NETWORKS AS P4 PROGRAMMABLE PLATFORMS

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Projects

```
table routing {
  key = { ipv4.dstAddr : lpm; }
  actions = { drop; route; }
  size : 204  8;
}
control ingress() {
  apply {
    routing.apply();
  }
}
```
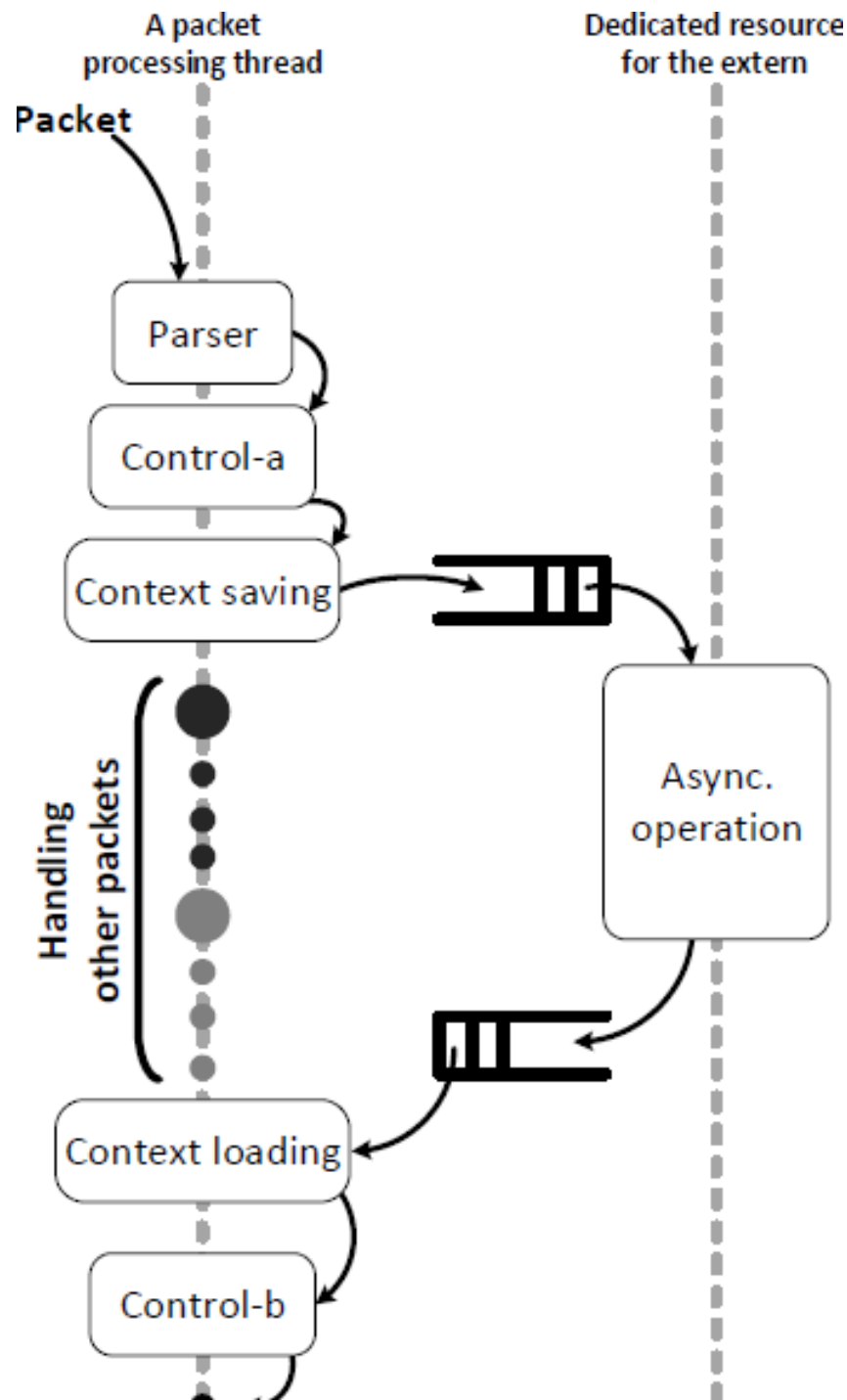
- Asynchronous P4 externs
- Hybrid P4 based 5G implementation
- P4 based AQM evaluation framework
- Industrial P4: robot control/event detection

