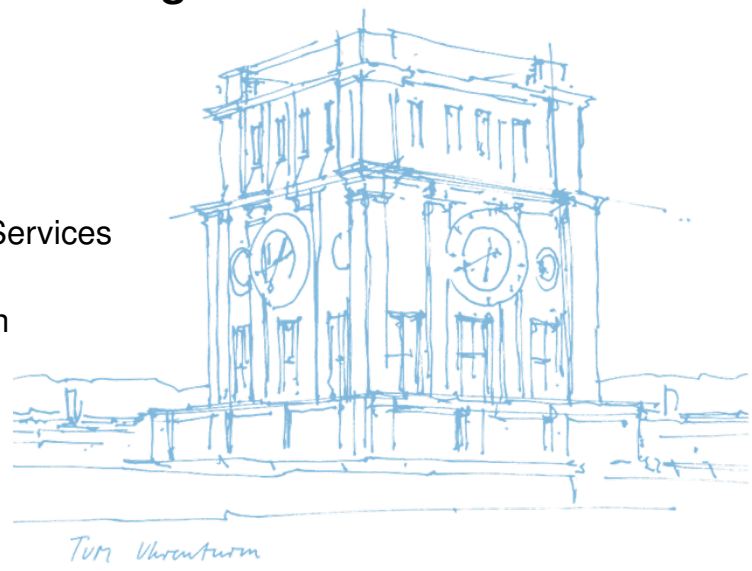


Basic Information

Lecturer

- Prof. Dr.-Ing. Georg Carle

Organization

- seminar@net.in.tum.de (only use this mail address!)
- Dr.-Ing. Stephan Günther
- Benedikt Jaeger

Overview

- Main Language: English
  - paper and reviews in English
  - talk can be in German or English
- Extent: 2 SWS, (5 ECTS)
  - 5 ECTS · 30 h = 150 h of work expected from you
- Course Type:
  - For B. Sc. Students: Advanced Seminar Course (Seminar)
  - For M. Sc. Students: Master's Seminar (Master-Seminar)

Seminar Procedure

First version of your paper

- Agree on the content with your advisor
- Use the provided paper template (LaTeX)
- Keep in touch with your advisor
- Try to finish in time so your advisor can give you feedback
- Your paper must be 4 pages in IEEE 2-column style (without references)
- Expected language for the paper is English

Present your topic

- German or English
- 20 min talk + 5 min discussion

Peer review

- You have to review two papers of your fellow students
- Reviews are part of your final grade
- Review language is English

Final version of your paper

- Use the received reviews to improve your paper
- You will also receive feedback from the advisor
- If you and your advisor agree $\rightarrow$ publication in the seminar proceedings

Learning Goals of the Seminar

Scientific research on individual topic

- Supported by your advisor you will survey literature for your topic
- Get used to searching digital libraries

Write a scientific paper

- Learn to write a paper in LaTeX with a given template
- Document your progress in a provided Git repository
- Follow the rules of good scientific practice

Prepare a scientific talk

- Prepare your slides using `beamerlatex`
- Convert your topic into an interesting talk

Give profound feedback on other seminar papers

- Like in real conferences we do a peer review among all participants
- Learn from your and others' mistakes

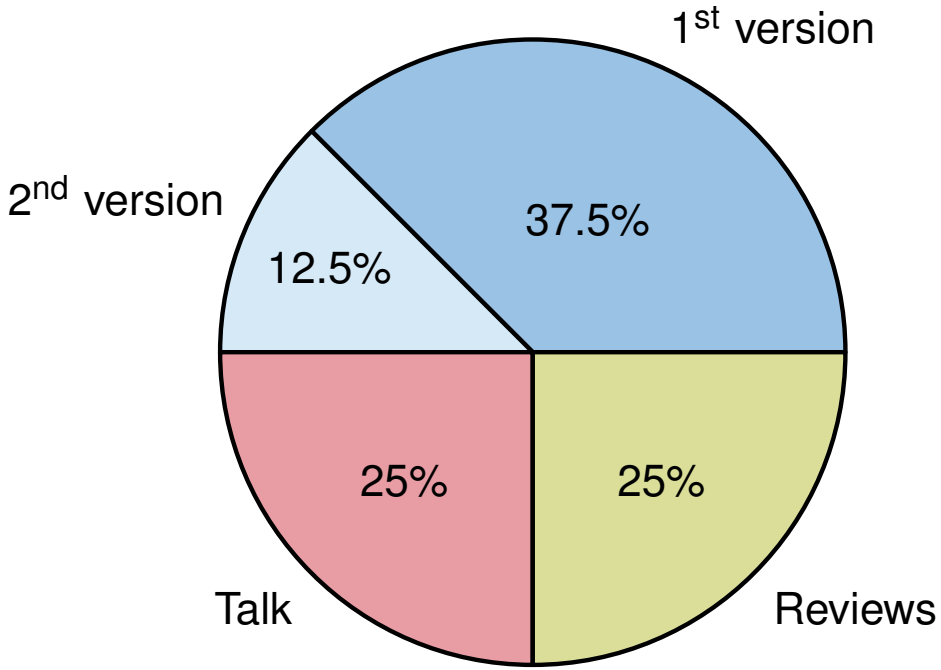
Schedule

	Dates
Topic presentation	**Oct 21, 14:00**
Update topic preferences	**Until Oct 27, 23:59**
Pick up literature from advisor (by mail if needed)	**Until Nov 12**
Two advisor meetings suggested 1.) Discuss literature 2.) Discuss structure and draft	**Nov 15 – Dec 10**
Final slides discussion with advisor (slides must be presentable)	**Until 1 week before your talk**
Upload paper, 1st version	**Dec 19, 23:59**
Talks	**Jan 20 / 27, Feb 3 / 10, 14:00 – 16:00**
Upload reviews	**Feb 5, 23:59**
Upload paper, 2nd version	**Feb 26, 23:59**

In red: hard deadlines or mandatory events

Grading

1. Both of your paper submissions, 4 pages in IEEE (50 %)
   - 1st version: 37.5 %
   - 2nd version: 12.5 %
2. Your talk, 20 – 25 min, following discussion, and feedback (25 %)
3. Your reviews of papers from other seminar participants (25 %)



Grading

Influencing Factors

- First version of paper must be acceptable
  - Grade worse than 4.0 $\rightarrow$ disqualification (seminar graded as 5.0)
  - Less than 4 pages in the seminar template $\rightarrow$ disqualification
    (not 3.1 pages + empty space, not 5 pages without references)
- Observe the deadlines
  - Advisor meetings are compulsory
  - You are provided with git repositories to check in your work and submissions
  - Hard deadline for each submission
- No submission
  - 1st version of paper $\rightarrow$ disqualification (seminar graded as 5.0)
  - Other submissions $\rightarrow$ grade 5.0 for the concerning part
- Write the paper yourself
  - Plagiarism $\rightarrow$ disqualification (and we will check!)
  - Attempted cheating will be reported to the examination office
  - Summary when and why to cite: `citation guide`
  - Regularly push your progress to avoid misunderstandings
- Absence during talks without valid excuse
  - 0.3 degrading per missed talk on your presentation grade
  - Talk graded worse than 4.0 $\rightarrow$ disqualification (seminar graded as 5.0)

The Advisor's Role

- Advisors create topics within their research context.
  - They have broad knowledge about the context of your seminar topic.
- Your task is to do research and write a scientific text about a specific topic beyond basic lecture content.
  - Your advisor is not responsible for your tasks.
- Adhering to the deadlines is your responsibility.
  - Your advisor will not remind you.
- Advisors will help you if you ask them to.
  - Keeping contact with your advisor allows you to write a much better seminar paper.
- Advisors can give you feedback.
  - Ask for feedback about your first paper version, the peer reviews, your slides for the talk, etc.

