Projektseminar KTS 8CP
Proseminar etit(Literaturseminar) 2 CP

TECHNISCHE UNIVERSITÄT DARMSTADT

Fachgebiet Kommunikationstechnik, Prof. Dr.-Ing. Anja Klein
October 15, 2020

1 Übersicht

- Im 5. bzw. 6. oder höheren Semester des Bachelor Studiums etit oder WI-etit
- Die Themen werden idealerweise zusammen mit dem Thema für die Bachelorarbeit gewählt
- Ansprechpartner: alle Mitarbeitenden, die eine Bachelorarbeit anbieten
- Startzeitpunkt und Dauer der Projektarbeit (z.B. im Block oder vorlesungsbegleitend) können mit dem Projektbetreuer individuell vereinbart werden
- Je nach Thema kann Teamarbeit möglich sein
- Wird jedes Semester angeboten
- Ansprechpartner für das Fachgebiet Kommunikationstechnik bei allgemeinen Fragen:
  - Kilian Kiekenap, k.kiekenap@nt.tu-darmstadt.de
  - Prof. Dr.-Ing Anja Klein, a.klein@nt.tu-darmstadt.de

2 Proseminar etit (Literaturseminar) 2 CP

- Forschungsnahe Erarbeitung eines fachlichen Themas in Zusammenarbeit mit einem wissenschaftlichen Mitarbeiter als Betreuer
- Detaillierte Beschäftigung mit technischen Artikeln
- Tiefes Verständnis des darin behandelten fachlichen Themas
- Praktische Erfahrung mit technischer Dokumentation
- Erlernen moderner Präsentationstechniken und deren Anwendung
- Präsentation und Diskussion des fachlichen Themas vor einer Gruppe

3 Projektseminar KTS 8 CP

- Vorbereitung auf die Bachelorarbeit
- Idealerweise werden das Projektseminar und die Bachelorarbeit am selben Fachgebiet beim selben Betreuer absolviert und die Themen aufeinander abgestimmt
- Tiefes Verständnis eines speziellen, komplexen Forschungsthemas der KTS
- Praktische Erfahrung mit aktueller Literatur
- Praktische Erfahrung mit Hardware, Software, Algorithmen und/oder Simulation
- Strukturierung einer komplexen Aufgabe
- Präsentation eines komplexen Themas
- Dokumentation eines komplexen Themas

4 Ergänzung zum Projektseminar KTS 2 CP

- Ergänzt das Modul Projektseminar
- Kann als Ersatz für das Einführungsprojekt belegt werden
- Kann nur zusammen mit dem Projektseminar belegt werden, dessen Aufwand sich dann von 8 CP auf 10 CP erhöht

5 Themen

Im Folgenden sind beispielhaft einige Themen des Fachgebiets Kommunikationstechnik dargestellt. Für weitere Informationen sowie zusätzliche, verwandte Themen kontaktieren Sie bitte den oder die jeweiligen Mitarbeiter per eMail. Natürlich können Sie auch, z.B. per Skype, ein persönliches Gespräch führen.

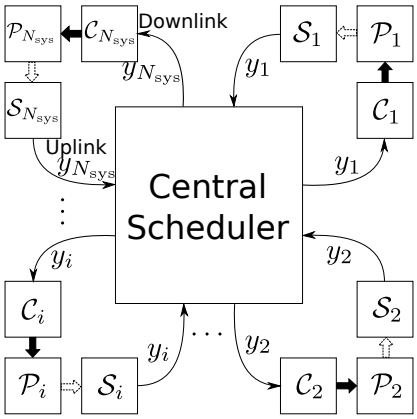
5.1 Communication and Control

Motivation:

Wireless communication is very important for upcoming developments in the fields of e.g. autonomous driving and Industry 4.0. Whereas in previous mobile communication standards the focus was mainly on communication between users, the communication between machines imposes different requirements to the communication channel.
In control systems, two types of data transmissions are possible. Sensor values need to be transmitted to controllers and control values from sensors to actuators. In this project the first transmission type is investigated.