Asynchronous P4 externs

- Some functions cannot be described in P4
  - encryption/decryption
  - compression/decompression
  - running an artificial neural network on the GPU
- External functions, may appear in the middle of the control flow
  - efficient offloading requires the ability of asynchronous function invocation

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PROGRAM FINANCED FROM THE NRDI FUND

Hybrid P4 based 5G implementation

- ASIC (Application-specific integrated circuit)
  - Fast packet processing
  - Predictable, fixed latency
  - Difficult programmability
  - Limited resources (e.g.: memory)
- FPGA/SmartNIC (Field Programmable Gate Arrays)
  - Smart network card with dedicated processor and memory
- CPU
  - High level of programmability
  - Flexible
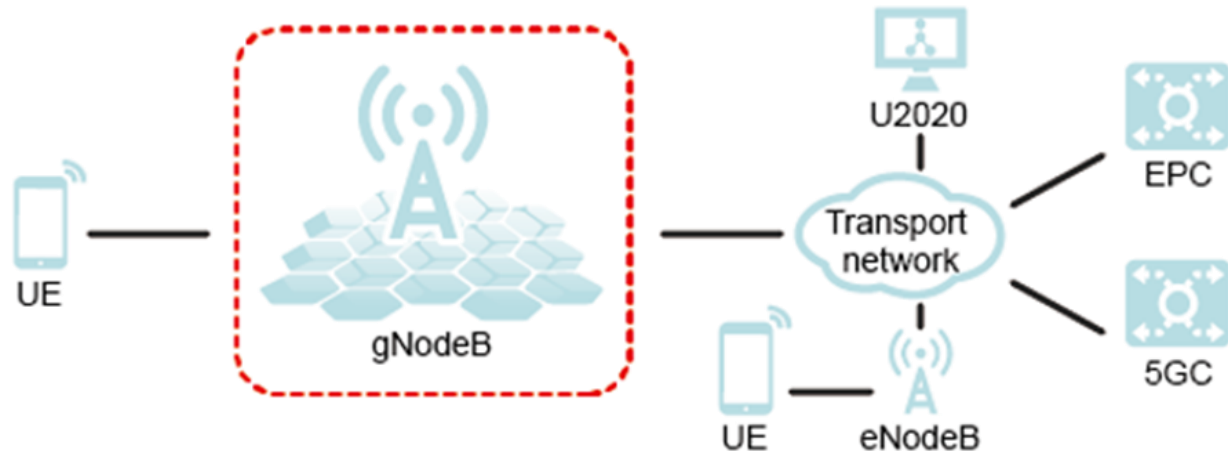 - Slow packet processing
  - Unpredictable latency