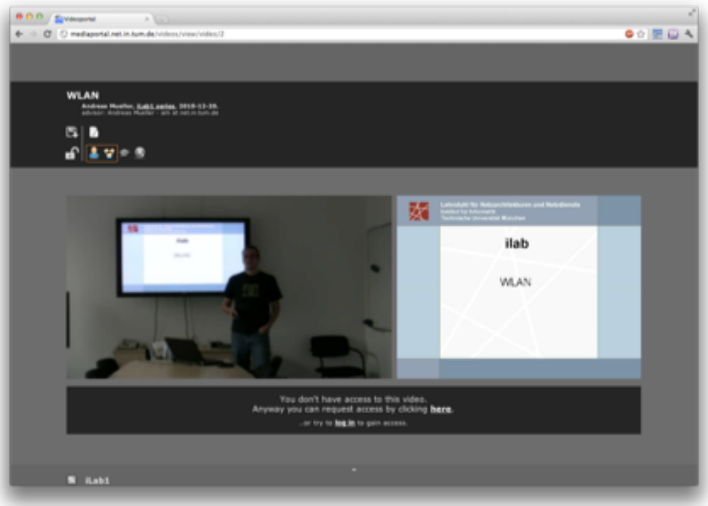
Talk Procedure

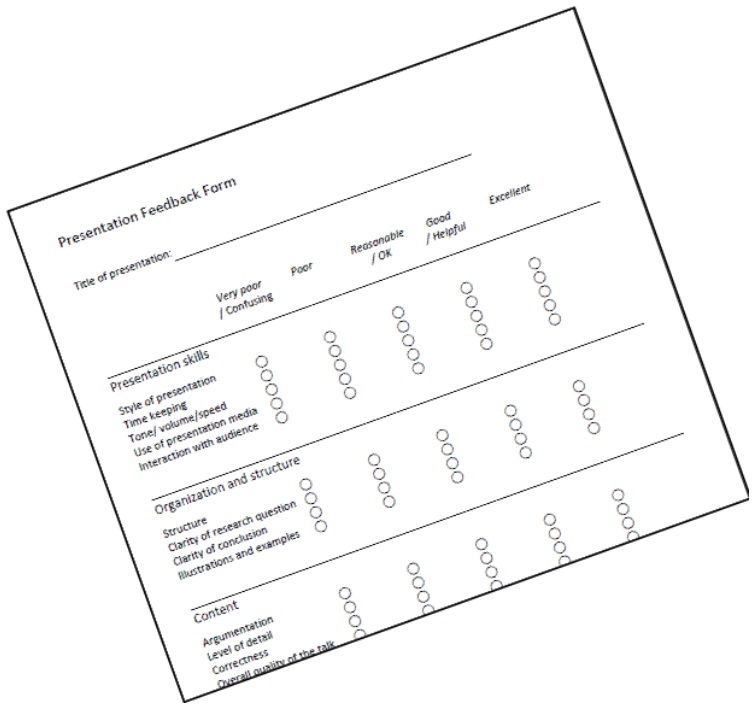
- Prepare your talk
  - Finished slides must be discussed with your advisor 1 week before the talk
  - Advisors may offer the opportunity of rehearsal talks
- Present your work
  - Scientific talk
  - Present the main results & give an interesting talk
- Session chair for one talk
  - Introduce the speaker
  - Watch the time constraints
  - Try to get the discussion started after the talk (ask at least one question if nobody else does)
- Mandatory attendance in all sessions
  - If you cannot attend for a good reason, contact `seminar@net.in.tum.de` **in advance**
  - Attending the talks is mandatory for passing the course
    (schedule of talks will be published after the first submission)

Talk Procedure

Improving Your Presentations Skills

- You have the chance to get your talk recorded
  - Have a **look at yourself** after the talk!
  - Your talk was great? Share it and show it to your friends
  - You fully control the access! Initially only you can access it
- Get feedback from your colleagues (not graded)
  - Feedback forms to be filled out during the talks





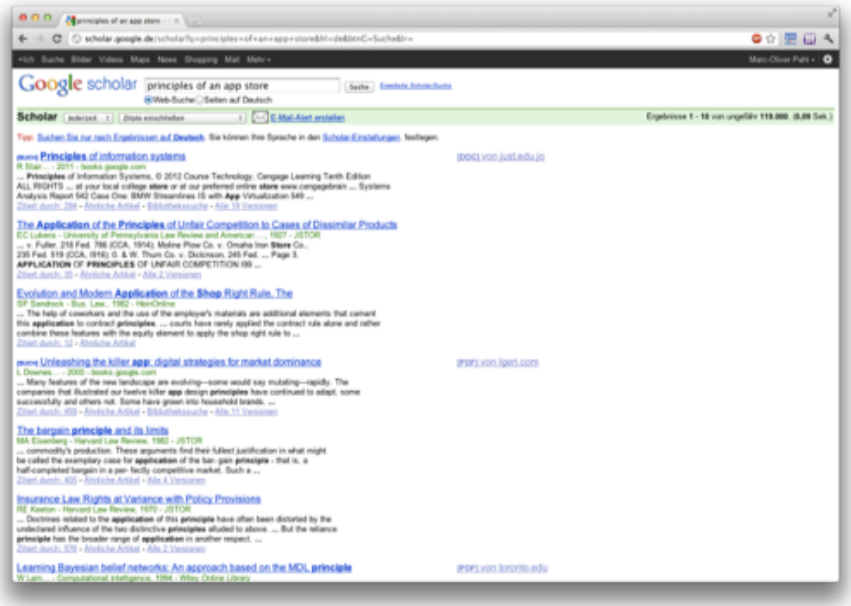
Seminar Proceedings

- We give the opportunity to publish your papers!
  - If both you and your advisor agree
  - Proceedings of the last years can be found on
    www.net.in.tum.de/publications/seminar%20proceedings
- Look at old proceedings
  - Examples of papers we consider "good"
  - Get an idea of the topics we cover
- Best Paper Award (only published papers)
  - We will choose the best paper in each seminar
  - They will receive a certificate and a hardcopy of the proceedings

Topic Handling

- You get some literature or hints where to start from your advisor
- This is just to get you started
- Find appropriate (scientific) sources yourself

  - `scholar.google.com`
  - `acm.org`
  - `ieee.org`
  - `semanticscholar.org`
  - Your sources' sources
  - ...



TUM provides access to non-free papers via `eaccess.ub.tum.de`.

Just presenting the given literature is **not** enough

Infrastructure

LRZ Gitlab

You will use the LRZ Gitlab to make your submissions. Everything must be **committed and pushed** before the deadlines.

- Continuously commit your changes:
  1. `git add <your file>`
  2. `git commit`
  3. `git push`
- Do not commit any built files (e. g. use `.gitignore`)
- Do not commit files like `final_version.pdf`
- Do not duplicate directories (e. g. for the second version) → Git keeps track of the versions
- **Always** stick to the given directory structure!
- We setup a Gitlab CI to automatically compile your LaTeXcode
  → so you have feedback if it compiles
- We use the last commit before the deadlines as submissions

Infrastructure

How to get access?