Tasks:

Multiple individual subsystems, each consisting of a plant P, a controller C and and Sensor S, compete for communication resources for transmitting values from the sensor to the controller. A central entity coordinates the transmissions. The task is now to optimize the allocation of communication resources to optimize the control performance. In the literature a dynamic programming approach is described, which is to be implemented and extended to a more complex model.



Introductory literature

- Onur Ayan et al. “Age-of-information vs. Value-of-information Scheduling for Cellular Networked Control Systems”. In: *Proceedings of the 10th ACM/IEEE International Conference on Cyber-Physical Systems*. ICCPS ’19. Montreal, Quebec, Canada, 2019. URL: http://mediatum.ub.tum.de/doc/1470538/1470538.pdf
- Onur Ayan, Mikhail Vilgelm, and Wolfgang Kellerer. “Optimal Scheduling for Discounted Age Penalty Minimization in Multi-Loop Networked Control”. In: *IEEE Consumer Communications & Networking Conference*. Oct. 2020. URL: https://mediatum.ub.tum.de/doc/1523844/268081.pdf

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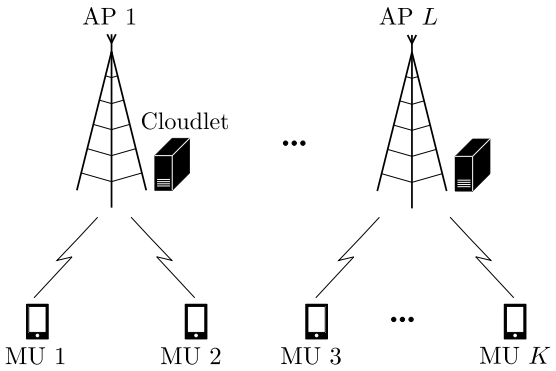
5.2 Computation Offloading

Motivation:

The number of battery powered mobile devices (laptops, smartphones, tablets, etc.) is rapidly growing. At the same time, the usage shifts from stationary computers to these mobile devices. Therefore, it is proposed to offload computation tasks from the mobile units (MUs) to more powerful servers in the network. There are mainly two popular approaches: mobile cloud computing (MCC) and mobile edge computing (MEC).
The project seminar will focus more on the popular filed of MEC where computing servers are close to access points (APs) or cellular base stations. This proximity to the MUs should provide a low latency for many emerging applications like augmented reality and natural speech processing that can enrich our daily life. These applications have a high demand for processing power and require to be processed in near real time.
A survey [1] shows a broad field of challenges of MEC systems. In our group, we are focussing on algorithms for the offloading decisions of MUs and the resource allocation in different network topologies.

Topics:

There are two possible topics to be investigated:
Topic 1: In a scenario where computation tasks are arbitrarily splittable and a mobile unit (MU) can offload fractions of its task, it is crucial to offload the right amount. In [2], the authors propose multiple algorithms based on optimization methods for energy efficient and time efficient computation offloading.
Topic 2: The considered scenario is larger with multiple MUs, multiple APs and multiple small cloudlet servers that can compute offloaded tasks of the MUs. In [3], the authors propose a framework based on game theory where the MUs can decide whether offloading of the tasks is beneficial and where the taks should be computed.
Tasks for the group: Based on the number of group members and existing skill level, the difficulty of both topics can be adapted. The general procedure for both topics is similar: the project group should define a simulation framework, implement it in MATLAB and test the presented algorithms. Both topics can be further extended by introducing new constraints to the system model and adapting the algorithms accordingly. The details will be discussed with the supervisor.



Introductory Literature

[1] Yuyi Mao et al. “A survey on mobile edge computing: The communication perspective”. In: *IEEE Communications Surveys & Tutorials* 19.4 (2017), pp. 2322–2358. URL: https://ieeexplore.ieee.org/abstract/document/8016573

[2] Yanting Wang et al. “Mobile-edge computing: Partial computation offloading using dynamic voltage scaling”. In: *IEEE Transactions on Communications* 64.10 (2016), pp. 4268–4282. URL: https://ieeexplore.ieee.org/abstract/document/7542156

[3] Slađana Jošilo and György Dán. “Wireless and Computing Resource Allocation for Selfish Computation Offloading in Edge Computing”. In: *IEEE INFOCOM 2019-IEEE Conference on Computer Communications*. IEEE. 2019, pp. 2467–2475. URL: https://people.kth.se/~josilo/Pub/JosiloD-Infocom19-edgeresource.pdf

