Network Softwarization

Introduction / Challenges / Solutions

Nikos Stasinopoulos

Big Data Engineer
Incelligent

ns@incelligent.net

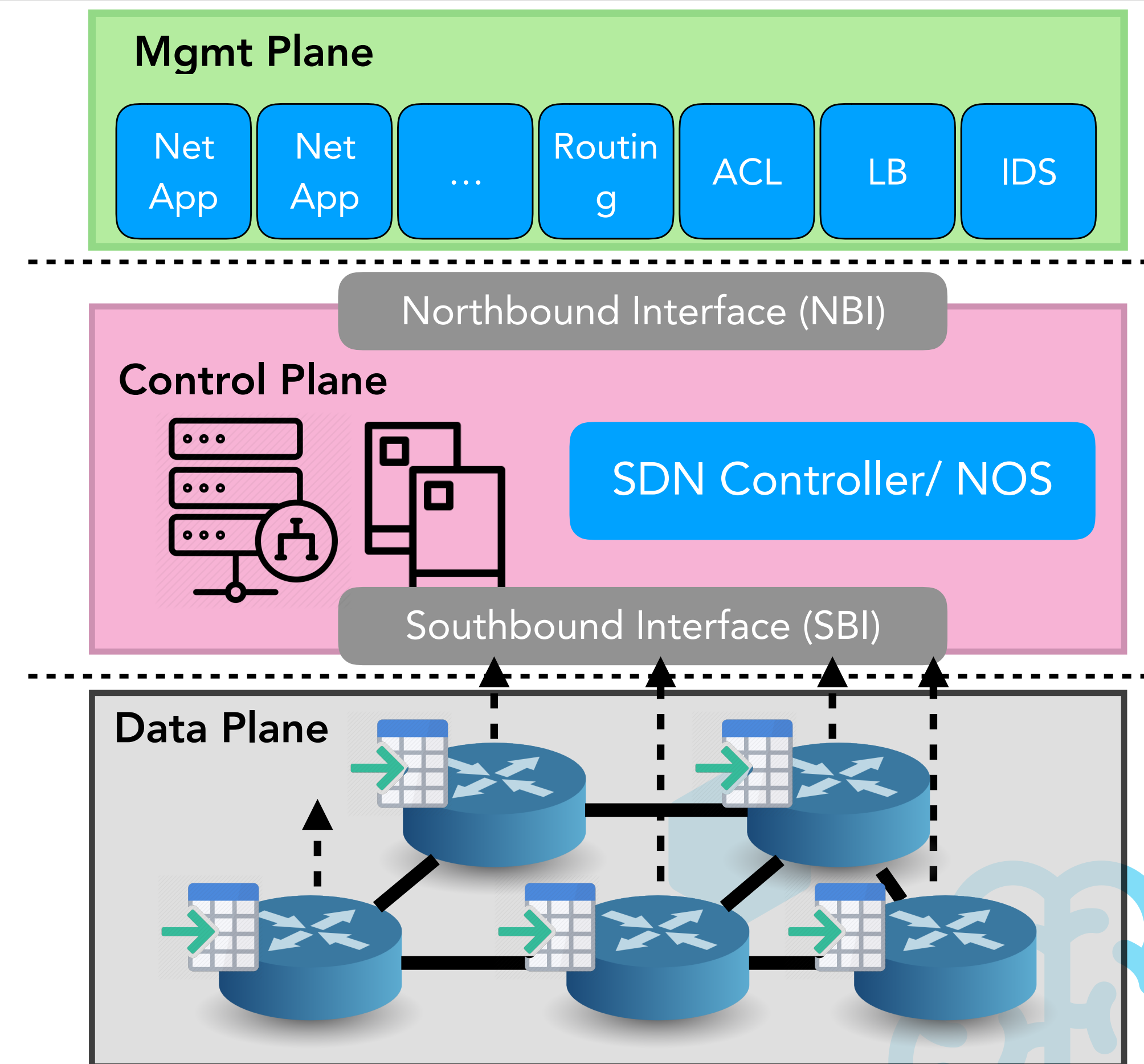CODE Workshop 5, Munich, 11/Jul/18

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SDN

About SDN

Software Defined Networking (SDN) is a relatively new paradigm introduced in the world of computer networking, promising a fundamental shift in the way network configuration and real-time traffic management is performed.