- Every TUM student has an LRZ Gitlab account, use your LRZ ID to login (e. g. ab12xyz)
- We need to match you (especially your TUMonline account) to your Gitlab account
- For this we have a webservice:

  https://iitm.net.in.tum.de/2022ws

- The website asks you to login both into TUMonline and Gitlab
- Once this was successful you are granted access to the required Git repositories
- If this is not the case, let us know so we can help you

Infrastructure

Repositories

All repositories are contained within the following Gitlab group:

https://gitlab.lrz.de/netintum/teaching/iitm

Material repository

- Here you can find slides and templates (if the templates are not already in your repo)
- All participants have read access

Container repository

- This repository is related to CI which compiles your LaTeXcode
- You can just ignore this one
- All participants have read access

Your working repository

- Here you commit everything related to your paper and presentation
- Only you have write access
- Stick to the given directory structure
- Do not commit any build files or temporary LaTeX files

Infrastructure

Repository Structure

```
your_repository
├── paper
│   ├── paper.tex
│   └── ...
├── talk
│   ├── slides.tex
│   └── ...
├── resources
│   ├── literature.pdf
│   └── ...
└── topic_preferences.txt
```

Directory structure of your repository

- Follow this structure, otherwise
  - we cannot build your source files
  - we cannot collect your submissions
- You **must not** push any other directories
- Use the provides templates, including Makefiles
- Make sure that your LaTeX code compiles (see Gitlab CI)
- You are only allowed to push to the `main` branch

directory	
/paper	source files of your paper
/talk	source files of your slides
/resources	literature and any other material

Infrastructure

Files you add to your repository

- `.gitignore` in the paper and talk directory. Use `git add -f` to add hidden files.
- `.tex`, `.txt`, `.png`, `.jpg` files which are either text-based or do not change (e.g. imported images)
- your literature as `.pdf`
- all files required to build your paper / slides

Files we **do not** want to find there

- the compiled versions of your paper and slides: `paper.pdf slides.pdf`
- anything within a `build` directory
- temporary files like `.swp`, `.pyc`, `.synctex.gz`, `.aux`, `.bbl`, `.blg`, `.log`, `...`
- `.pdf` files from your stand-alone figures

Infrastructure

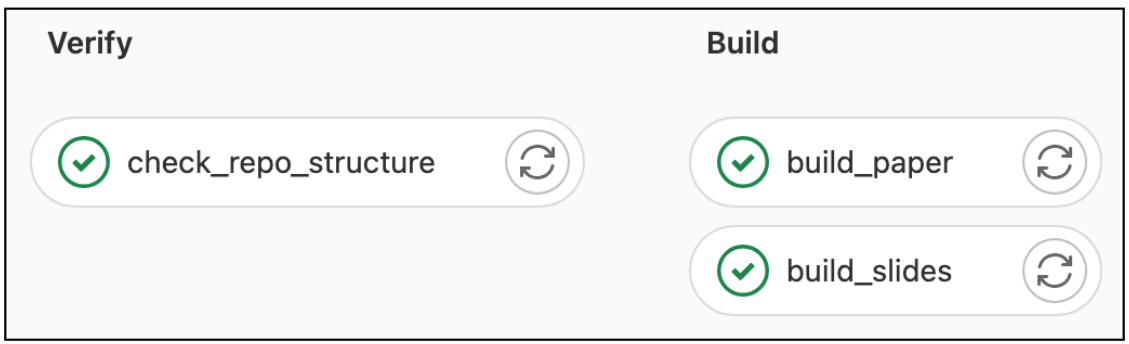
Gitlab CI

- We setup an automatic build service for your LaTeXcode
- This gives you feedback, if your code compiles
- Make sure that your final submissions do compile!
- If you are interested, the CI code is in the container repository

Stages

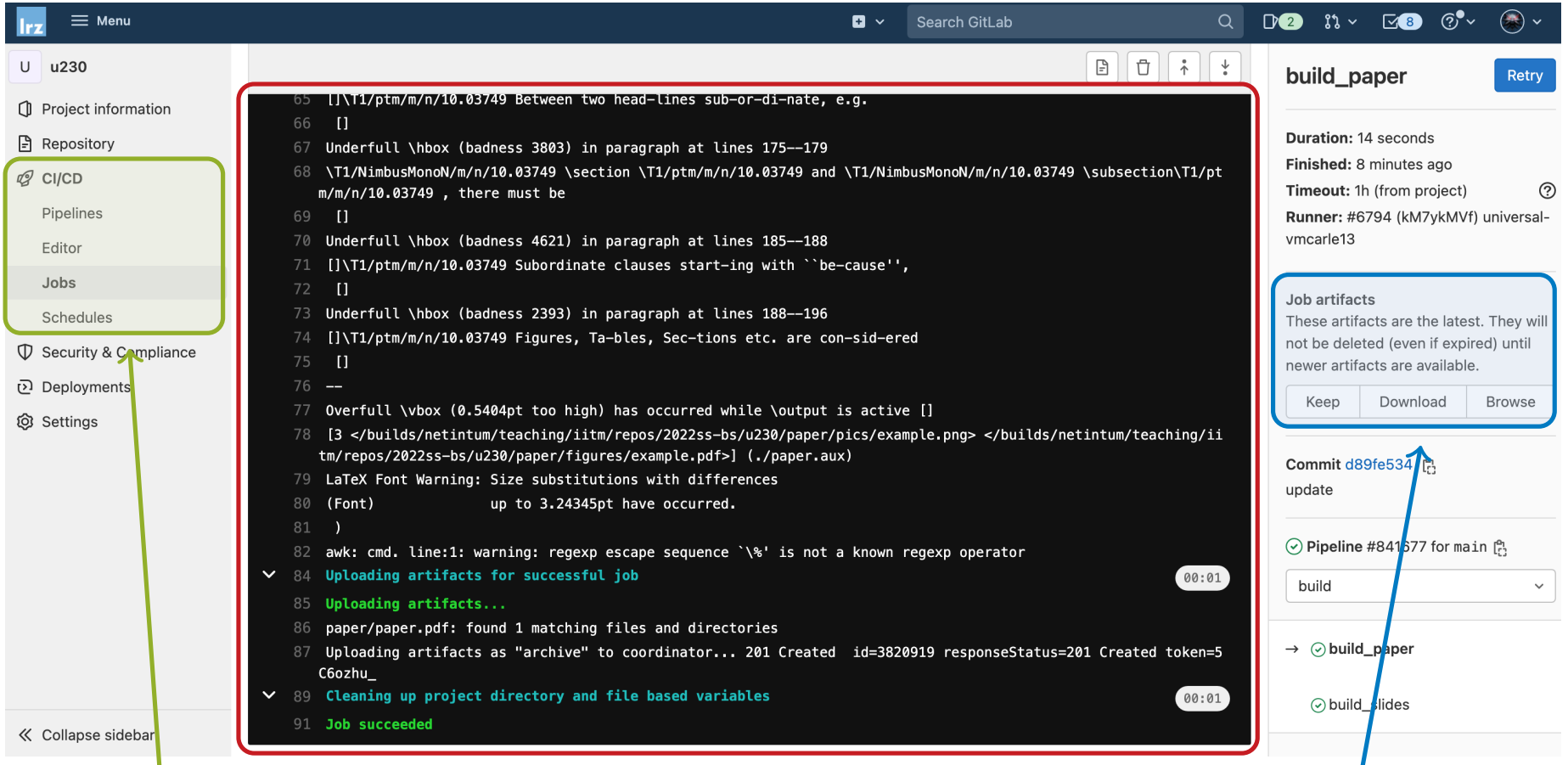
1. Verify directory structure
   This stage checks the directory structure in your repository and fails when there are any violations. Have a look at the output to identify what is wrong.
2. Build paper and slides
   This stage simply calls the Makefile for the paper and slides directory and uploads the resulting PDFs as artifacts.