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5.3 Channel estimation for large intelligent surface aided communication systems

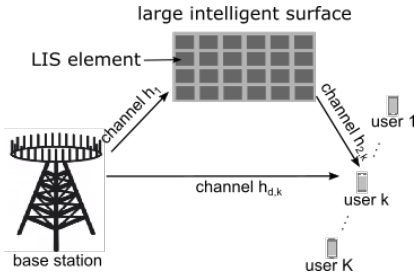
Motivation:

The 5G mobile communication standard aims to provide broadband, massive and ultra-reliable low-latency connectivity relying on different technologies for system performance including millimeter wave, massive MIMO (mMIMO) and cell densification. However, its practical realization comes with the price of high power consumption, hardware cost and processing complexity that compromise scalable deployments in future networks. Therefore new communication techniques for system efficiency and ubiquitous connectivity is of relevant importance.

Large intelligent surface (LIS) is an emerging technology that has been recently proposed to achieve the above goals. It enables the reconfiguration of the radio propagation environment for favorable transmission as well as the design of low-complex mMIMO radios. The LIS operates by changing the electromagnetic characteristics of its elements in a way the incoming waves are reflected towards desired destinations (e.g. base stations and mobile users) to increase the network coverage and reliability and provide signal-to-interference-plus-noise ratio gains. This concept can be realized by arrays of low cost antennas, smart reflect arrays and reconfigurable meta-surfaces. The LIS is assumed to be an energy-limited passive device with limited processing capability unlike active relay/beamforming technologies.

The performance of a practical LIS system depends on the acquisition method and accuracy of the channel state information (CSI) of the BS-users, BS-LIS and LIS-users links. However, the CSI acquisition can impose high communication and computational resource burdens, especially in high-dimensional channel and time-constrained scenarios. Moreover, prior methods for mMIMO do not directly apply to LIS because of differences in their system models and operation regimes. Therefore, novel CSI acquisition methods with low resource utilization and low complexity are of timely importance to enable a practical realization of LIS systems.

Topic:



The scenario shown in the figure consists of a single-cell multiple-user MISO transmission assisted by one passive LIS where h_1, $h_{2,k}$ and $h_{d,k}$ are the BS-LIS, LIS-user$_k$ and BS-user$_k$ channels respectively. This project aims to study state-of-the-art CSI acquisition methods for LIS systems and develop a novel centralized low-complex algorithm based on uplink pilot training that leverages LIS phase shifts patterns for channel matrix estimation.

References:

Introduction:

- Marco Di Renzo et al. *Smart Radio Environments Empowered by AI Reconfigurable Meta-Surfaces: An Idea Whose Time Has Come*. URL: https://jwcn-eurasipjournals.springeropen.com/articles/10.1186/s13638-019-1438-9
- Emil Björnson. *Fundamentals of Intelligent Reflecting Surfaces (video)*. URL: https://youtu.be/CDt0JNrOKxk

LIS channel estimation:

- D. Mishra and H. Johansson. *Channel Estimation and Low-complexity Beamforming Design for Passive Intelligent Surface Assisted MISO Wireless Energy Transfer*. URL: https://ieeexplore.ieee.org/abstract/document/8683663
- Beixiong Zheng and Rui Zhang. *Intelligent Reflecting Surface-Enhanced OFDM: Channel Estimation and Reflection Optimization*. URL: https://arxiv.org/abs/1909.03272

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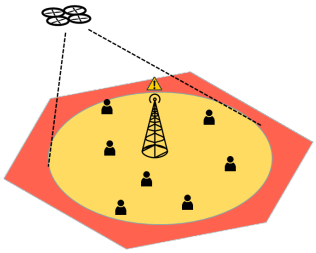
5.4 Optimal UAV deployment as base station

