NOKIA Bell Labs

AI for (B)5G Network Automation

November 5, 2019

Henning Sanneck, Janne Ali-Tolppa
Nokia Bell Labs Research, Munich, Germany

  Public

AI for (B)5G Network Automation

Two guiding scenarios

Use cases	CSP scenario (B5G)	NPN scenario (5G)
Application	**Remote** (wide area) servicing, Remote emergency assistance (AR/VR/holography)	Logistics **Local** I4.0 production lines re-configuration and optimization, incl. AGV* operations
Communication	**B5G: combined** ultra-reliable, ultra low-latency, ultra high throughput, sliced **public network** connectivity	**5G:** eMBB-, mMTC-, cMTC-sliced **private network** connectivity Interconnection of local NPNs
Network Automation (NA)	Optimisation / prediction for **radio** and (ultra) **far edge** (scalable to **wide area**), efficient **human / machine** interface	**Zero touch** reconfig and optimization of **local RAN**, incl. 5G/TSN integration
AI/ML for NA	**AI/ML „orchestration“ and „platform“** (interfaces, workflows, training, validation). **Cross-layer** optimisation involving RAN and edge cloud	**Fusion** of I4.0 production and network data; **network state diagnosis** / prediction, **transfer learning**

*Autonomous Guided Vehicles

NOKIA Bell Labs

AI for (B)5G Network Automation

Network Infra → Automation → applied AI/ML

B5G Network Automation (NA): E2E management complexity (distributed data / ML and computing / energy consumption)

- Management of NFs, slices AND context/environment → network states
- Beam configuration and prediction
- ML model distribution and management

NA Applications

NA Platform

Network Infrastructure

B5G Network Infra:
numerous (indoor) small cells, decomposed RAN functions, highly distributed edge clouds (“fog”), scalable Core

- Ultra dense networks (mmWave → THz radio, narrow beamforming, D2D): extreme, but volatile capacity → multi-connectivity, quality prediction
- AI/ML-enabled PHY/MAC, e.g., channel model learning
- Environment as Network Infra, e.g., smart reconfigurable surfaces
- Dynamic network slicing, e.g., per campus network production line
- AI/ML-specific processing capabilities everywhere

AI/ML for Network Automation:

- Autoencoder, LSTM RNN
- Reinforcement learning
- Distributed learning, Transfer learning
- “Explainable” models → human / machine interface
- “ML platform”: orchestration / pipelining, standard interfaces

AI for (B)5G Network Automation

Network Infra → Automation → applied AI/ML (multi-vendor)

B5G Network Automation (NA): E2E management complexity (distributed data / ML and computing / energy consumption)

- Management of NFs, slices AND context/environment → ETSI ZSM
- Beam configuration and prediction
- ML model distribution and mgmt.

3GPP SA5

O-RAN ALLIANCE WG 2

NA Applications

ONAP

Acumos AI

Network Infrastructure

3GPP RAN 2/3

3GPP SA2

B5G Network Infra:
numerous (indoor) small cells, decomposed RAN functions, highly distributed edge clouds ("fog"), scalable Core

- Ultra dense networks (mmWave → THz radio, narrow beamforming, D2D): extreme, but volatile capacity → multi-connectivity, quality prediction
- AI/ML-enabled PHY/MAC, e.g., channel model learning
- Environment as Network Infra, e.g., smart reconfigurable surfaces
- Dynamic network slicing, e.g., per campus network production line
- AI/ML-specific processing capabilities everywhere

AI/ML for Network Automation:

- Autoencoder, LSTM RNN
- Reinforcement learning
- Distributed learning, Transfer learning
- "Explainable" models → human / machine interface
- "ML platform": orchestration / pipelining, standard interfaces

LSTM

ITU FG-ML5G

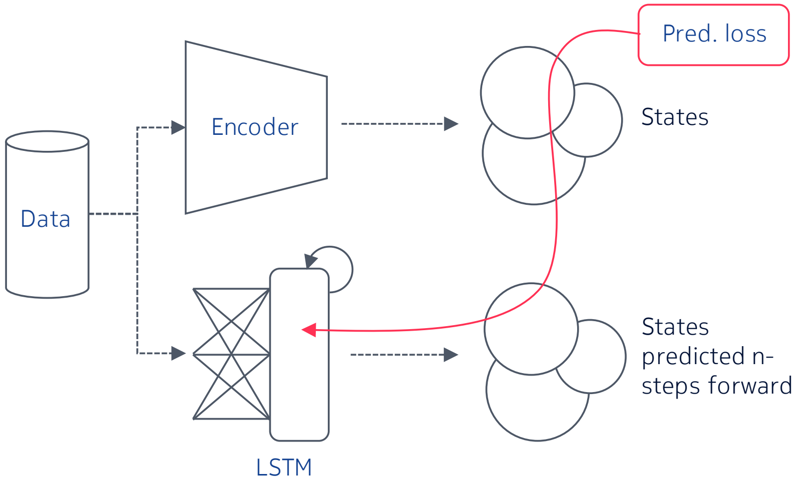
5G Slice Analytics & Diagnostics

@ 5G-MONARCH Hamburg seaport testbed

Problem statement

- Network slicing creates additional dimensions wrt. RAN management automation
- For resource allocation optimization, SLA assurance, anomaly detection & diagnosis slicing-aware prediction methods are required

Hamburg seaport testbed: evaluate concepts in a controlled environment (ground truth available; closed-loop automation possible)