Note: this first stage must be successful for the second to be executed



Infrastructure

Gitlab CI Output



Here you can find a list of all pipelines and jobs.

Here you find the log output of the executed job. In case of a failure, you can start here searching for the error.

Here you can download the job artifacts, i.e. the compiled PDFs.

Plagiarism

Plagiarism, the act of taking the writing of another person and passing them off as one's own.[1]

- Correctly cite any resources to avoid plagiarism
- Avoid verbose citations entirely. If necessary, mark them correctly with "..."
- Also copying from blog posts, videos, or other sources is plagiarizing (and we will find out)
- Consequences will be an exclusion from the seminar and a grading with 5,0-U (same as cheating during an exam)
- Extreme example:

package occurs. In [4], a new interesting innovation that this algorithm brings, is a new recovery strategy is mentioned. An intermediate node may detect a disconnection with the next forwarding node due to high mobility, which indicates the failure of the discovered path. In this case, RGR switches to GGF mode and forwards the packets to the closest neighbor UAV until the destination UAV is reached. If GGF fails to transmit the next forwarding UAV, the packet will be dropped. In parallel, a Route Error (RERR) will be sent to the previous node until reaching the source node. If the source UAV has more data packets to transmit, it initiates a new path discovery so as to create a new reactive path to the target destination. In [4] are also mentioned some advantages and drawbacks of using this routing protocol:

From 4

Seminar paper

The novelty in RGR is that the geographic position of the destination UAV D is cached in the routing table (maintained periodically based on Hello packets) of each intermediate UAV traversed by the RREP packet when it is sent back to the source. As a recovery strategy, an intermediate node may detect a disconnection with the next forwarding node due to high mobility (*see* Figure 6(b)), which signifies the failure of the discovered path. In this case, RGR switches to GGF mode and forwards the packets to the closest neighbor UAV to UAV D until reaching it. If GGF fails to find the next forwarding UAV, the packet will be dropped. In parallel, a Route Error (RERR) will be sent to the previous node until reaching the source node. If the source node has more data packets to transmit, it initiates a new path discovery so as to create a new reactive path to the target destination.

Related literature

[1] From the TUM's Student Code of Conduct

Choose Topic

- Assign a preference to each topic (smaller ranks mean higher preferences)
- Equal preferences to multiple topics are possible
- We will normalize your preferences
- Example:

```
90. "Topic A"
60. "Topic B"
50. "Topic C"
70. "Topic D"
70. "Topic E"
```

→

```
1. "Topic C"
2. "Topic B"
3. "Topic D"
3. "Topic E"
4. "Topic A"
```

→

Highest preference is
`"Topic C"`

Choose Topic

The advisors now present their topics

- Listen to the presentations and ask questions
- Afterwards:
  - Think about which topics you find interesting
  - Inform yourself about the topics (e.g. contact the advisor)

Submit your topic preferences via Git until **Thursday, October 27th**

- Adjust the preferences in your repository
- Do not rename it
- Commit **and** push

We perform a matching on your topic preferences and inform you by mail.

Frequently Asked Questions

- I have never worked with LaTeX, can I write the paper with Word?
  No, we expect you to accquire basic LaTeX skills within the seminar to finish both the paper and the presentaion slides.
- Can I use Git and Makefile on Windows?
  We recommend to use a Linux System (or Mac), but Windows 10 provides an `Ubuntu shell`
- How can I check if all files are uploaded correctly?
  After you pushed clone your repository into an empty directory and check if all files are there.
- Help, my LaTeX code does not compile anymore and I have no idea what the log output wants to tell me.
  Try to comment out paragraph by paragraph and line by line to localize the source of the error.

In general, write emails only to

seminar@net.in.tum.de

Artificial Intelligence for Energy-efficient Management of Cloud-native Mobile Networks

Sayantini Majumdar (sayantini.majumdar@tum.de)

Motivation:

- Goal of energy-efficient (EE) management is to manage resources (e.g. virtual CPUs) such that it
  - achieves optimal energy efficiency
  - satisfies Key Performance Indicators (KPIs) e.g. served load of users in the network.
- Problem: Complex conditions exist - multiple network objectives (e.g. latency, throughput etc.)
- Artificial Intelligence (AI)-based approaches previously studied for EE - e.g. Reinforcement Learning [1]

Your tasks:

- Collect literature on AI-based EE management of cloud-native networks
- Identify **two** interesting EE problem scenarios e.g. energy-aware Virtual Network Function placement
- Identify the AI algorithms (**at most two, except Q-Learning, Deep Q-Networks**) to solve the above problem scenarios
- Note: Focus on mobile networks (5G), network slicing [2]

[1] Chergui, Hatim, et al. Zero-Touch AI-Driven Distributed Management for Energy-Efficient 6G Massive Network Slicing. IEEE Network 35.6 (2021)

[2] Gomes, Rafael L., et al. Energy-aware slicing of network resources based on elastic demand through daytime. 2019 IFIP/IEEE Symposium on Integrated Network and Service Management (IM). IEEE, 2019.

Deep Learning based Malware Detection

Johannes Zirngibl

Topic:

- Deep learning is an emerging approach to detect malware in traffic traces or on actively collected information. [1, 2]
- One of the major challenges is the identification and availability of valuable features.
- Especially in case of increased traffic encryption, features are rarely visible.
  - e.g., HTTP requests and exact URLs are encrypted using TLS.

Your Tasks:

- Research how deep learning approaches are used for maleware detection.
- Identify relevant literature.
- Compare different approaches and which features are used.
- Analyze whether data sources, implementations and documentations are available to allow reproducibility.

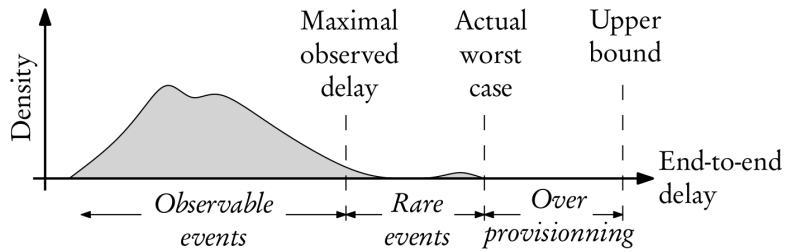
[1] Jiawei Zhou, Zhiying Xu, Alexander M. Rush, and Minlan Yu. Automating Botnet Detection with Graph Neural Networks. CoRR, abs/2003.06344, 2020.

[2] Gibran Gómez, Platon Kotzias, Matteo Dell'Amico, Leyla Bilge, and Juan Caballero. Unsupervised Detection and Clustering of Malicious TLS Flows, 2021.

Prediction of Rare Latency Events

Max Helm, Benedikt Jaeger

Latencies of data frames in communication networks generally follow a long-tailed distribution. The tail of these distributions contain rare events as caused by specific network configurations and influences. Predicting the occurence and magnitude of such events is important for finding counter-measures. Extreme Value Theory (EVT) is one approach to solve this problem [1,2]. It can be used to create a statistical model of the behavior of rare events, given historical data, and has been succesfully applied in other areas such as peak wind speed or tidal wave height prediction [3].



