AI/ML as an Enabler for Autonomous Network Management

5G-CLARITY Vision and Use Cases

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5GPPP, TB meeting, 27/05/2020
5G-CLARITY Project Overview

- 5G-CLARITY: Beyond 5G multi-tenant private networks integrating Cellular, WiFi, and LiFi, Powered by Artificial Intelligence and Intent Based Policy
  - Public-private network integration
  - Multiple WAT
  - AI/ML for autonomous network management
  - Intent-based policies

- Partners
  - Coordinators
  - Operators
  - Vendors
  - 5G SMEs
  - Verticals
  - Universities
5G-CLARITY Use Cases

- Museum Pilot (Uni Bristol)
  - Enabling enhanced human-robot interaction
5G-CLARITY Use Cases

- **Museum Pilot (Uni Bristol)**
  - Enabling enhanced human-robot interaction

- **Industry 4.0 Pilot (Bosch)**
  - Wireless multi-service support in Industry 4.0
    - Alternative network to exchange production data
    - Enhanced positioning for AGVs used to move Bosch containers
Complexity of Network Management in 5G

- Different 5G use cases exist in the same network
  - Different requirements and configurations for each use case
- Need for fast changing network
  - Flexibly reacting to demand
  - Scalability
- Need for ease-of-use
  - Reducing OPEX
- AI-supported network management needed to tackle 5G requirements

5G Usage scenarios

- Enhanced Mobile Broadband (eMBB)
- Massive Machine Type Communications (mMTC)
- Ultra-reliable and Low Latency Communications (uRLLC)
Role of AI/ML and Intent in 5G-CLARITY

- AI-supported network management
  - Slice setup and provisioning
  - Resource scheduling
  - SLA violations
  - ATSSS
  - Positioning

Diagram:
- AI engine
  - NF1
  - NF2
  - NFn
Role of AI/ML and Intent in 5G-CLARITY

- **AI-supported network management**
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  - Resource scheduling
  - SLA violations
  - ATSSS
  - Positioning

- **Intent-based policies**
  - Operator tells the AI what they want, AI takes care of the rest
  - Using intent engine to determine who/what can fulfil the request
Role of AI/ML and Intent in 5G-CLARITY

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Intent interface

- AI engine provides algorithm x

I want to set up a slice, prioritising private network users over public ones

Required: slice manager and scheduling algorithm x

NF1

NF2

NFn

Slice manager provides slice setup
5G-CLARITY AI Engine with Intent Interface

Service 1: Flow scheduling
Service 2: Resource provisioning
Service n: AI/ML use case n

5G-CLARITY AI Engine

Cloud Data Store and Processing

5G-CLARITY Dashboard

ML Lifecycle Manager
ML Service Registry

5G-CLARITY Network Components (e.g. Slice Manager, RT RIC)

5G-CLARITY Telemetry and Event Collector

ML SDK
ML Training Data Store

5G-CLARITY AI/ML Vision
5G-CLARITY Telemetry Framework

Management & Orchestration stratum
- NFVO
- Slice Manager
- Multi WAT non-rt Controller
- Telemetry Agent(s)
- Telemetry Message Queue / Bus

Telemetry Agent(s)
- Compute Nodes
- Ethernet switching
- Wireless PNFs

Telemetry Consumer
- Value added functions (cloud)
  - Intent Engine
  - AI Engine

Data Lake
- Ingress Filter
- Telemetry PCF
- Metadata Registry

Data Storage
- Telemetry Consumer
- Wireless VNFs

5G-CLARITY AI/ML Vision
Use Case 1: Non RT Slice Resource Control

- **Problem:**
  - Maintain per-tenant SLA defined as % resources over geographic area

- **Inputs:**
  - PRBs used for data traffic per cell and per tenant
  - Throughput per cell and per tenant
  - Offered load per cell and per slice
  - SLA terms

- **Outputs:**
  - Capacity share per tenant and per cell measured as the % of resources in the cell
    - PRBs (5GNR), air time (WiFi), λ (LiFi)

- **Periodicity:**
  - Minutes (Non RT)
  - Location: AI engine

![Diagram](attachment:image.png)
Use Case 1: Non RT Slice Resource Control

I want a network slice with SLA (aggregate capacity across all cells, maximum bit rate per cell)

SLA
I want to get telemetry for (PRBs used for data traffic per cell/tenant, throughput per cell/tenant, Offered load per cell/tenant)

Request telemetry data
Receive data pointer
Forward data pointer
I want network configuration (%PRBs per cell/tenant)

SM request (%PRBs per cell/tenant)
Use Case 2: RT AT3S Control Plane

Problem:
- Optimize resource utilization for multi-connectivity UEs, s.t. per-UE policies (e.g. reliability, max. throughput, etc)

Inputs
- UE connected cell/AP/SSID – user mobility pattern
- UE DL packet drop rate – handover failure
- RSSI – link performance/blockage
- Available Cell resources
- End-to-end aggregation metrics (measured at AT3S UP function)

Outputs
- Scheduling weights in Multi-connectivity framework in UE and UPF

Periodicity:
- 100 – 500 ms
- Location: O-RAN RIC in RAN Edge
Use Case 2: RT AT3S Control Plane

AI Engine

I want to maintain link reliability, decrease packet drop rate

Intent Engine

ML Model

Telemetry

ATSSS

ML policy (model aided deep learning)

I want to get telemetry for:
(i) RSSI - link performance
(ii) DL packet drop rate - failure
(iii) UE connected cell/AP - user mobility pattern
(iv) etc.

Request telemetry data

Receive data pointer

Forward data pointer

I want network configuration: Duplicate traffic and/or associate UE to another LiFi AP (handover)

Configuration request
Reference 5G-CLARITY documents

- D2.2: “Primary system architecture”
  - General Architecture. Introducing role of AI-Engine
  - Due date: October 31st, 2020

- D4.1: “Initial design of the SDN/NFV platform and identification of target 5G-CLARITY ML algorithms”
  - Initial AI Engine design. AI use case definitions
  - Due date: October 31st, 2020

- D4.2: “Validation of 5G-CLARITY SDN/NFV platform, interface design with 5G service platform, and initial definition of evaluation of ML algorithms”
  - Design and initial evaluation for AI engine and ML use cases
  - Due date: June 30th, 2021
Summary

- **AI/ML to support autonomous network management in 5G**
  - Traditional network management can’t handle complexity

- **AI/ML use cases in 5G-CLARITY**
  - Slice setup and provisioning
  - Resource scheduling
  - SLA violations
  - ATSSS
  - Positioning

- **AI engine as host for AI/ML algorithms**
  - Covering each AI/ML use case

- **Intent engine for communication to and from the AI engine**
  - Enabling ease-of-use for network management