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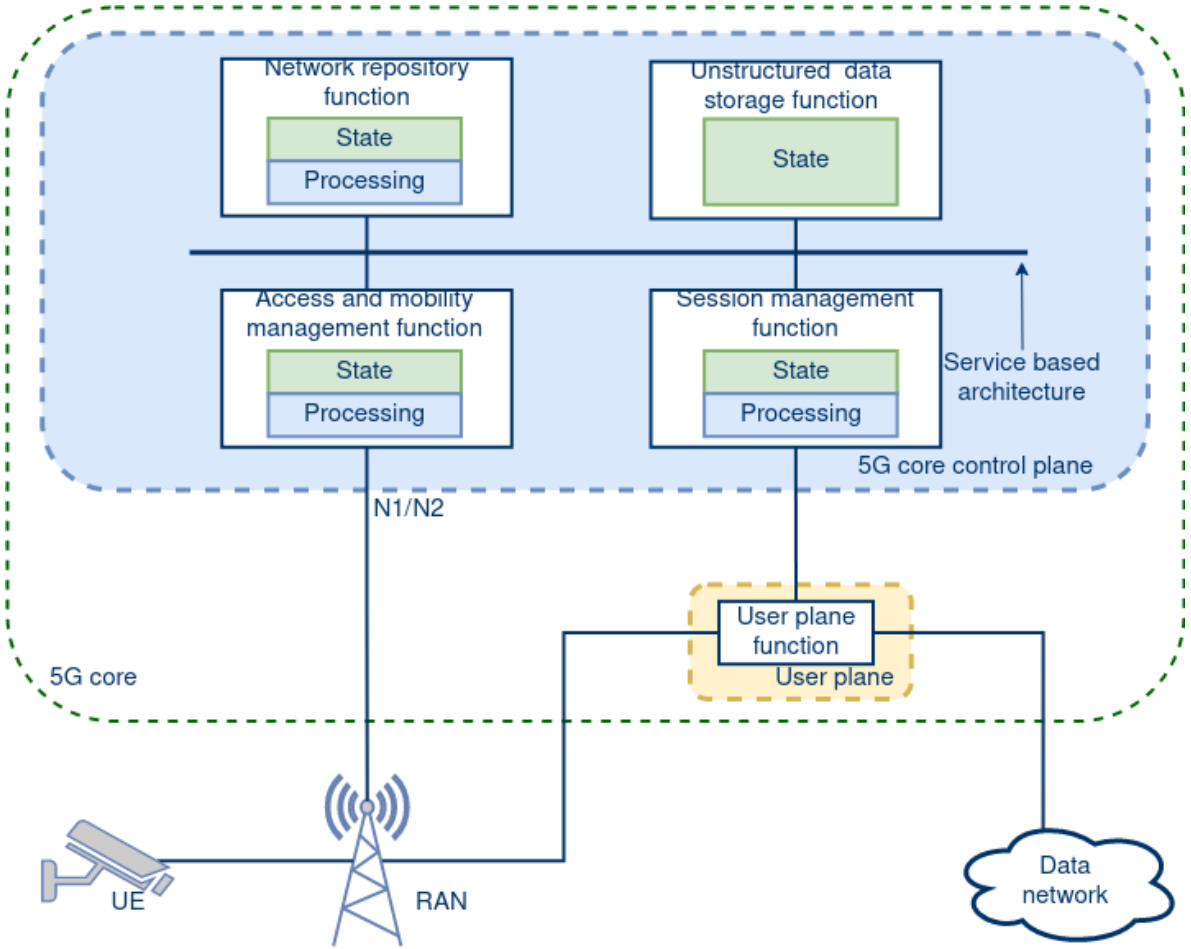
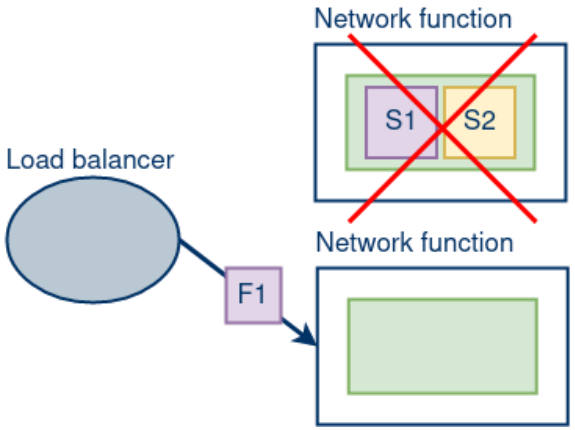
Towards Stateless Core Networks: Measuring State Access Patterns