Your tasks:

- Introduce the theoretical background of EVT
- Find and present applications of EVT in the networking area
- Search for and compare EVT to other approaches with similar goals
- **Optional:** Application of EVT to real-world measurement data

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[1] https://en.wikipedia.org/wiki/Extreme_value_theory

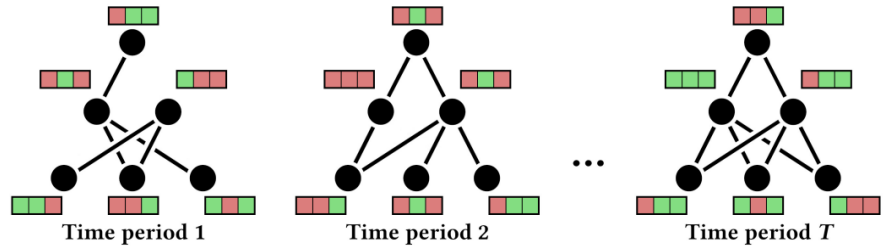
[2] https://link.springer.com/book/10.1007/978-1-4471-3675-0

[3] https://arxiv.org/pdf/1204.1022.pdf

Temporal Graph Neural Networks

Max Helm, Benedikt Jaeger

Temporal Graph Neural Networks (Temporal GNNs) [1] can be used to predict time-varying properties of changing graph structures.



source: [1]

Your tasks:

- Summarize principles of temporal GNNs
- Compare different architectures
- Find related work that applies temporal GNNs to (network-related) problems

Requirements:

- Completion of a machine-learning-related lecture or other prior knowledge of machine learning

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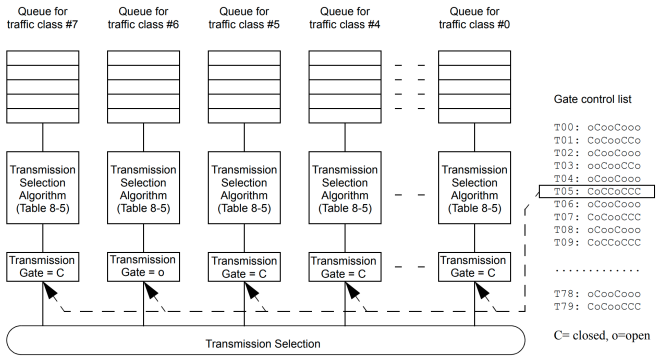
[1] Rozemberczki, Benedek, et al. "Pytorch Geometric Temporal: Spatiotemporal Signal Processing with Neural Machine Learning Models." Proceedings of the 30th ACM International Conference on Information & Knowledge Management. 2021.

TSN Qbv and Schedule Generation Approaches

Max Helm, Benedikt Jaeger

Time Sensitive Networking (TSN) is a set of standards to enable deterministic services over Ethernet. IEEE 802.1Qbv is one of these standards which decribes the Time Aware Scheduler (TAS). TAS schedules frames to be sent on time-triggered events, allowing for low and deterministic latencies. This requires schedules of when to send which frame at each output port of a given network.
The generation of such schedules is a complex problem for which a multitude of solutions exist.



source: [1]

Your tasks:

- Describe the inner workings of IEEE 802.1Qbv (TAS)
- Collect information on state-of-the-art approaches to schedule generation
- Compare the different approaches w.r.t. metrics such as efficiency and quality

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[1] IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks - Amendment 25: Enhancements for Scheduled Traffic `https://standards.ieee.org/ieee/802.1Qbv/6068/`

Failure Detection in P4

Manuel Simon

Upcoming 6G networks aim for ultra-low latency and very high reliability. While in 5G networks, reliability of 99.999% was targeted, 6G wants to increase this about 1000 times. Therefore, failures, e.g., link failures, have to be detected very efficiently and quickly to start failover mechanisms. These mechanisms are fundamental when it comes to routing. Packets have to get efficiently rerouted without packet loss and in the desired latency timeframe when failures occur.

P4 is a domain-specific language enabling programming data planes of networking devices directly. Implementing the before mentioned mechanism in P4 and thus directly in the data plane seems to be a promising approach since it bypasses the overhead of the control plane.

Your tasks:

- Find different approaches for failure detection and failover in P4
- Describe the approaches
- Compare their performance and advantages and disadvantages
- You can either focus on comparing different approaches from literature *or*
  set one of them up in our testbed and do some basic performance measurements

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[1] S. Lindner et al., "P4 In-Network Source Protection for Sensor Failover," IFIP 2020

[2] R. Sedar et al., "Supporting Emerging Applications With Low-Latency Failover in P4", NEAT 2018

$P4_{16}$ INT Applications

Sebastian Gallenmüller, Kilian Holzinger

In-Band Telemetry using P4

- Comparable to “traceroute” but on layer 2
- Can provide per-hop switch utlization and per-hop latency information
- Allows detailed monitoring of network

Your task:

- Brief summary of $P4_{16}$ and INT
- Create a suitable mininet setup
- Apply existing P4/INT examples
- Start with simple introductory applications
- Include advanced topics (INT)

Applied topic: lower requirements for literature research, but you need to program P4

Sources

- `p4.org`, `p4.org/events`, `p4.org/specs`
- `https://github.com/p4lang/p4-applications/blob/master/docs/INT.pdf`
- `https://github.com/p4lang/tutorials/tree/master/exercises`

Saving and Recovering Systems

Sebastian Gallenmüller, Manuel Simon

Testbed infrastructure @ our chair

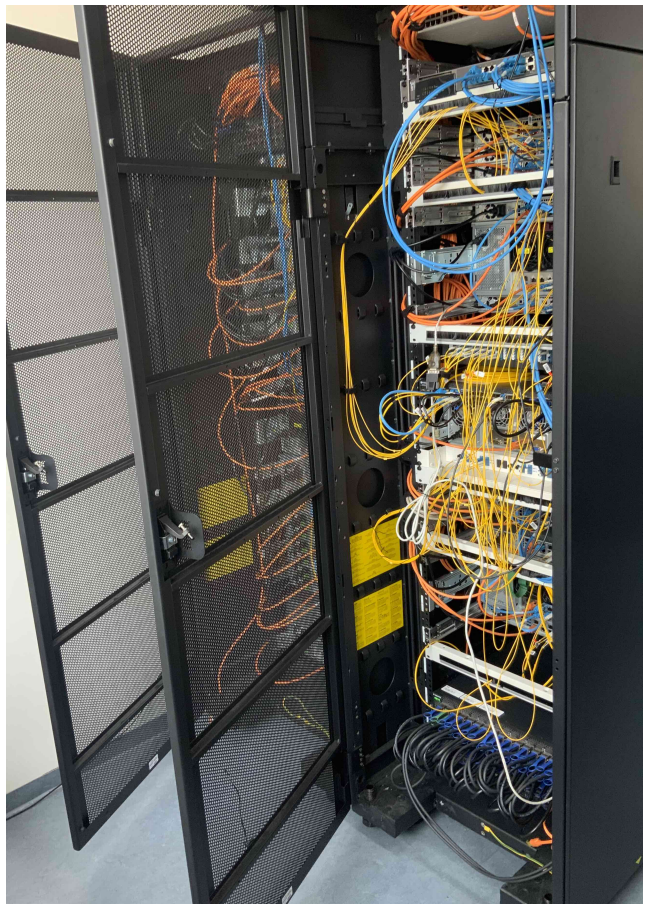
- Shared infrastructure at the chair
- Different users (researchers, students)
- Different experiments (theses, projects)

Common problem

- Preparing a system configuration takes a lot of time
- Saving system state after configuration is complex

Your task

- VMs offer convenient snapshots
- VMs can quickly reload snapshots
- Create a framework that can be used by students and researchers to easily save and reload the testbed from snapshots using VMs



Testbed Hardware

Applied topic: lower requirements literature research, but you need to create running code

- `https://www.net.in.tum.de/fileadmin/bibtex/publications/papers/gallenmueller_scholz_conext2021.pdf`

Probabilistic Network Telemetry

Kilian Holzinger

Motivation:

- goal of network telemetry is to give precise insights into current network state
- performing analysis on a per-packet basis is often not feasible:
  - requires a lot of hardware resources
  - network speeds are growing faster than CPU speeds
  - to much overhead of additional information required within packets
- probabilistic data structures such as Sketches can be used for performant network telemetry with good precision and low overhead.