Intent based networking
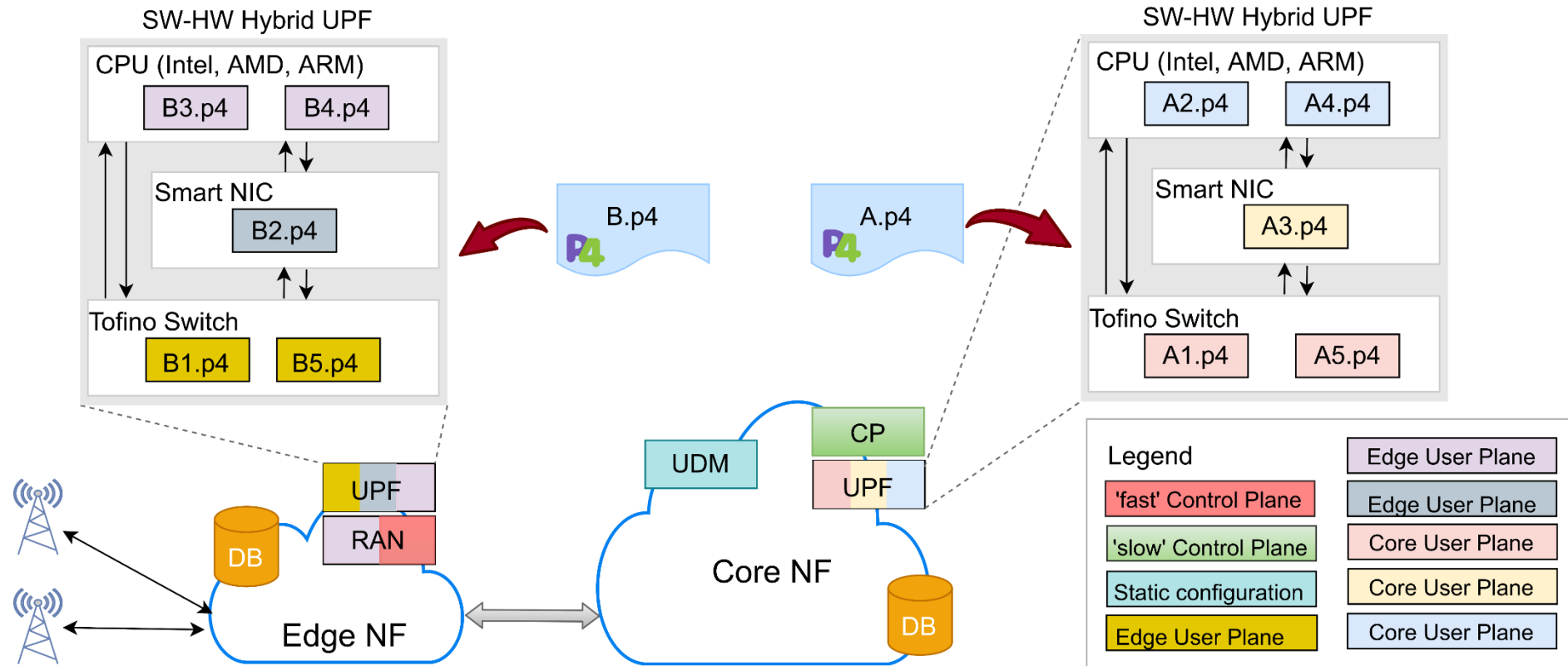
Requirements for 5G

- 5G User plane functions (UPF)
  - 5G core network functions
  - L2/Ethernet and IPv4 routing
  - QoS support
  - Firewall
  - GTP en-/decapsulation

- gNodeB
  - Base station
  - GTP, RLC+PDCP en-/ decapsulation
  - Automatic repeat request (ARQ)
  - Encryption/Decryption
  - Buffering