▷ Break vertical integration in the network (in control+data planes)

▷ Separate the network's control plane from underlying routers and switches

  ◉ Switches are now Simple Packet Forwarding elements

  ◉ Flow tables forwarding/ Datapath

▷ Promote (logical) centralization of network control

  ◉ SDN Controller or Network Operating System (NOS)

▷ Program the Network

  ◉ Develop Software Applications on top of NOS

Mgmt Plane

| Net App | Net App | ... | Routing | ACL | LB | IDS |

Northbound Interface (NBI)

Control Plane

SDN Controller/ NOS

Southbound Interface (SBI)

Data Plane

Benefits of the SDN paradigm

Low Complexity, Low Investment and Operational Cost, Leaner Development and Deployment

▷ It is simpler and less error prone to modify network policies

▷ Automatically react to spurious changes of the network state

▷ Global network view and Network programmability, useful & innovative SDN applications

▷ Commodity servers & switches (reduced CAPEX)

▷ Logically Centralized management over physically distributed controllers (reduced OPEX)

▷ HA and Scalability in the control plane through VM Virtualization
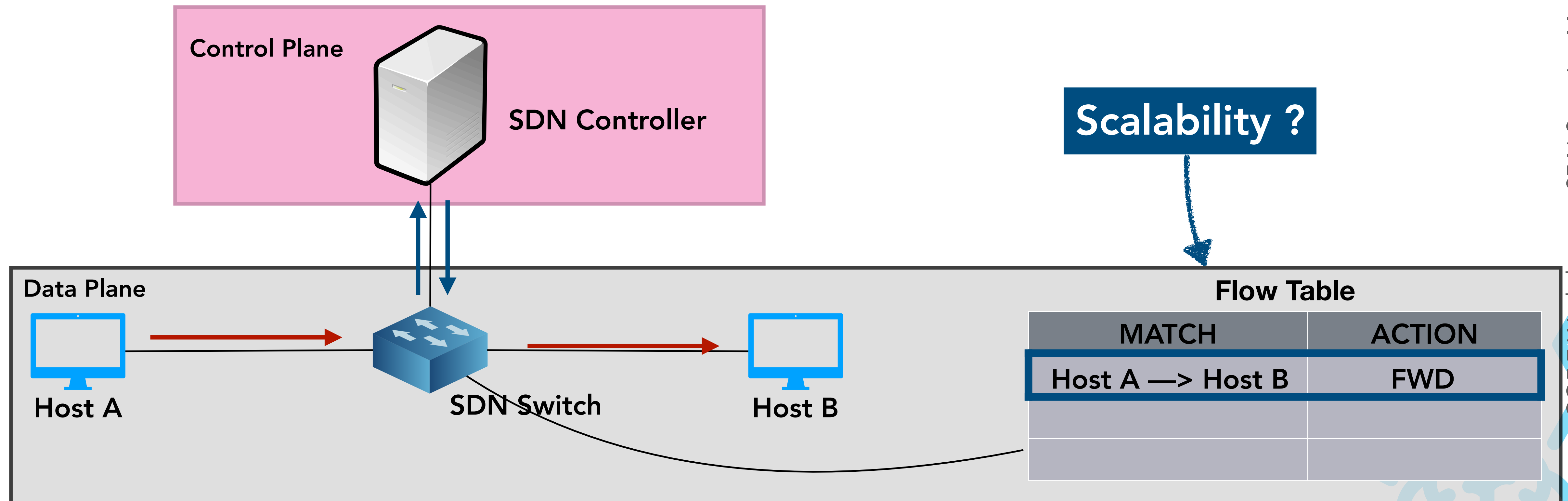
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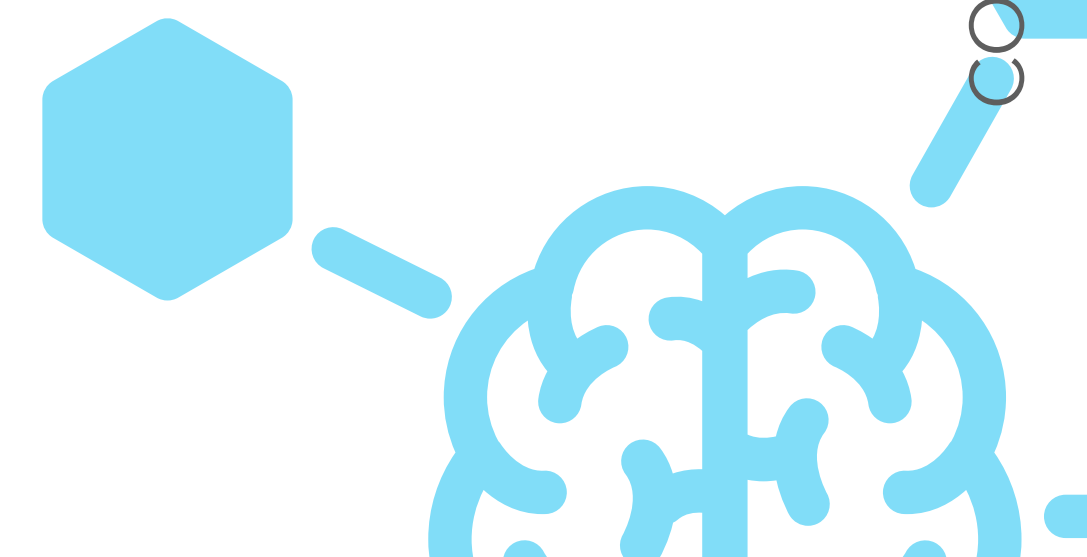
The SDN Controller