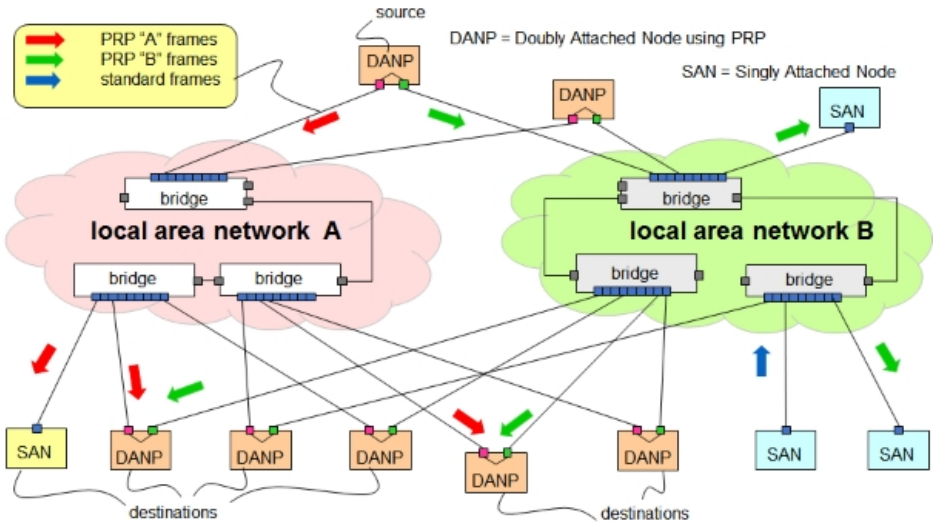
Your Tasks:

- collect literature and identify the most important publications
- write an introduction to the topic
- present and compare approaches and their variants w.r.t
  - hardware, software and topology requirements for the deployment of those methods
  - accurracy
  - possible metrics (latency, packet loss...)
  - latency (from change in network behavior to detection)
  - overhead of additional data to be transmitted
- find available implementations and their state

Mechanisms and Protocols for Reliable Communication Networks

Kilian Holzinger, Henning Stubbe

- various degrees of reliability e.g.
  - TCP
  - Parallel Redundancy Protocol (PRP): two complete redundant networks
- reliability can be implemented on various layers
  - L1: IEEE802.11 (W-LAN)
  - L2: IEEE802.1CB
  - L4: mTCP



Hubert Kirrmann, CC BY-SA 4.0, via Wikimedia Commons

Your tasks:

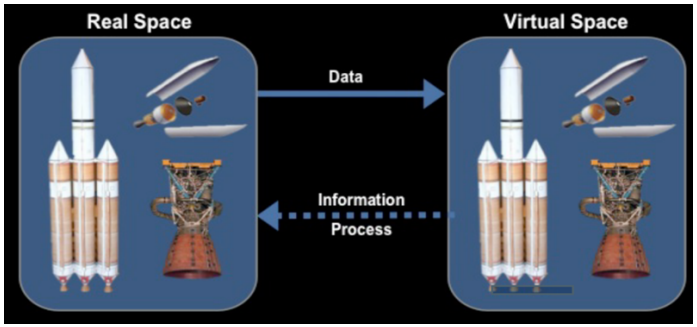
- identify relevant mechanisms and protocols for reliable communication networks
- compare different approaches regarding popularity, overhead, implementation tradeoffs, flexibility, applicability depending on use-cases. . .

Digital Twins of Computer Networks

Kilian Holzinger

Topic:

- real-time “co-simulation” as a virtual counterpart of a real-world process
- approach originates from Cyber Phyisical Systems
- emerging trend in the operation of computer networks



Wilmjakob, CC BY-SA 4.0, via Wikimedia Commons

Your Tasks:

- define necessary terminology and relate them to computer networks
- describe use-cases and goals of this technology
- collect literature and identify important publications
- write a good introduction to the topic
- present and discuss proposed methods
- find available implementations
- identify trends and research questions

Reproducible Network Experiments using NixOS

Kilian Holzinger, Henning Stubbe

Topic:

- reproducible, declarative and reliable system and package management using NixOS
- make NixOS available on chair's testbed
- there is some existing work

Your Tasks:

- **Hands-on topic: requires willingness to familiarize with nix and significant practical work**
- write HowTo in testbed wiki
- automate as many steps as possible
- possible integrate into CI
- summarize your work in tech report paper

Analysis of Cloud Provider Ranges

Patrick Sattler, Johannes Zirngibl

Topic:

- Usually prefix owners are determined through BGP announcements or Internet Routing Registry (IRR) information
- Cloud providers (e.g., AWS, Cloudflare, and Google) publish their ranges
- Cloud providers often host infrastructure inside the local ISPs network (called off-nets)
- Where are the published prefixes located?
- Which problems appear when research is based on only one source for prefix ownership?

Your Tasks:

- Search for additional IP ranges published by other cloud providers
- Obtain information on the published prefixes through BGP announcements and IRR
- Compare these results and evaluate differences between the sources

Sources

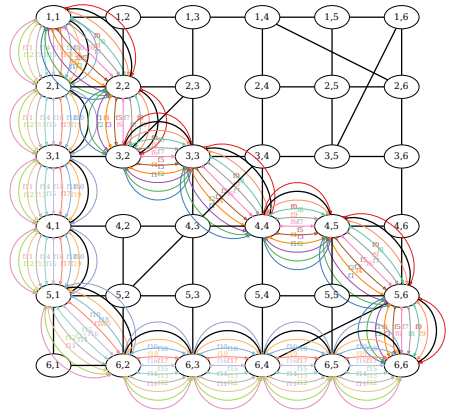
- `https://docs.aws.amazon.com/general/latest/gr/aws-ip-ranges.html`
- `https://www.gstatic.com/ipranges/goog.json`
- `https://www.cloudflare.com/ips/`
- G. Petros, et al. "Seven Years in the Life of Hypergiants' Off-Nets." Proceedings of the 2021 ACM SIGCOMM 2021 Conference. 2021.

Combining Machine Learning with Back-Pressure-based Routing

Christoph Schwarzenberg, Florian Wiedner

Motivation:

- Back-Pressure Routing: Route packets based on network congestion
- Goal: Provide low latency and high throughput
- Problem: Path length can be high, route finding can be expensive
- ML-based approaches provide an alternative to computationally expensive solutions



Your Task:

- Compile a survey on combining Back-Pressure-based routing algorithms with ML approaches
- Focus on wired multihop networks
- Focus on flow-based routing
- Compare different approaches

[1] Gao, Juntao, et al. “Bias based general framework for delay reduction in backpressure routing algorithm.” 2018 International Conference on Computing, Networking and Communications (ICNC). IEEE, 2018.

[2] Gao, Juntao, et al. “Multi-Agent Q-Learning Aided Backpressure Routing Algorithm for Delay Reduction.” arXiv preprint arXiv:1708.06926 (2017).