WueWoWas2022, Würzburg // Wednesday 13.07.2022

Overview 5G System



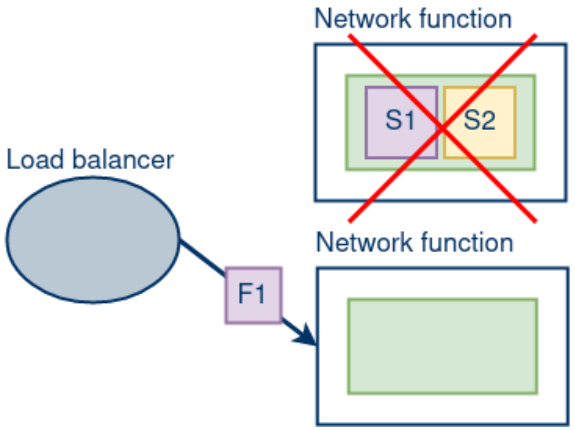
State Management Problems



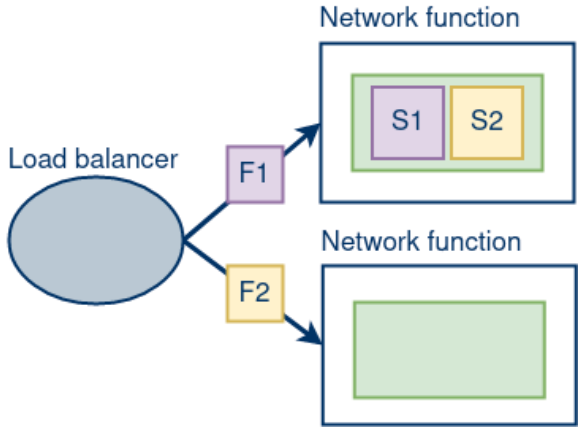
Failed Network Function (NF) instance

S: State
F: Flow

State Management Problems



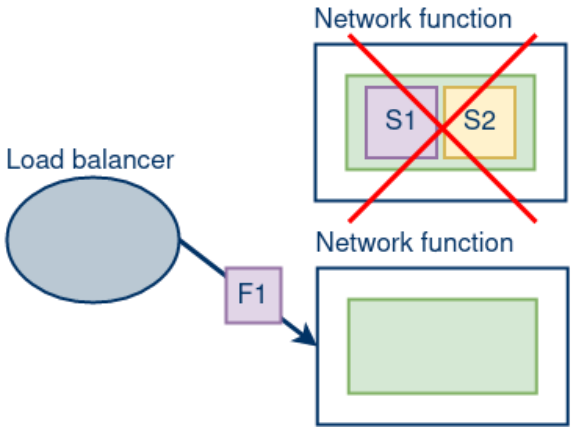
Failed (NF) instance



Newly spawned NF instance

S: State
F: Flow

State Management Problems



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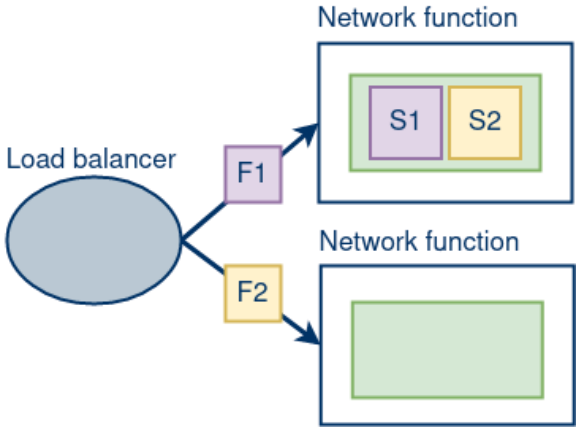

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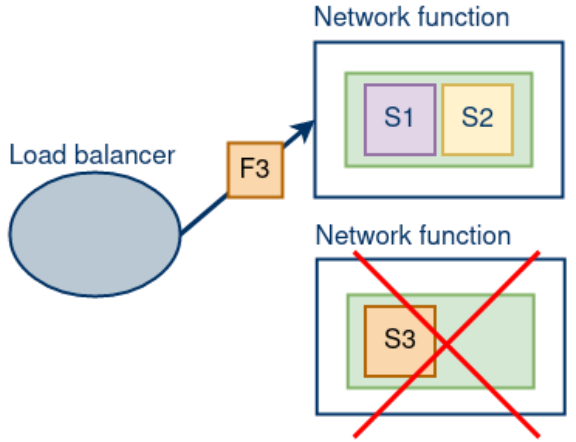
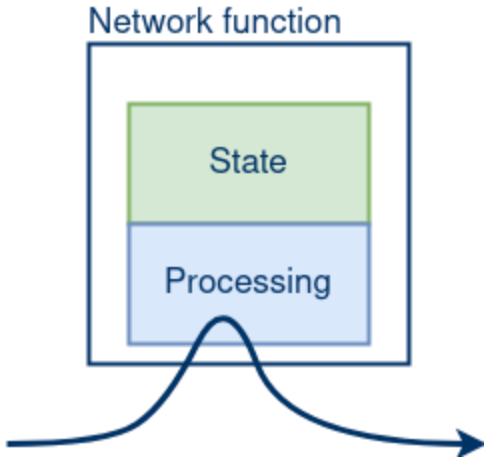