gNodeB

Ericsson Research
    Pongrácz Gergely
University of Campinas
    Christian Esteve Rothenberg
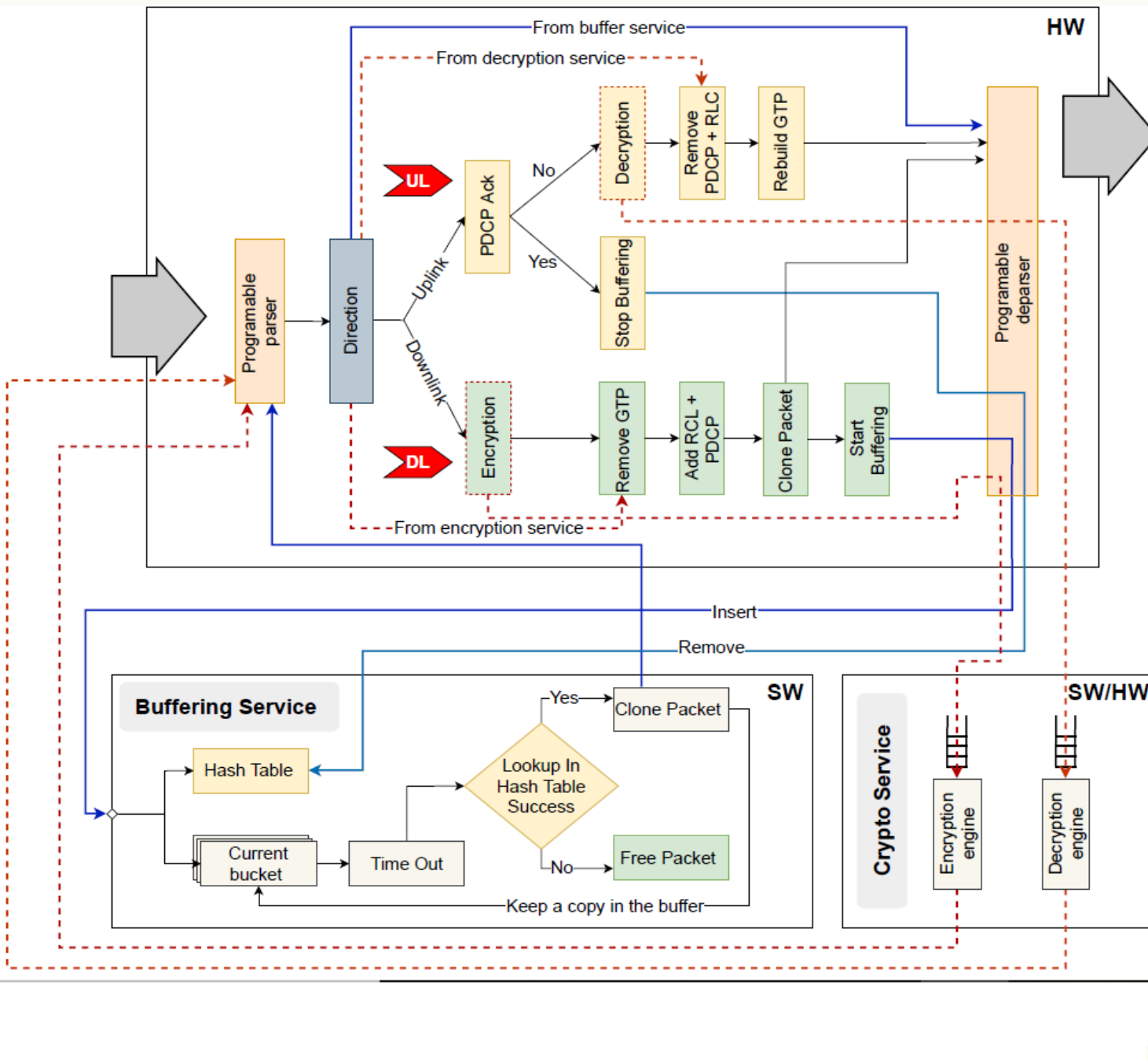   Suneet Singh
Karlstad University
    Andreas Kassler

P. Vörös, G. Pongrácz, S. Laki
Towards a Hybrid Next Generation NodeB
The 3rd P4 Workshop in Europe (EUROP4 2020)

Hybrid P4 Programmable Pipelines for 5G gNodeB and
User Plane Functions (IEEE Transactions on Mobile
Computing –Q1) (Revisioning)