Hardware-assisted virtual network benchmarking tools for low-latency

Florian Wiedner, Christoph Schwarzenberg

Motivation:

- Ensuring latency requirements for networking software increments continously is hard
- Either huge setups and cabling, or emulation of the network is required
- Emulating network measurements typically reduces precision
- Using entirely hardware-setups is inflexibel

Your Task:

- Compile a survey on benchmarking tools for network services within topologies of multiple hosts
- Compare their Challenges and Features
- Suggest a list of Requirements for such an benchmarking framework/tool set

[1] Lantz, Bob, and Brian O'Connor. "A mininet-based virtual testbed for distributed SDN development." ACM SIGCOMM Computer Communication Review 45.4 (2015): 365-366.

[2] Stoller, M. Hibler R. Ricci L., et al. "Large-scale virtualization in the emulab network testbed." USENIX annual technical conference, Boston, MA. 2008.

Container vs. Virtual machines: An survey on latency optimizations

Florian Wiedner, Jonas Andre

Motivation:

- Low-latency combined with virtualization is difficult, but required in future networks
- Resource sharing and optimizations are needed in 5G networks
- URLLC is an requirement in 5G

Your Task:

- Compile a survey on latency optimizations
- Focus on the differences between container and virtual machines
- Provide major differences and possible optimization techniques
- (Optional:) Measure derived performance gaines on our Testbed

[1] Sebastian Gallenmüller, Florian Wiedner, Johannes Naab, Georg Carle, “Ducked Tails: Trimming the Tail Latency of(f) Packet Processing Systems,” in 3rd International Workshop on High-Precision, Predictable, and Low-Latency Networking (HiPNet 2021), Izmir, Turkey, Oct. 2021.

[2] Ruan, Bowen, et al. "A performance study of containers in cloud environment." Asia-Pacific Services Computing Conference. Springer, Cham, 2016.

Link cost estimation for QoS-aware routing

Florian Wiedner, Jonas Andre

- QoS is a mechanism to differentiate traffic between different requirements
- In queuing before sending on the cable it is handled a lot
- It is fairly not considered in routing algorithms for dynamic routing
- Different paths can be suited for different types of traffic
- Automatic selection is hard

Your tasks:

- Perform a research on Link cost estimation algorithmen for routing
- Focus on QoS-awareness or combine different sources to suggest such an algorithm
- Provide advantages and disadvantages of different approaches
- Figure out what are possible metrics to be considered in such algorithms

Requirements:

- Interest in Algorithm and routing processes
- Good understanding of link quality

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[1] K. Akkaya and M. Younis, “Energy and QoS Aware Routing in Wireless Sensor Networks,” Cluster Comput, vol. 8, no. 2–3, pp. 179–188, Jul. 2005, doi: 10.1007/s10586-005-6183-7.

[2] A. Orda, “Routing with end-to-end QoS guarantees in broadband networks,” IEEE/ACM Transactions on Networking, vol. 7, no. 3, pp. 365–374, Jun. 1999, doi: 10.1109/90.779205.

802.11ad 60GHz (WiGig)

Jonas Andre, Stephan Günther

802.11ad

- WiFi standard that provides throughputs higher than 1Gbit/s
- Very low latency
- Used e. g. with wireless display connections

But it has drawbacks . . .

- Requires more or less a direct line of sight
- No alternative to 802.11ac?

Your task: 802.11ad — A usable next generation WiFi standard?

- Search for evaluations of 60GHz usage
- Current progress with 802.11ad research
- Availability study (client hardware, APs)
- Linux compatibility

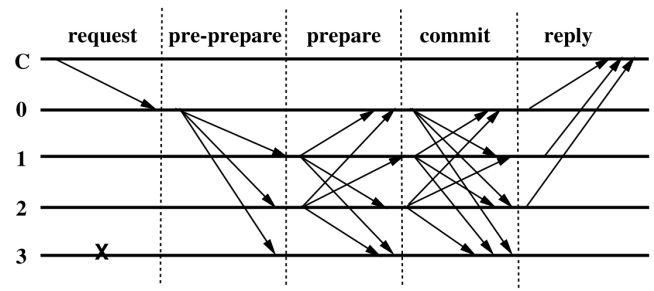
Recent Optimization Approaches for Consensus

Richard von Seck

Consensus algorithms are an integral part of building fault-tolerant systems, as used in the State-Machine-Replication (SMR) approach. Due to high communication and processing complexity of these algorithms, different (hardware-based) optimization strategies emerged in recent years. This includes execution of application logic in lower layers (e.g. Kernel space) [1] or network hardware [2], simplification of the agreement problem through assumptions on network behaviour and hardware [3] as well as exploitation of special communication primitives like RDMA [4].

Your tasks:

- Search for related optimization approaches
- Categorize the found related work
- Reason about usecases for each category
- Summarize your findings



[1] Esposito, Emanuele Giuseppe, Paulo Coelho, and Fernando Pedone. "Kernel paxos." 2018 IEEE 37th Symposium on Reliable Distributed Systems (SRDS). IEEE, 2018.

[2] Dang, Huynh Tu, et al. "P4xos: Consensus as a network service." IEEE/ACM Transactions on Networking 28.4 (2020): 1726-1738.

[3] Li, Jialin, et al. "Just say NO to paxos overhead: Replacing consensus with network ordering." 12th USENIX Symposium on Operating Systems Design and Implementation (OSDI 16). 2016.

[4] Wang, Cheng, et al. "Apus: Fast and scalable paxos on rdma." Proceedings of the 2017 Symposium on Cloud Computing. 2017.

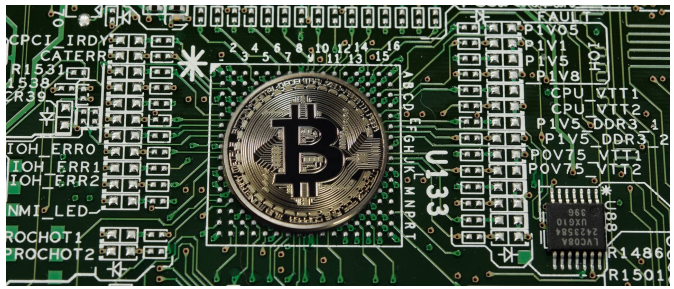
Survey of Cryptographic Offloading techniques for Blockchain Systems

Richard von Seck, Filip Rezabek

Widespread use of symmetric cryptographic primitives in digital communication has led to prevalence of dedicated hardware instructions in modern CPUs. These instructions implement either common subroutines or complete operations of modern crypto algorithms. Modern Blockchain-based systems often require significant amounts of additional asymmetric and threshold cryptography to operate. As the operation of DLT systems is usually linked to considerable cost in itself, hardware acceleration of asymmetric and threshold cryptographic primitives is a desirable goal.

Your tasks:

- Search for recent work on asymmetric/threshold crypto offloading (in context of DLT)
- Analyze the practicality and features of the results
- Summarize your findings



[1] Mahony, Aidan O., and Emanuel Popovici. "A systematic review of blockchain hardware acceleration architectures." 2019 30th Irish Signals and Systems Conference (ISSC). IEEE, 2019.

[2] Chang, Jed Kao-Tung, et al. "The performance analysis and hardware acceleration of crypto-computations for enhanced security." 2010 IEEE 16th Pacific Rim International Symposium on Dependable Computing. IEEE, 2010.

[3] Ikeda, Makoto. "Hardware Acceleration of Elliptic-Curve based Crypto-Algorithm, ECDSA and Pairing Engines." 2021 IEEE 14th International Conference on ASIC (ASICON). IEEE, 2021.

[4] Di Matteo, Stefano, et al. "Secure elliptic curve crypto-processor for real-time IoT applications." Energies 14.15 (2021): 4676.