Shutting down an NF instance

S: State
F: Flow

General Approach for stateless Systems

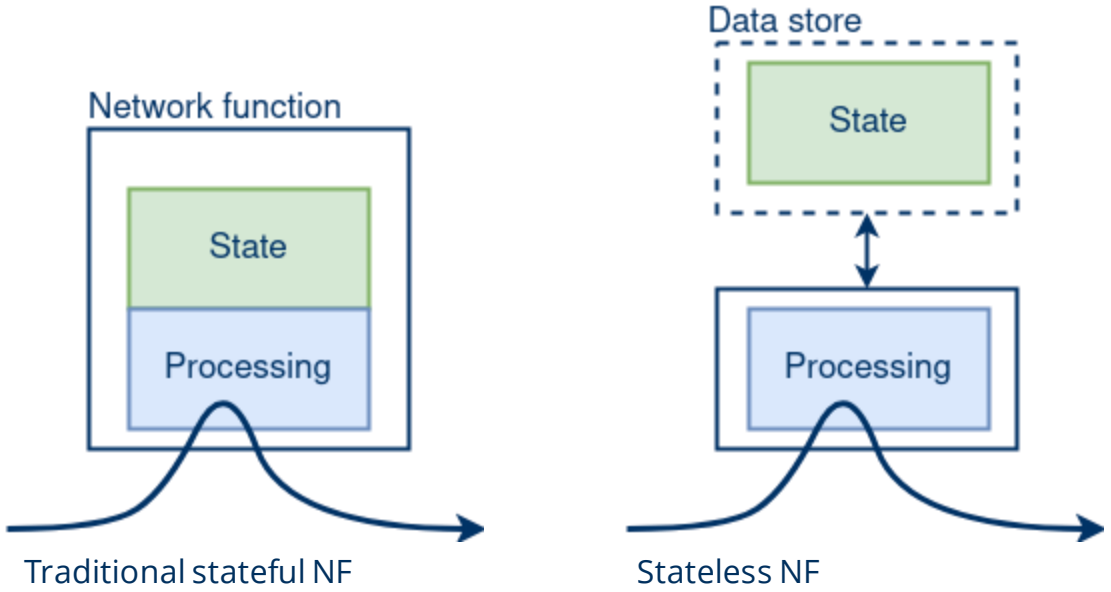
- State is **locked** into a **single NF** instance
- **Big design challenge** in NFV



Traditional stateful NF

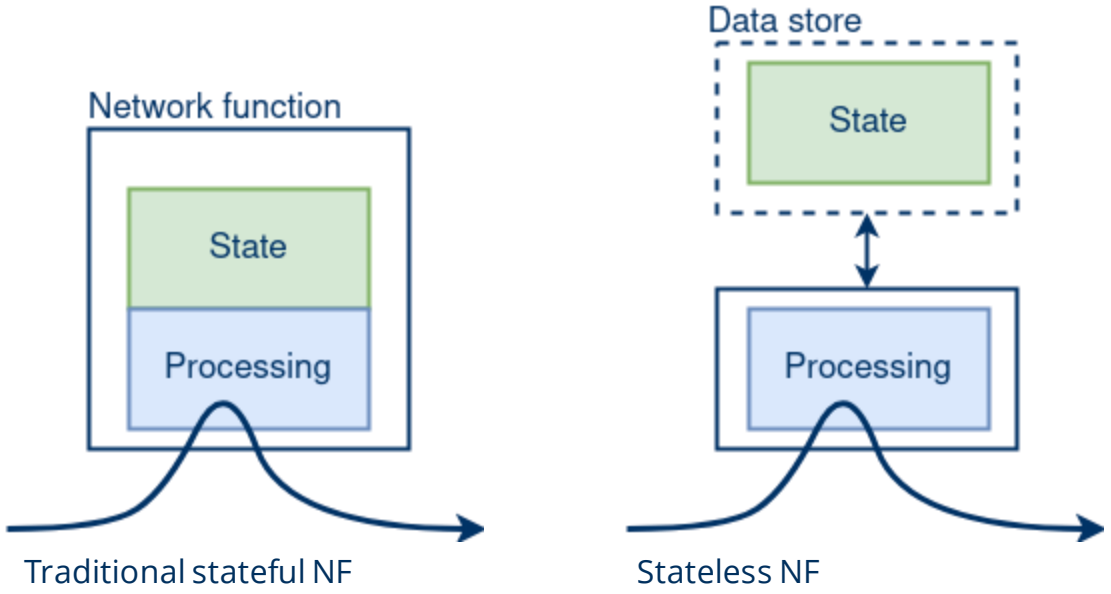
General Approach for stateless Systems

- State is **locked** into a **single NF** instance
- **Big design challenge** in NFV
- So, **breaking the coupling of state and processing**
  - Stateless processing component and a data store layer