Motivation

In case of an extreme event, such as natural disasters, congestions within the cell, or malfunctions of the infrastructure, the ground base stations may become unable to serve all users within their area. However, these situations are either unexpected, or temporary. As a result, it is not feasible to invest in an infrastructure that will operate for a relatively short amount of time. Unmanned aerial vehicles (UAV) that can serve as aerial base stations are proposed to assist cellular networks with their quick deployment opportunity and low cost. However, one of the biggest challenges is to determine the optimal placement of the UAV so that the network can benefit the most.
Placement of a UAV base station (UAV-BS) poses a different challenge than terrestrial cell placement due to multiple reasons. Firstly, in addition to choosing the UAV's location in the horizontal space, we need to determine its altitude as well. Secondly, the coverage area of a terrestrial cell is known a priori. However, the coverage area of a UAV-BS depends on its altitude and is unknown before solving the placement problem. Lastly, the mobility of the UAV-BS allows it to move wherever the demand is, in contrast to terrestrial cells waiting for the demand to come towards them. As a result, the coverage region providing the maximum revenue to the network should be found.



Tasks

This scenario depicts several users in the cell that cannot be served due to infrastructure failure, which will be served with help of the deployed UAV base station. Task in this project is to implement a simulation environment for the depicted scenario and the solution provided by literature. It could be also further extended to a more complex model with more constraints.

Introductory Literature

- R. I. Bor-Yaliniz, A. El-Keyi, and H. Yanikomeroglu. "Efficient 3-D placement of an aerial base station in next generation cellular networks". In: *2016 IEEE International Conference on Communications (ICC)*. 2016, pp. 1–5. URL: https://arxiv.org/abs/1603.00300

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5.5 Matching-Based Resource Allocation for Reliable Communication

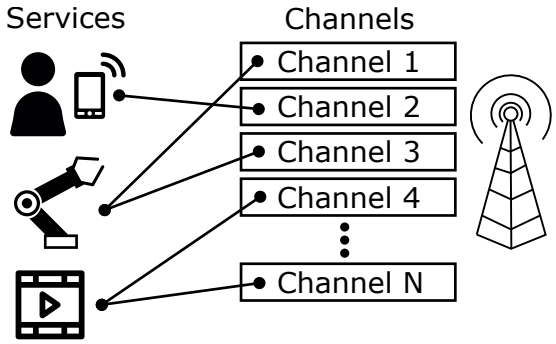
Motivation:

A broad range of applications depending on reliable and fast transfer of information will play an important role in future wireless networks. These delay-sensitive services include control tasks like factory automation or real-time human and machine interaction like augmented reality. To enable the use of these applications in edge networks, the upcoming standard for cellular networks (5G) will provide a new communication paradigm: Ultra Reliable Low Latency Communications (URLLC).

To measure the performance of the wireless network the quality-of-service (QoS) metric is used. The QoS models the relevant performance metric for an application considering latency, throughput or packet error rate. In URLLC each application has strict minimum requirements on the QoS. These strict requirements concern e.g. the maximum latency, the minimum throughput or the maximum packet loss of the transmission. Because of the time-varying channel conditions the correct transmission of a packet in a wireless channel cannot be guaranteed. The more resource blocks are assigned to a user the higher is the probability of correct decoding the transmitted message. To provide stochastic guarantees sufficient communication resources are required for every user depending on its application type.

Topic:

Instead of solving the problem from a centralized perspective, we model the problem as a strategic game with interaction of individual rational users and the available communication channels provided by the network operator. The game is called a one-to-many-matching, meaning that one user is matched to multiple communication channels. The goal is the design of a game-theoretic mechanism that provides a decentralized solution for resource allocation.



The research questions of this project are:

1. How to model the reliability requirements and available communication resources?
2. How to achieve a stable matching between users and and channels concerning their preferences?
3. How is the performance of the solution compared to state-of-the-art methods?

Introductory Literature:

[1] T. Hößler, M. Simsek, and G. P. Fettweis. “Matching-Based Resource Allocation for Multi-User URLLC in Unlicensed Frequency Bands”. In: *2019 16th International Symposium on Wireless Communication Systems (ISWCS)*. 2019, pp. 102–106. URL: https://ieeexplore.ieee.org/abstract/document/8877361

[2] Zhu Han et al. *Game Theory for Next Generation Wireless and Communication Networks: Modeling, Analysis, and Design*. Cambridge University Press, 2019. DOI: 10.1017/9781108277402. URL: http://dx.doi.org/10.1017/9781108277402

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