P4 based AQM evaluation framework

- Active queue management

- Testbed
  - Real-time
  - Traffic generation
  - Artificial bottleneck
  - Customizable latency
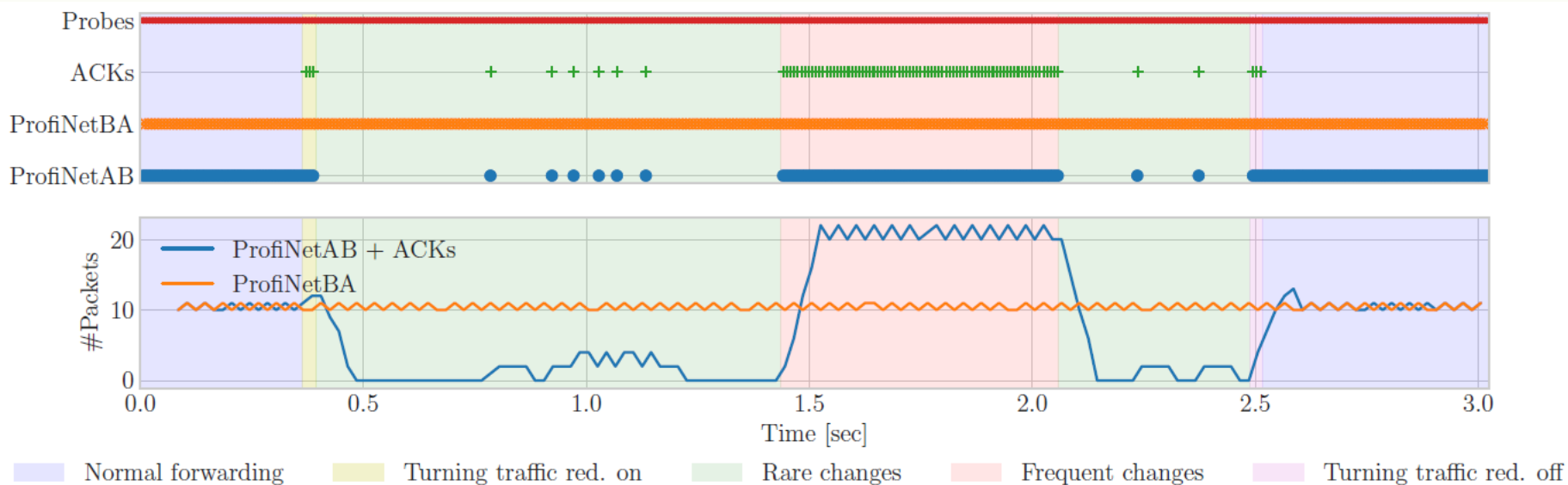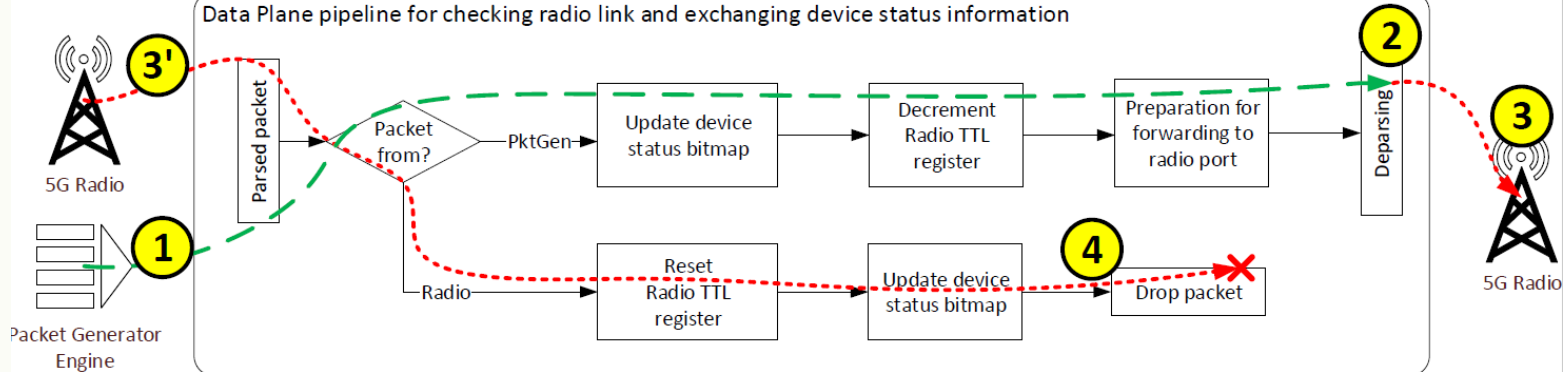
- AQM algorithms in P4
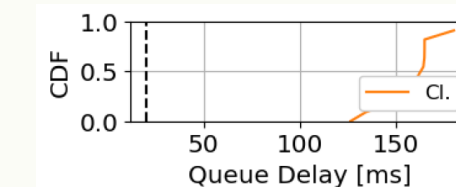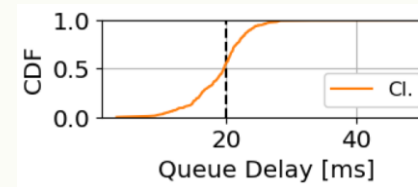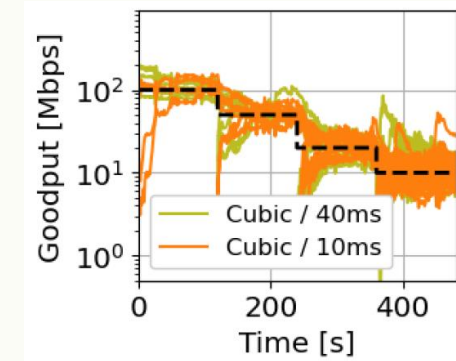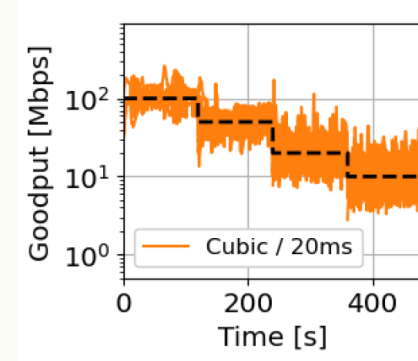
Industrial P4