Selecting an **SDN Controller (Control Plane)** is key to support complex Network and Business Applications

▷ The list of most popular controllers comprises of **OpenDayLight, Floodlight, Ruy** and many others.

▷ Key aspects to look for in SDN Controllers

  - Efficiency (performance, reliability, **scalability** and **security**), Flexibility, Modularity, Network Programmability and Functionality, the programming language, good Memory Management and GUI, multi-threading handling, Platform support, OpenFlow support, Southbound and Northbound APIs, Network Virtualization, Centralized Monitoring and Visualization

  - **Scalability**: Separation of concerns and reactive flow increases traffic.

    - Remedies: Delegation of control to FDs, improving Controllers, hybrid: hierarchic control to certain FDs.

    - Challenge: State (Data) Consistency across Physically Distributed Controllers?

  - **Security**:

    - Attack/ Threat Vectors across all Planes: Forwarding Devices, NOS, Applications

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Scalability: The Basic SDN Operation

A packet of flow is forwarded by the SDN switch according to the Flow Table, or if the packet in new to the SDN switch it is sent first to the controller. Proactive, Reactive and Hybrid Methods.

Control Plane

SDN Controller

Scalability ?

Data Plane

Flow Table

MATCH	ACTION
Host A —> Host B	FWD

Host A

SDN Switch

Host B

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Security: Issues and Attack Vectors

The **distributed** and **softwarized** nature of the SDN raises challenges (already known or previously unmet)
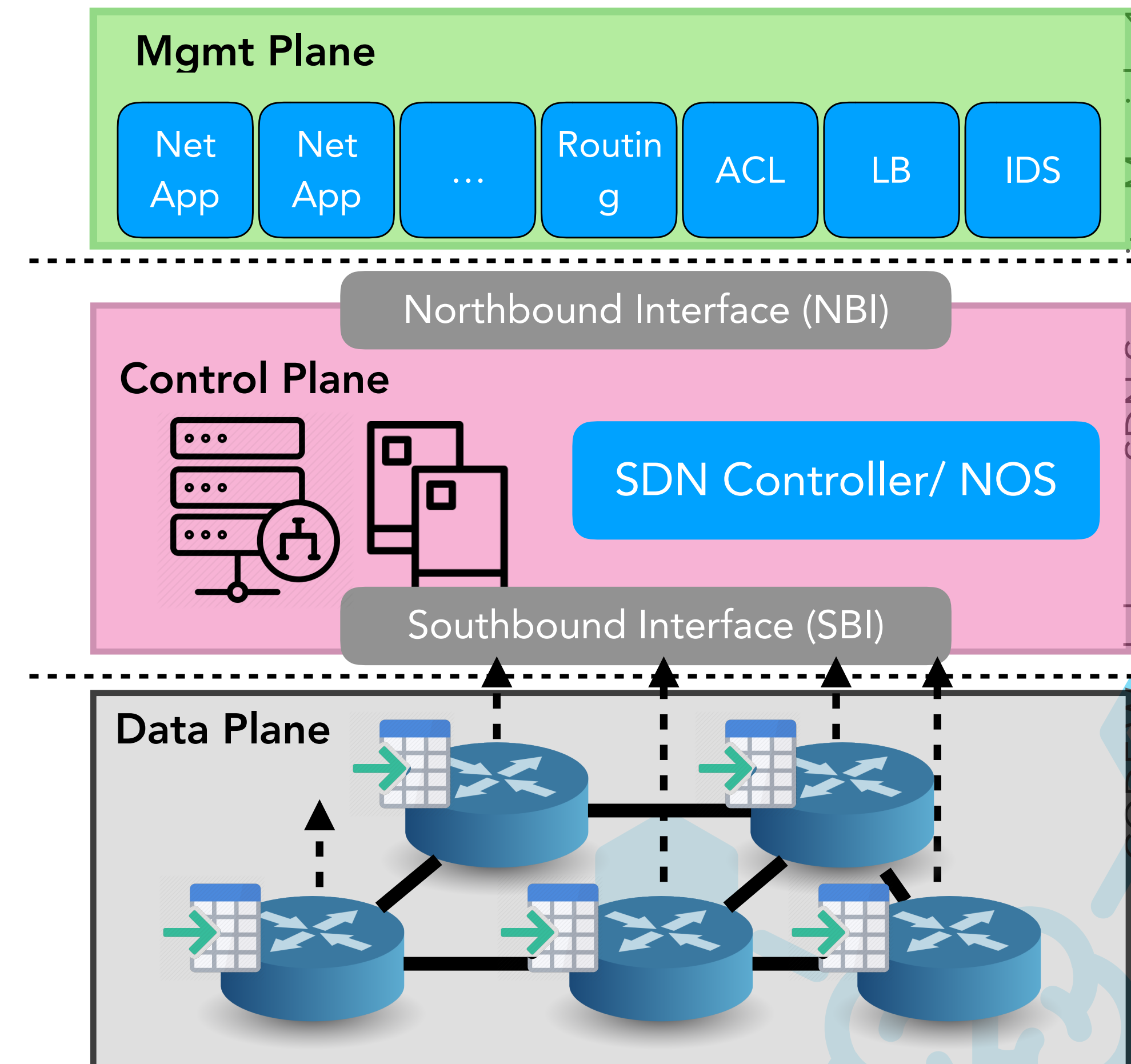
Security Threats per Plane

