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FACHTAGUNG MOBILKOMMUNIKATION

PERFORMANCE EVALUATION OF SDR-BASED 5G NETWORKS

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RESEARCH TEAM

Tom Bojer	**Core Network Setup & Evaluation** • Lastverteilung im 5G Kernnetz mithilfe von Container-Technologien • Automatisiertes Deployment eines 5G Systems mit konfigurierbaren Slices in einer cloud-native Umgebung
Oliver Kästner	**RAN Deployment, Monitoring & Evaluation** • Aufbau und Leistungsbewertung eines 5G-Mobilfunknetzes basierend auf Software-Defined Radio • Entwicklung und Evaluation einer abstrahierten Programmier- und Monitoring-Schnittstelle für 5G-Mobilfunkdienste
Carolin Christoph, Julian Dreyer	**Further Research** • Aufbau und Evaluation eines 5G Netzes für echtzeitfähige Kommunikation mit Agrarrobotern • Open5GpaceMaker

MOTIVATION

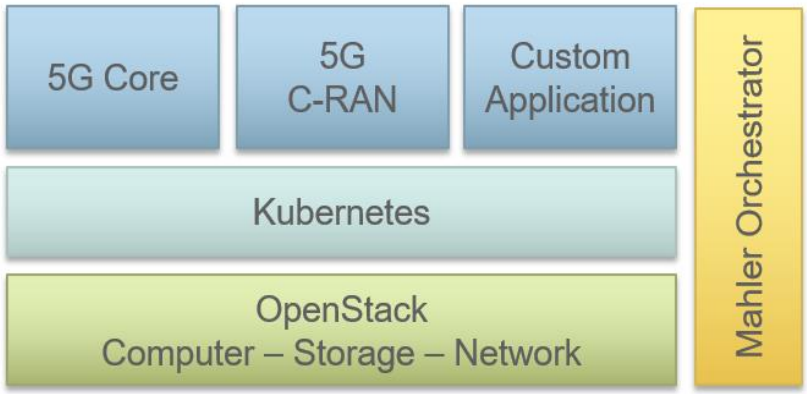
- Private 5G campus networks are enablers for flexible and application-oriented mobile communications (e.g. in SMEs)
- Implementation & investigation of technological capabilities are highly relevant
- Objectives and contributions of our work:
  - → Orchestrated 5G-Core Campus Network deployment
  - → 5G-Core Network Performance Evaluation
  - → Performance evaluation of SDR-based 5G Networks
  - → Platform-independent 5G Monitoring software library