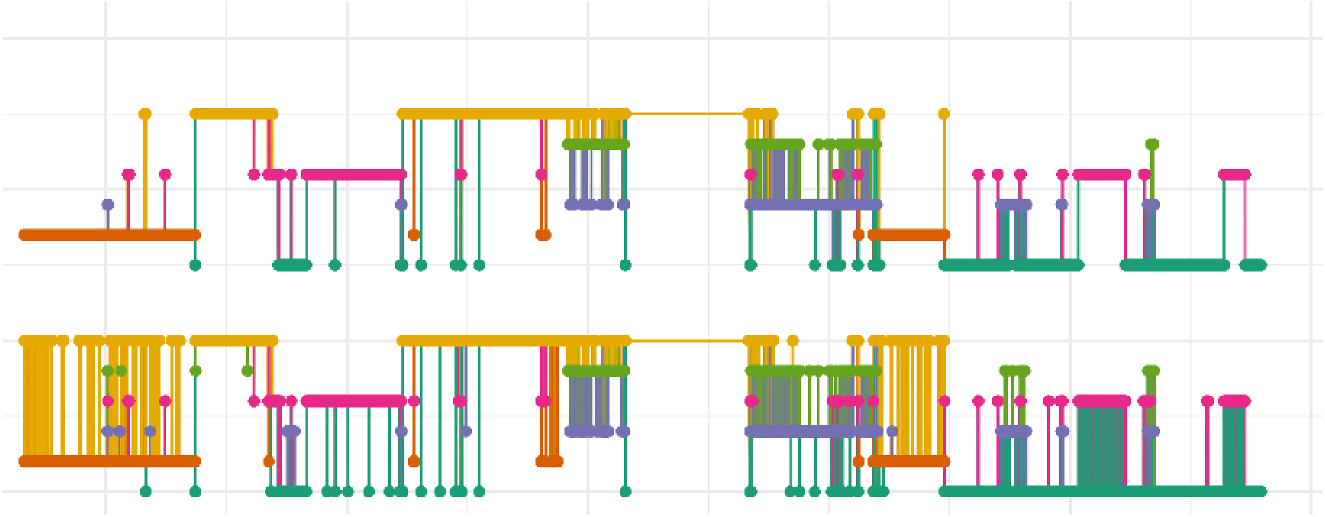


Results

- Slice-aware Network Element (NE) state model: quantization of NE KPIs into a selected number of states using a sparse autoencoder
- States → Long-Short Term Memory (LSTM) Recurrent Neural Network (RNN) → State Prediction

Predicted states (T+3):

Original states:

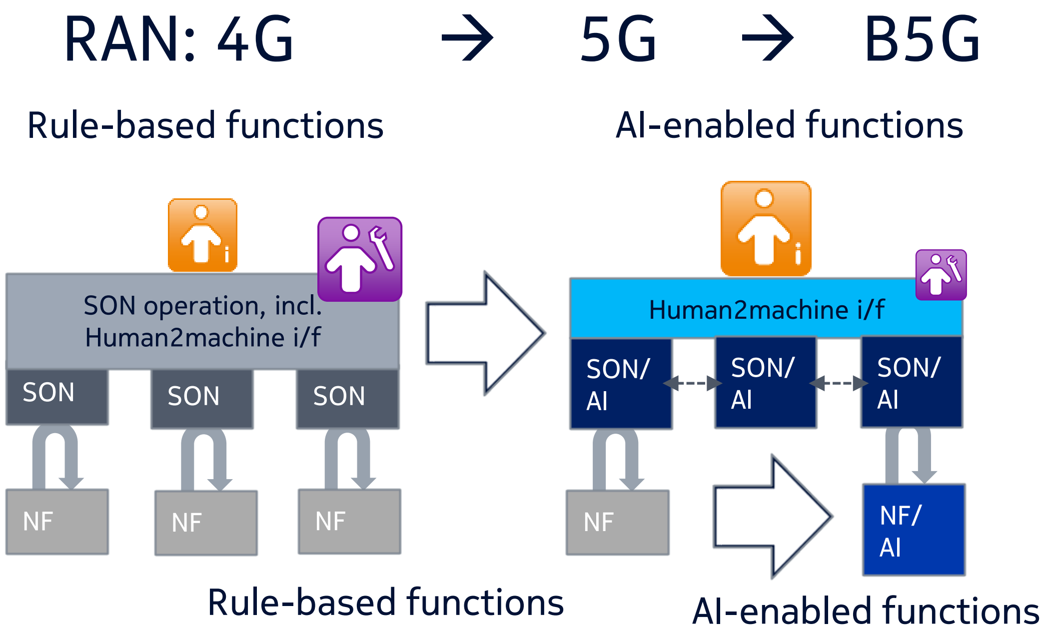


- State A: eMBB (UL, DL) + IoT (UL, DL)
- State B: eMBB (DL) + IoT (DL)
- State C: eMBB
- State D: eMBB + IoT (UL)
- State E: URLLC (UL, DL)
- State F: URLLC (DL)

AI for (B)5G Network Automation

Conclusions: challenges & opportunities

- Opportunities / Benefits of AI for Network Automation
  - Adaptation to different deployments / contexts / operating points
  - Exploitation or available data; fusion of network and application data
  - Symbiosis of human operator and machine capability
- Challenges
  - Data: amount / quality; labels; interfaces
  - Choice / adaptation of suitable AI/ML algorithms
  - “AI/ML-friendly”architecture: distributed AI/ML-processing capability, AI/ML orchestration, AI/ML-specific interfaces, integration with legacy / transition
  - “AI/ML-Explainability”; Human factor: combination of telco and data science skills



→ AI/ML-related multi-vendor requirements need to be exposed to the relevant SDOs / open source projects (→ ITU-T FG ML5G)

NOKIA Bell Labs

NOKIA