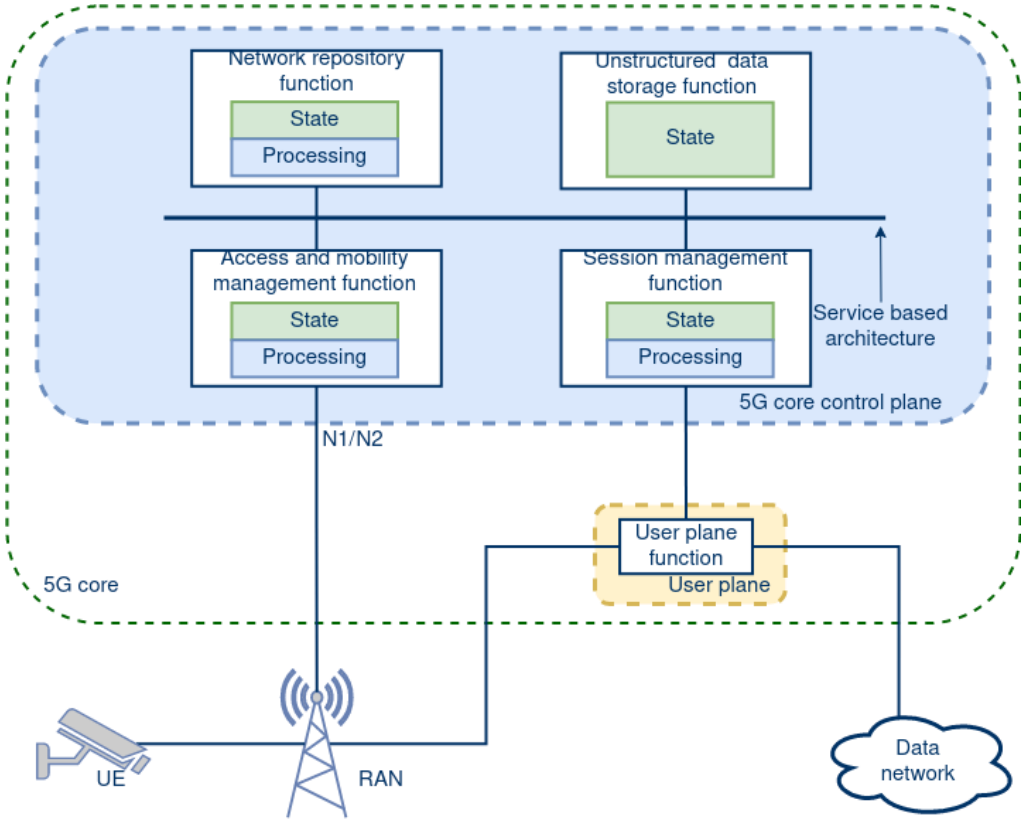
General Approach for stateless Systems

- State is **locked** into a **single NF** instance
- **Big design challenge** in NFV
- So, **breaking the coupling of state and processing**
  - Stateless processing component and a data store layer
- But how to ensure:
  - Low latency,
  - High throughput,
  - Atomicity,
  - Availability?