CORE DEPLOYMENT & EVALUATION

BASED ON THE RESEARCH WORK OF TOM BOJER

CORE NETWORK DEPLOYMENT

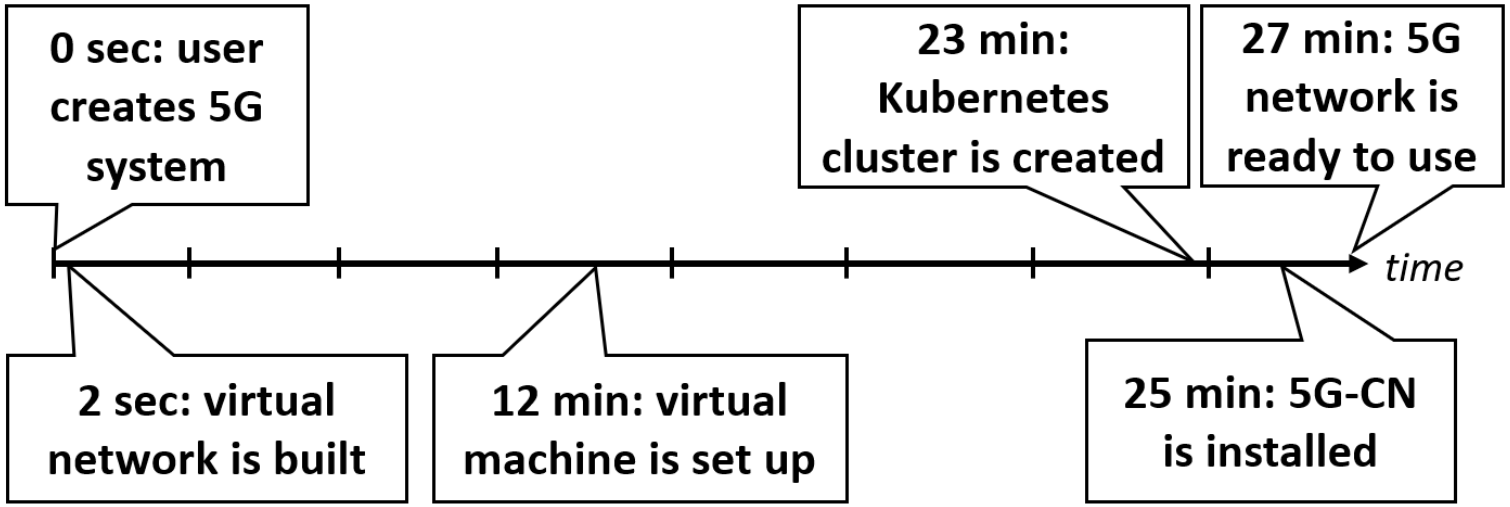
- Virtual deployment of the core network
  - → NF description based on OpenAirInterface software
  - → Each network function (NF) runs in its own Docker container
  - → Kubernetes cluster as runtime environment for RAN and CORE
  - → Infrastructure-as-a-Service using OpenStack
  - → Health & status information via Prometheus



- Network orchestration
  - → self-developed orchestration tool “Mahler Orchestrator”
  - → Components: Web User Interface, Representational State Transfer API, Kubernetes Operator

CORE NETWORK DEPLOYMENT

- Easy setup via user interface
- Core network deployment in 27 minutes
- Dynamic core monitoring



CORE PERFORMANCE EVALUATION

- Core network setups based on Kubernetes & Docker Compose
- Simulation of RAN and User Equipment using gnbsim
- Throughput measurement using iperf3, latency measurement with Ping and CPU load measurement with docker stats

Results:

- On average 18 ms Round Trip Time (RTT) under Load
- UPF CPU load rises with number of gNBs & UEs → bottleneck

5G CORE RTT MEASUREMENT

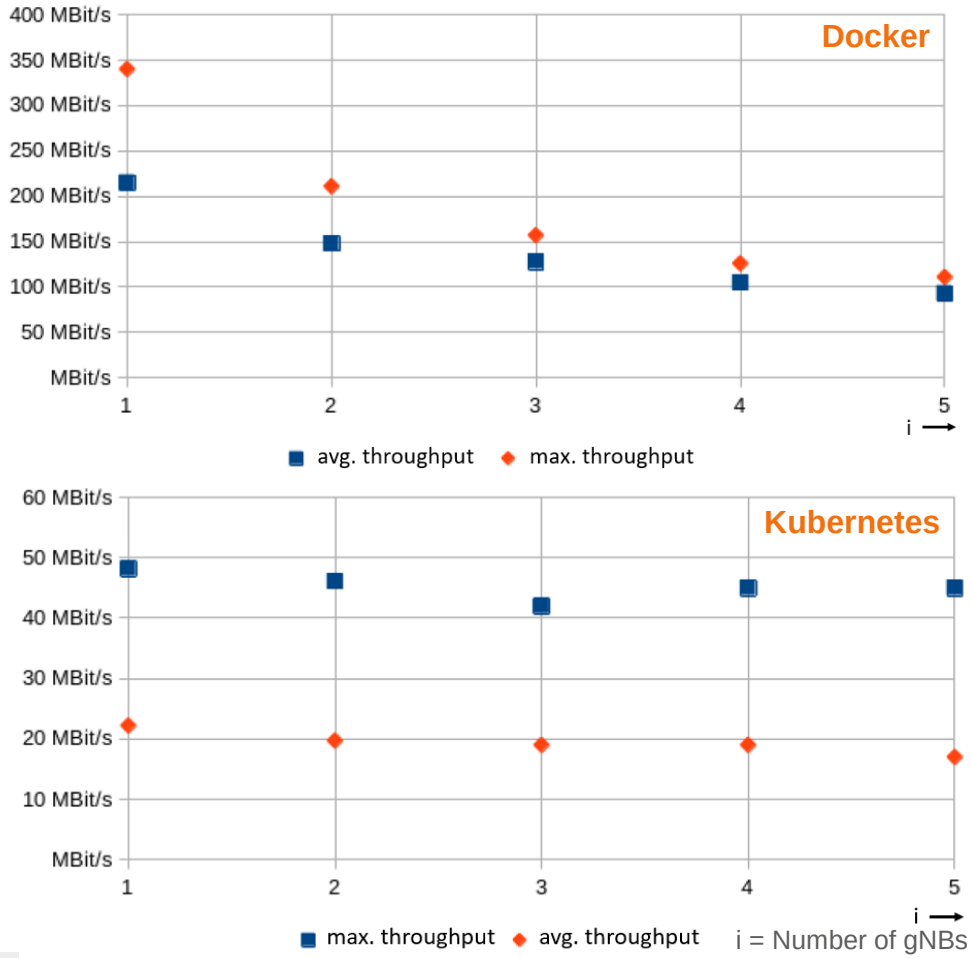
	min	avg	max
Idle	0.377 ms	0.823 ms	2.631 ms
Under Load	2.164 ms	18.157 ms	46.227 ms