- Robot controller
  - Trajectory points
  - Alternate trajectories
- P4 switch
  - Controlling individual servos
  - Seamless transition to alternate path

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Industrial P4

Data Plane pipeline for checking radio link and exchanging device status information
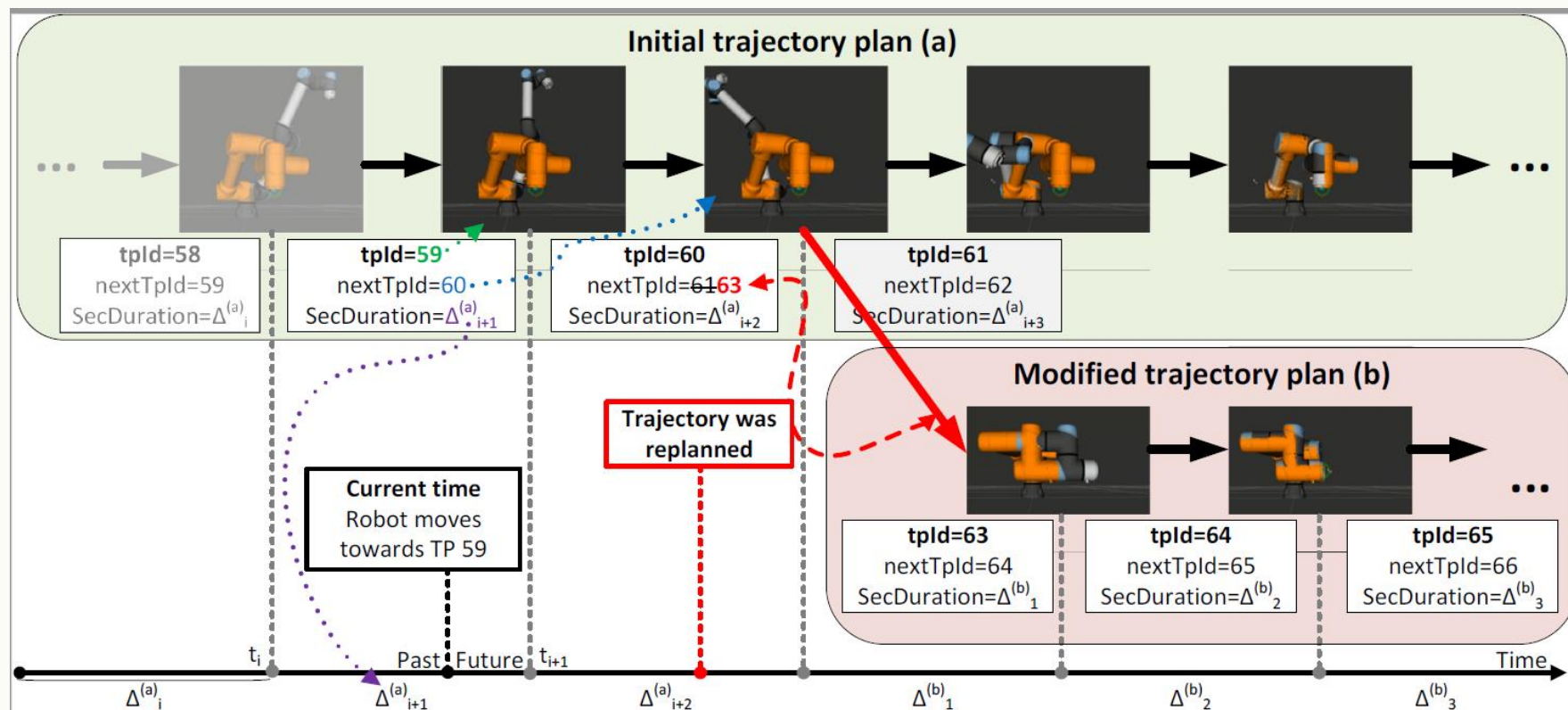
- Countless tiny packets e.g.: heartbeat
  - Spectrum efficiency issues
  - Energy consumption