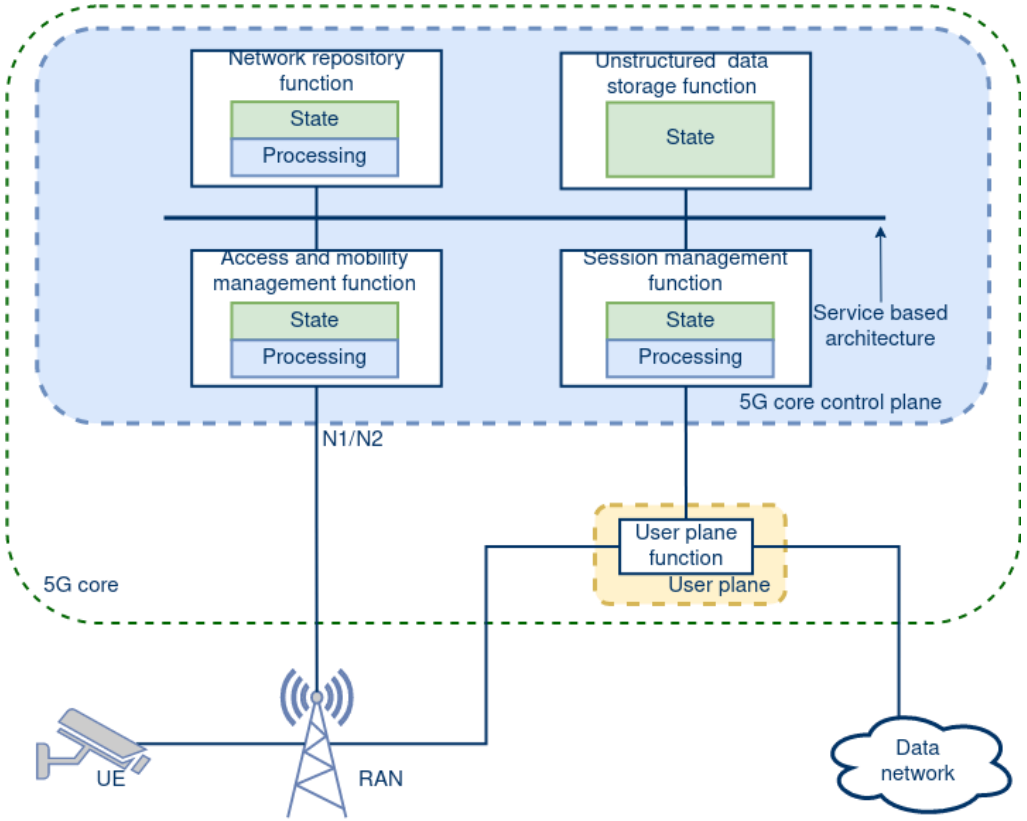
Related Work

- A lot has been done for user plane (UP) NFs
- **Increasing number of NFs on the control plane (CP)**
  - State is completely different with **new challenges** towards its management



Related Work

- A lot has been done for user plane (UP) NFs
- **Increasing number of NFs on the control plane (CP)**
  - State is completely different with **new challenges** towards its management
- Only a **few works** look specifically at CP NFs and even less at 5G's CP [1, 2]



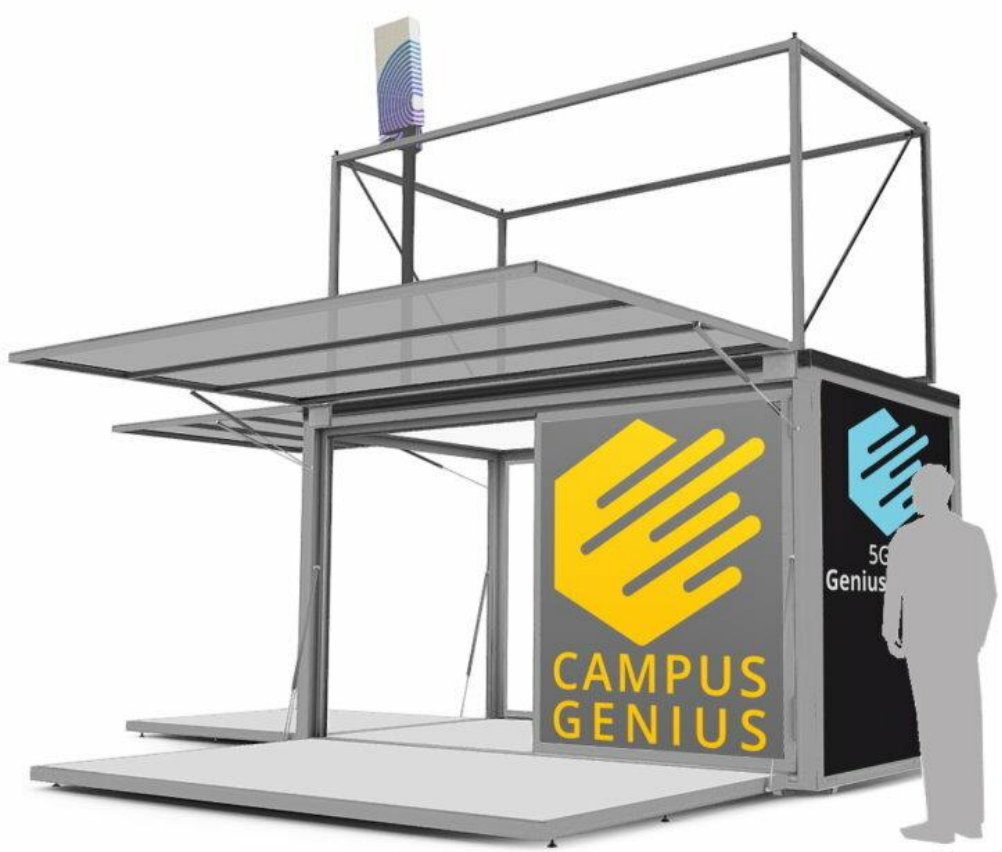
Related Work

Standard proposes an NF that takes this role, but **implementation is entirely up to the programmer**