i = Number of gNBs

CORE PERFORMANCE EVALUATION

Results:

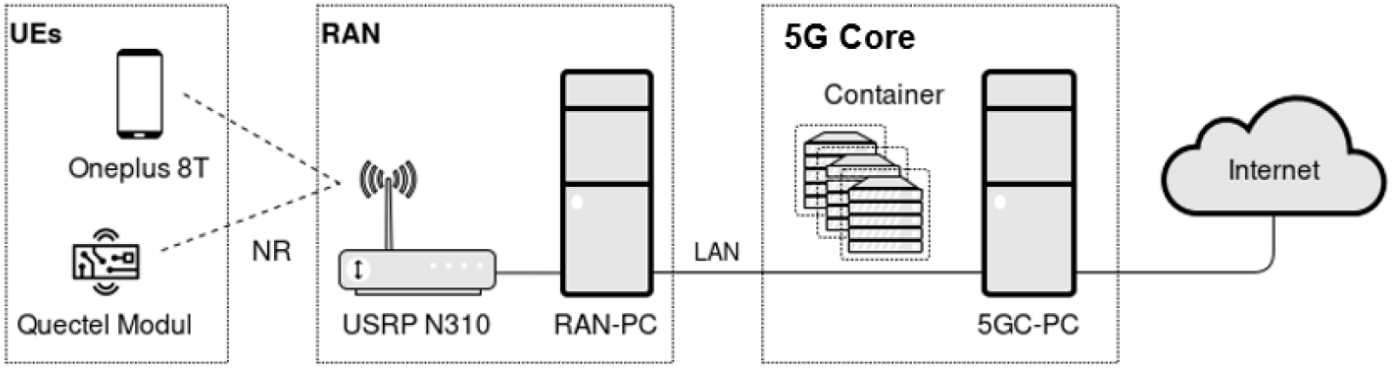
- Higher throughput with Docker than with Kubernetes
- Docker also offers more flexibility in network configuration
- Instable network conditions with kubernetes if > 5 gbsim instances (= 1 gNB & 1 UE) are registered



RAN DEPLOYMENT, EVALUATION & MONITORING

BASED ON THE RESEARCH WORK OF OLIVER KÄSTNER

5G CAMPUS NETWORK SETUP



- Core deployment based on Docker compose
- RAN setup based on OpenAirInterface
- SDR-Device = Ettus USRP N310
- UEs = Smartphone (Oneplus 8T), Quectel-Module (RM500Q-GL) + Raspberry Pi (4 GB)