- P4 switch
  - Traffic filter at both sides of the radio

Cs. Györgyi, K. Kecskeméti, H. Mallouhi, **P. Vörös**, S. Laki
NetReact: Distributed Event Detection in Sensor Data Streams with Disaggregated Packet Processing Pipelines
IEEE International Conference on Network Softwarization (IEEE NetSoft'22)
Cs. Györgyi, K. Kecskeméti, **P. Vörös**, G. Szabó, S. Laki
In-network Solution for Network Traffic Reduction in Industrial Data Communication
IEEE International Conference on Network Softwarization (IEEE NetSoft'21)

Published papers

1. Cs. Györgyi, K. Kecskeméti, H. Mallouhi, **P. Vörös**, S. Laki
NetReact: Distributed Event Detection in Sensor Data Streams with Disaggregated Packet Processing Pipelines
IEEE International Conference on Network Softwarization (IEEE NetSoft'22)

2. **P. Vörös**, D. Kis, P. Hudoba, G. Pongrácz, S. Laki
Towards an in-network GPU-accelerated packet processing framework
The 2022 IEEE 2nd Conference on Information Technology and Data Science (CITDS 2022)

3. S. Laki, Cs. Györgyi, J. Pető, **P. Vörös**, G. Szabó
In-Network Velocity Control of Industrial Robot Arms
19th USENIX Symposium on Networked Systems Design and Implementation (NSDI'22)

Published papers

4. Cs. Györgyi, K. Kecskeméti, **P. Vörös**, G. Szabó, S. Laki
In-network Solution for Network Traffic Reduction in Industrial Data Communication
IEEE International Conference on Network Softwarization (IEEE NetSoft'21)

5. **P. Vörös**, G. Pongrácz, S. Laki
Towards a Hybrid Next Generation NodeB
The 3rd P4 Workshop in Europe (EUROP4 2020)

6. S. Laki, D. Horpácsi, **P. Vörös**, M. Tejfel, P. Hudoba, G. Pongrácz, L. Molnár
The Price for Asynchronous Execution of Extern Functions in Programmable
Software Data Planes
Proceedings of NETPROC 2020 @ICIN2020 23rd Conference on Innovations in
Clouds, Internet and Networks

In progress

7. Radio Propagation Digital Twin Aided Multi-Point Transmission with In-network Dynamic On-Off Switching

8. Adaptive Network Traffic Reduction on the Fly with Programmable Data Planes

9. Hybrid P4 Programmable Pipelines for 5G gNodeB and User Plane Functions (IEEE Transactions on Mobile Computing)

10. P4 based AQM evaluation (MDPI Electronics)

THANK YOU FOR YOUR ATTENTION!