> “ The UDSF [Unstructured Data Storage Function] is an optional function that supports the following functionality: Storage and retrieval of information as unstructured data by any NF.
>
> TS 23.501: “System Architecture for the 5G System (5GS)”

Latest Trend

- Demand for **private and secure** networks → **5G campus networks**
  - Used for **delay-sensitive** machine type communication
  - High requirements towards **reliability** and **elasticity**



Analyse the State Access Pattern for Machine Type Communication

- Machine type peers exhibit different communication patterns compared to mobile users [3]
  - Different up to down link ratio
  - **Stationary**
  - **Considerably deterministic**

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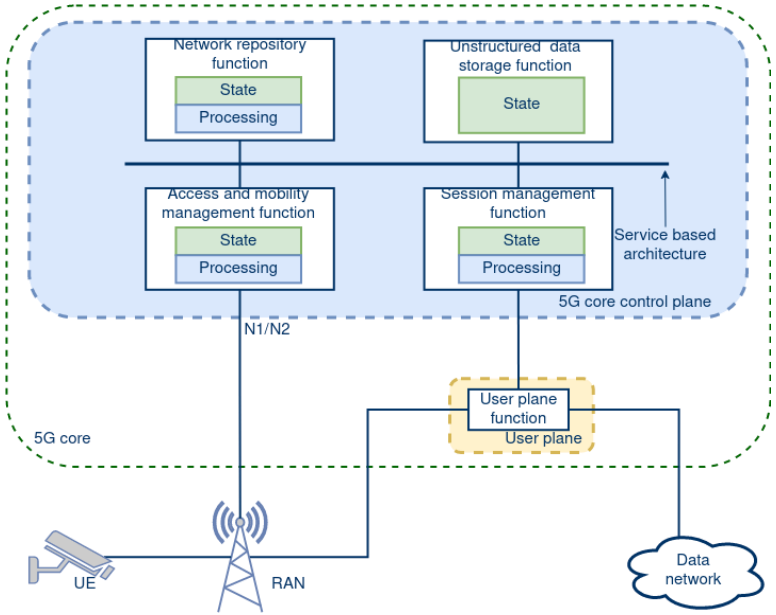
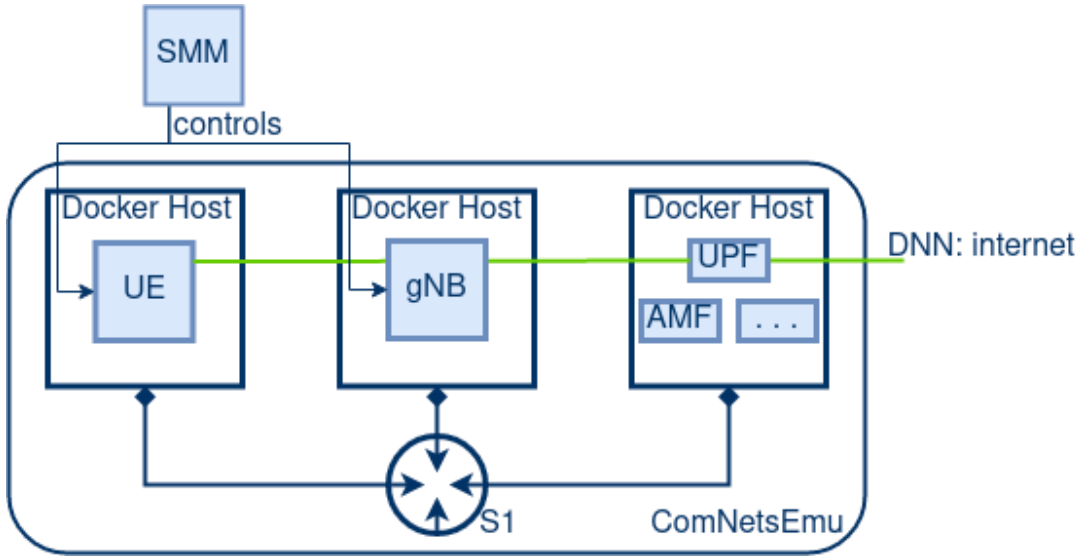
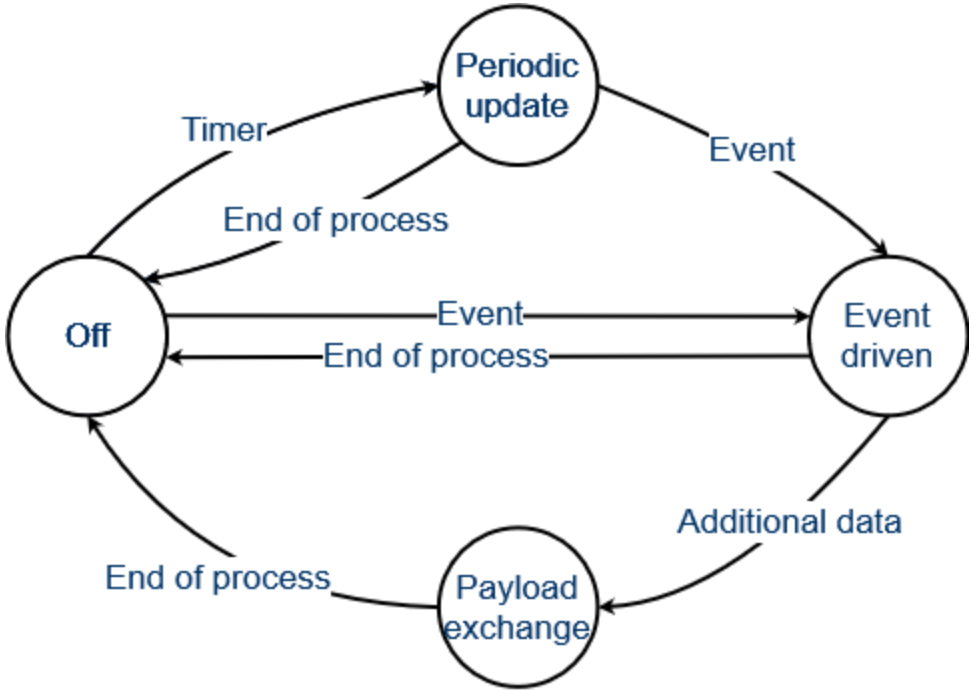