RAN PERFORMANCE EVALUATION

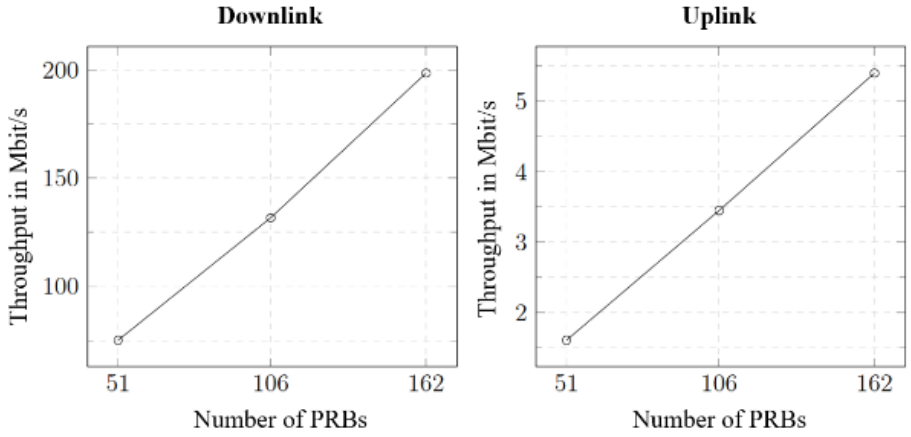
- 3 Configurations:
  1. PRB = 51, BW = 20 MHz
  2. PRB = 106, BW = 40 MHz
  3. PRB = 162, BW = 60 MHz
- Measurements of Latency (Ping), Throughput (iperf3), internet speed (Ookla Speedtest)
- Disclaimer: Not all desired configurations could be tested

RAN Round Trip Time

Configuration	UE	min	avg	max
1	Quectel	7 ms	10 ms	19 ms
1	Oneplus	7 ms	10 ms	20 ms
2	Quectel	7 ms	9 ms	12 ms
2	Oneplus	7 ms	9 ms	21 ms
3	Quectel	7 ms	9 ms	12 ms
3	Oneplus	7 ms	8 ms	13 ms

RAN Network Throughput

Config	UE	Downlink in Mbit/s			Uplink in Mbit/s		
		min	avg	max	min	avg	max
1	Quectel	72.9	75.1	77.1	1.55	1.61	1.67
1	Oneplus	63.1	64.5	65.4	1.68	1.69	1.70
2	Quectel	126	131.7	137	3.43	3.45	3.47
2	Oneplus	124	125.1	127	3.46	3.47	3.47
3	Quectel	194	198.6	203	5.36	5.40	5.43
3	Oneplus	179	180.6	182	5.32	5.38	5.42



Throughput vs. number of PRBs

USER EQUIPMENT MONITORING

- Monitoring C++ API based on ModemManager
- Accessing network & connection parameters of the UEs via D-Bus
- Manufacturer open library for linux-based systems

5G-UE LIBRARY FEATURE OVERVIEW

Feature	Value	Function
Unlock SIM card		×
Query SIM Information	×	
Connect to IP network		×
Query IP information	×	
Data Network Name (DNN) information	×	
NR / LTE query	×	
Reference Signal Received Quality (RSRQ)	×	
Reference Signal Received Power (RSRP)	×	
Signal to Interference plus Noise Ratio (SINR)	×	
Synchronization Signal Block (SSB) Frequency	×	
Bandwidth	×	
Public Land Mobile Network (PLMN)	×	
Tracking Area Code (TAC)	×	
NR Cell Identifier (NCI)	×	
Physical Cell Identity (PCI)	×	

CONCLUSION

- Demonstration of a functional 5G standalone setup
- In general satisfactory results for throughput & latency
- However:
  - Network stability problems for specific configurations
  - Not all network functions of 5G deployed / tested (e.g. MIMO, network Slicing)
  - Sudden disconnections from UE
- Further research areas: 5G in time critical and agricultural applications

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Thank you for your attention!

PERFORMANCE EVALUATION OF SDR-BASED 5G NETWORKS