Towards Flexible and Dynamic 5G Networks

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Oct. 1, 2019
IEEE 5G Summit, Dresden

This work is part of a project that has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation program grant agreement No 647158 – FlexNets (2015 – 2020).
5G Challenges: *Dynamic Changes and Timely Adaptation*

Beyond eMBB, massive IoT and URLLC new stakeholders bring ...

- Exploding user densities
- Sudden change in demands
- High rate vs. low latency requests
- Local events vs. wide area popularity

... to be addressed in a timely and cost efficient manner
5G Opportunities: *Programmability and Flexibility*

- Technology basis to support flexibility and adaptation
  - Network and RAN slicing
  - Network Function Virtualization
  - RAN Function Split
  - SDN for control plane programmability
  - Programmable hardware
  - Data-driven adaptation

- Yet, we miss experience with adaptive 5G systems …
- … from an end-to-end perspective
What is a flexible 5G system?

Example: Dynamic 5G RAN function split

Based on a full Proof-of-Concept implementation at TUM
Fixed 5G Function Split

- Function split implemented on dedicated hardware
- Difficult to update
- User dynamics lead to

![Diagram of Distributed and Centralized Units]

- PHY
- MAC
- RLC
- PDCP
- Fixed 5G Function Split
Function split implemented on dedicated hardware
- Difficult to update
- User dynamics lead to
  - Network congestion
Fixed 5G Function Split

- Function split implemented on dedicated hardware
- Difficult to update
- User dynamics lead to
  - Network congestion
  - Unmanaged interference
NFV-based 5G+ Function Split

- Softwarized functions on off-the-shelf hardware
- Simple to deploy and update
NFV-based 5G+ Function Split

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- Functions can be migrated to adapt to dynamics
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NFV-based 5G+ Function Split Use Case: **Focus on Adaptation**

- **Use case**: PHY-MAC split and RLC-PDCP split (*for this example*)
- **Adaptation**: dynamic migration between the two split options
- **Constraints (for measuring flexibility *)**
  - Time $T$ to complete function migration
    - to avoid packet losses and latency
  - Cost $C$ required to perform the adaptation
    - Packet losses
    - Computational cost
    - Power consumption

Objective: maximize data rate for all UEs

Topology: 18 DUs and 1 CU
  - The CU can implement up to 4 MAC-PHY DUs

Challenges: change in the UEs distribution

Successful adaptation: reach 80% of the data rate of the optimal configuration within \( T \) ms with cost \( C \) packet losses

Systems under comparison:
  - Fixed functional split

NFV-based functional split:
  - Greedy algorithms (load-based)
  - Greedy algorithm (IF-based)
  - Lagrangian-relaxed BnB (branch-and-bound)
  - Brute-force search
NFV-based 5G+ Function Split: Flexibility Measure Results

Flexibility measure

\[ \varphi = \frac{\text{successful adaptations given } T \text{ and } C}{\text{all challenges}} \]

for \(C \to \infty\)

Simple (faster) algorithms do not reach high flexibility

Adaptable systems show flexibility vs. adaptation time trade-off

Fixed split is least flexible (and \(T\) indep.)

Adaptation time matters
What’s next: *End-to-End Flexible 5G Networking*

- 5G Research Hub Munich: 5G Experimental Platform
- www.5Gmunich.de
**Focus application area: eHealth**

**Scenario: Telepresence and Teleservice**
- Teleoperation and semi-autonomous task execution
- Visual immersion: 3D 360° video
- Object recognition
- Localization and mapping

**5G requirements**
- Ultra low delay
- Network-based processing
- High reliability
- High data rates (video)
- QoS differentiation → Slicing
Core network slicing: HyperFlex Hypervisor

Through HyperFLEX we trigger the migration of the security VNF to the edge cloud and re-route the vSDN traffic flows.
Objectives of the 5G Research Hub Munich

- **Realization of a 5G experimental lab platform** and its continuous advancement according to latest 5G standard releases and related research

- **Fundamental research** to significantly shape the state of the art for selected areas in 5G technologies and applications

- **Realization of a methods and technologies platform** as a modular framework being open for emerging applications

fundamental research on 5G and beyond  
modular experimental 5G platform

open for collaboration  
Innovative 5G applications  
demonstration of 5G capabilities
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References