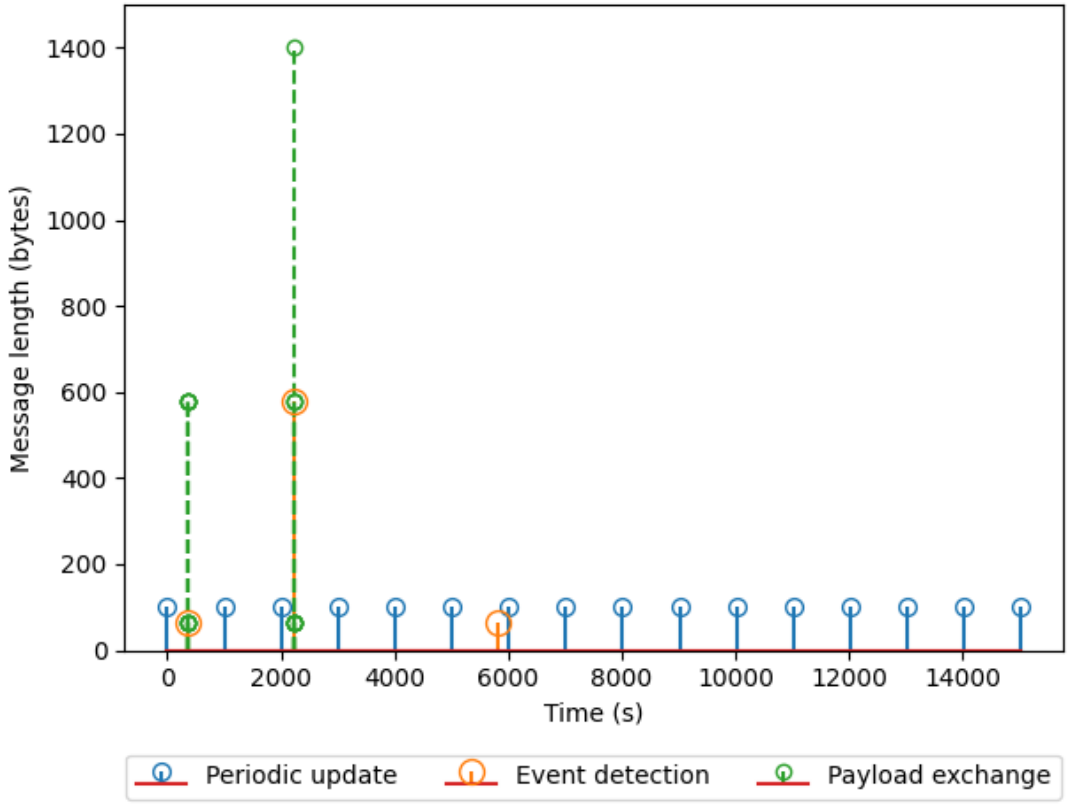
Emulation setup

Traffic Model for Machine Type Devices

- Source model to get fine-grained control over the UE [4, 5]