[5] Karl, Patrick, et al. "Post-Quantum Signatures on RISC-V with Hardware Acceleration." Cryptology ePrint Archive (2022).

Increase the Latency! Simulations on Cable Lengths

Eric Hauser, Sebastian Gallenmüller

The Chair hosts testbeds for experiments on computer networks up to 100 Gbit/s

- Complex network topologies can be already created
- Missing feature: Simulation of long cables
- Longest cable in testbed: 30 m
- Due to the speed of light: additional latency only approx. 100 ns

Your task: Find methods to simulate cable lengths supporting speeds up to 100 Gbit/s

- Ideas: Buffer in RAM, using FPGA network cards, fiber delay lines (FDL), etc.
- Familiarize with the topic propagation delay of copper/fiber networks
- Evaluate possible methods in terms of performance, accuracy, complexity, and cost

Survey: you need to work through appropriate papers and the documentation of switches, (FPGA) network cards, and optical delay systems

Starting point

- `https://web.archive.org/web/20060720145307id_/http://www.utdallas.edu:80/~txz021000/files/taozhang_jsac.pdf`
- `https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.27.5031&rep=rep1&type=pdf`
- `https://netfpga.org/NetFPGA-SUME.html`

Recognizing Activity in Noisy Spectrograms Using Image Detection

Lars Wüstrich

Topic:

- Spectrograms visualize sound over a period of time.
- In noisy environments make it hard to identify known activity automatically.
- A method to recognize sounds in spectrograms is image recognition (IR) [1].
  - e.g., the spinup of fans of a booting server

Your Tasks:

- Identify challenges for using IR for this task
- Implement a pipeline (using OpenCV) to
  - extract a reference of activity
  - recognize references in new spectrograms

Required Skills:

- Experience in Python
- (optional) experience using OpenCV

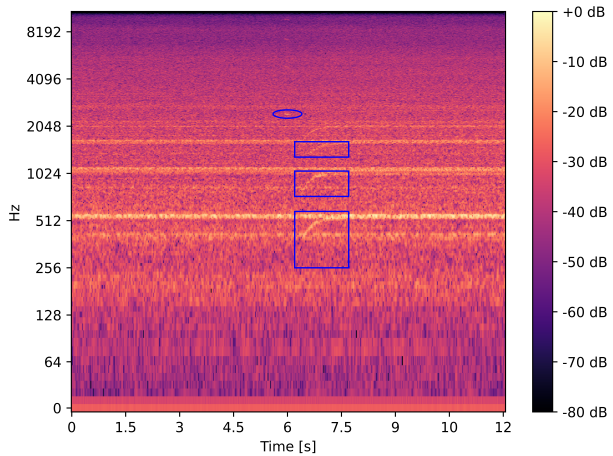


Figure 3: A server booting in a server room

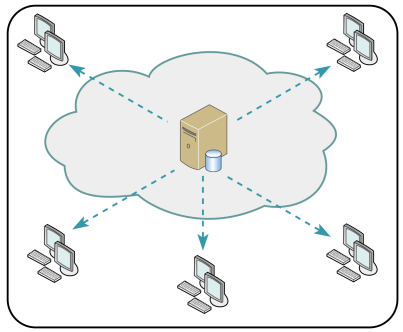
Applied topic: You need to create running code

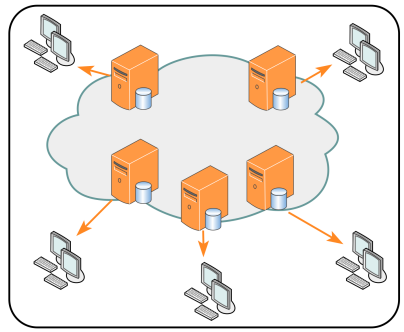
[1] Cecilia Zanni-Merk et al., Classifying Environmental Sounds Using Image Recognition Networks. KES, 2017.

Content and API Acceleration Using Content Delivery Networks

Markus Sosnowski

CDNs [1] play a major role in our current Internet. They can speed up web pages and reduce load on servers. Without them services like Netflix would be impossible. Their main success relies in a large networks of servers deployed as close as possible to a customer.





- Through efficient routing they can speed up a connection in general
- Caching content speeds up loading time and reduces load on the origin
- CDNs start to include more logic (e.g., image processing or edge computing [2])

However, without a lot of logic in the network acceleration is quickly limited (e.g., application APIs usually contain sensitive data that cannot be cached easily)

Your tasks:

- Research on major CDNs and their approach to accelerate delivery of content and APIs
- Create test accounts for major CDNs and search through their documentation
- Find relevant research and, if possible, find specialized CDNs focusing on API acceleration

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[1] Nygren, E., Sitaraman, R. K., & Sun, J. The Akamai Network: A Platform for High-Performance Internet Applications.
[2] A. Davis, J. Parikh, and W. E. Weihl. 2004. Edgecomputing: extending enterprise applications to the edge of the internet

Survey on the Chinese Governments Censorship Mechanisms

Lion Steger

Topic:

- The Chinese government employs intricate technology to implement digital censorship
- Research is published under the umbrella term Great Firewall of China (GFW or GFC)
- Techniques range from DNS injections [1] over SNI Filtering [2] to active scans [3]
- There is a constant battle between censorship mechanisms and new bypassing tech [4][6]
- Interactions between emerging technologies and the GFW are not fully researched [5]

Your Task:

- Collect, summarize and contextualize recent publications about the GFW
- A comprehensive overview over the GFWs methods and their current evasion possibilities
- Identify open research questions and run small experiments to answer them if possible

References:

[1] https://www.usenix.org/system/files/foci20-paper-anonymous_0.pdf

[2] https://gfw.report/blog/gfw_esni_blocking/en/

[3] https://blog.torproject.org/learning-more-about-gfws-active-probing-system/

[4] https://gfw.report/publications/imc20/data/paper/shadowsocks.pdf

[5] https://dl.acm.org/doi/pdf/10.1145/3487552.3487836

[6] https://ensa.fi/active-probing/imc2015.pdf

Benchmarking Secure Multiparty Computation Frameworks

Christopher Harth-Kitzerow

Secure Multiparty Computation (SMC/MPC) [1] is an area in cryptography and privacy that enables multiple parties to perform a function on their private inputs without revealing those to each other. Evaluating a function with multiple peers efficiently requires high network bandwidth and low network latency. While there are multiple open source frameworks available to perform a secure computation, there is little understanding on the resulting performance in non-optimal network conditions.

Your tasks:

- Compare open-source SMC frameworks based on performance results presented in the current academic literature.
- Implement a set of reference use cases in that framework.
- Benchmark the performance of that framework using the chair's Testbed [2].

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[1] Lindell, Yehuda. "Secure multiparty computation." Communications of the ACM 64.1 (2020): 86-96.

[2] Gallenmüller, Sebastian, et al. "The pos framework: a methodology and toolchain for reproducible network experiments." Proceedings of the 17th International Conference on emerging Networking EXperiments and Technologies. 2021

Using Secure Multiparty Computation for Private Blockchains

Christopher Harth-Kitzerow

Secure Multiparty Computation (SMC/MPC) [1] is an area in cryptography and privacy that enables multiple parties to perform a function on their private inputs without revealing those to each other. Using peer-to-peer SMC protocols complementary to a public Blockchain could enable privacy of transactions and smart contracts.

Your tasks:

- Conduct a literature review of use cases for combining SMC protocols and Blockchain.
- Implement one use case using an open-source Secure Multiparty Computation framework.

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[1] Lindell, Yehuda. "Secure multiparty computation." Communications of the ACM 64.1 (2020): 86-96.