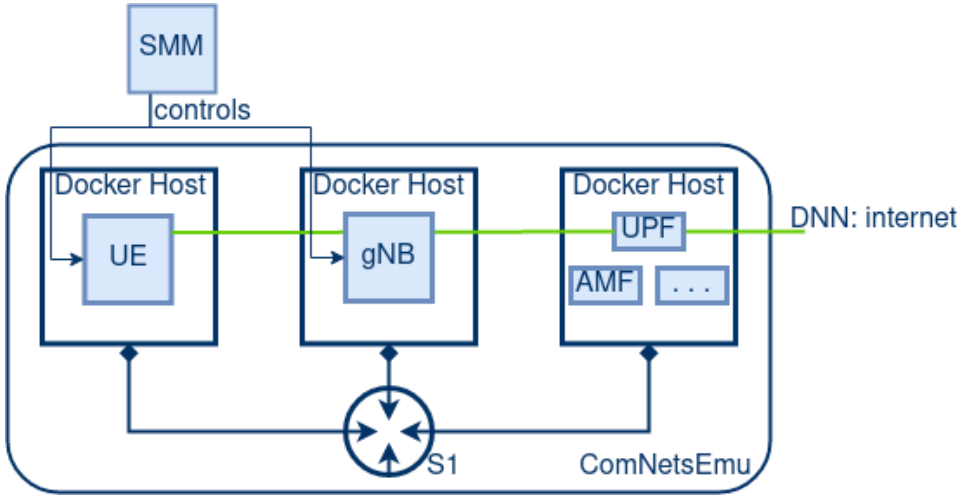
Source Semi-Markov Model procedure



Time series for an IoT sensor device based on a Source Semi-Markov Model

Analyse the State Access Pattern for Machine Type Communication

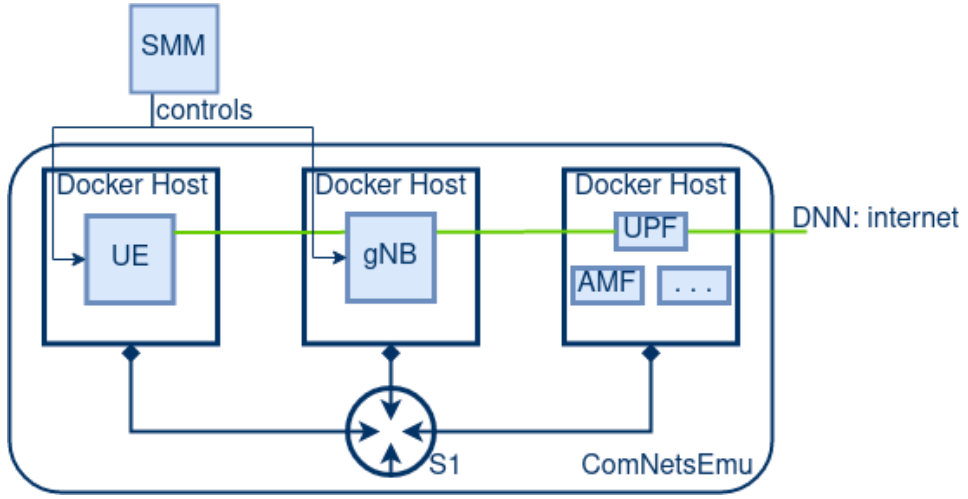
- Machine type peers exhibit different communication patterns compared to mobile users [3]
  - Different up to down link ratio
  - **Stationary**
  - **Considerably deterministic**
- Track how each NF is accessing its state
  - **At what events**
  - With consecutive writes and reads or
  - Write once read many



Emulation setup

Analyse the State Access Pattern for Machine Type Communication

- First results show that **determinism is reflected** in the access pattern
- But some **more complex data needs to be analyzed**
  - Timers
  - Stateful connections between CP, RAN, UE, and UP



Emulation setup

Contributions and Outlook

- Approaching the state management problem with a bottom-up approach
  - Emulation environment to perform rigorous state access measurements
- Extend our emulation to support multiple UEs that are possibly correlated with each other
- Analyse measurements in terms of their state management demands
- Design and implement a state management framework for 5G campus networks

End – Thank you! ☺

Sources

[1] A. Katsarakis, Z. Tan, M. Balkwill, B. Radunovic, A. Bainbridge, A. Dragojevic, B. Grot, and Y. Zhang, “rvnf: Reliable, scalable and performant cellular vnfs in the cloud,”

[2] U. Kulkarni, A. Sheoran, and S. Fahmy, “The cost of stateless network functions in 5g,”

[3] M. Z. Shafiq, L. Ji, A. X. Liu, J. Pang, and J. Wang, “A first look at cellular machine-to-machine traffic: Large scale measurement and characterization,”

[4] M. Sansoni, G. Ravagnani, D. Zucchetto, C. Pielli, A. Zanella, and K. Mahmood, “Comparison of m2m traffic models against real world data sets,”

[5] N. Nikaein, M. Laner, K. Zhou, P. Svoboda, D. Drajic, M. Popovic, and S. Krco, “Simple traffic modeling framework for machine type communication,”