Application Plane
✳ Malicious Code or libraries that Build rogue SDN Applications (integrity)
✳ Deployment of compiled SDN apps on the NOS through poisoned repositories (integrity)

Ctrl Plane
✳ Take advantage of distributed controller to **deploy rogue NOS Node** (authentication/ authorization) —> Take over network topology
✳ Performance degradation by network control saturation/DoS

Data plane (esp. hybrid)
✳ Direct access to elevated privileges SDN FDs (hw or sw) - CLI, SSH etc can alter datapaths through infested Flow tables (RBAC for application components

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Control Plane

SDN Controller/ NOS

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Data Plane

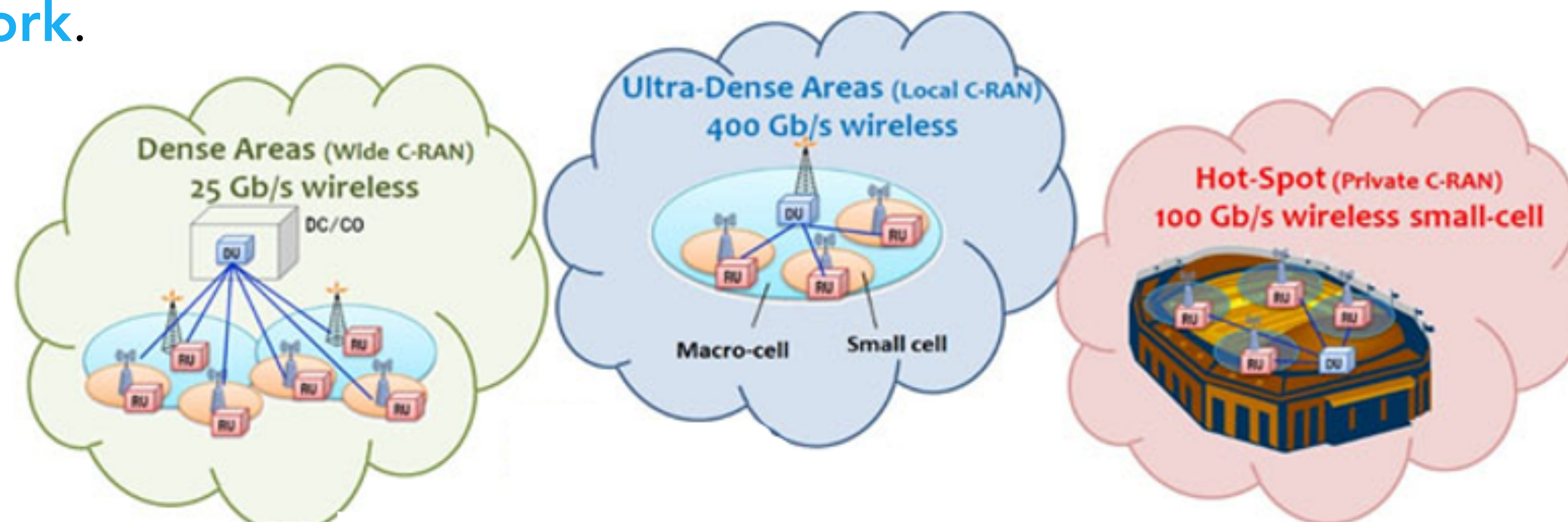Machine-Learning Powered Networks
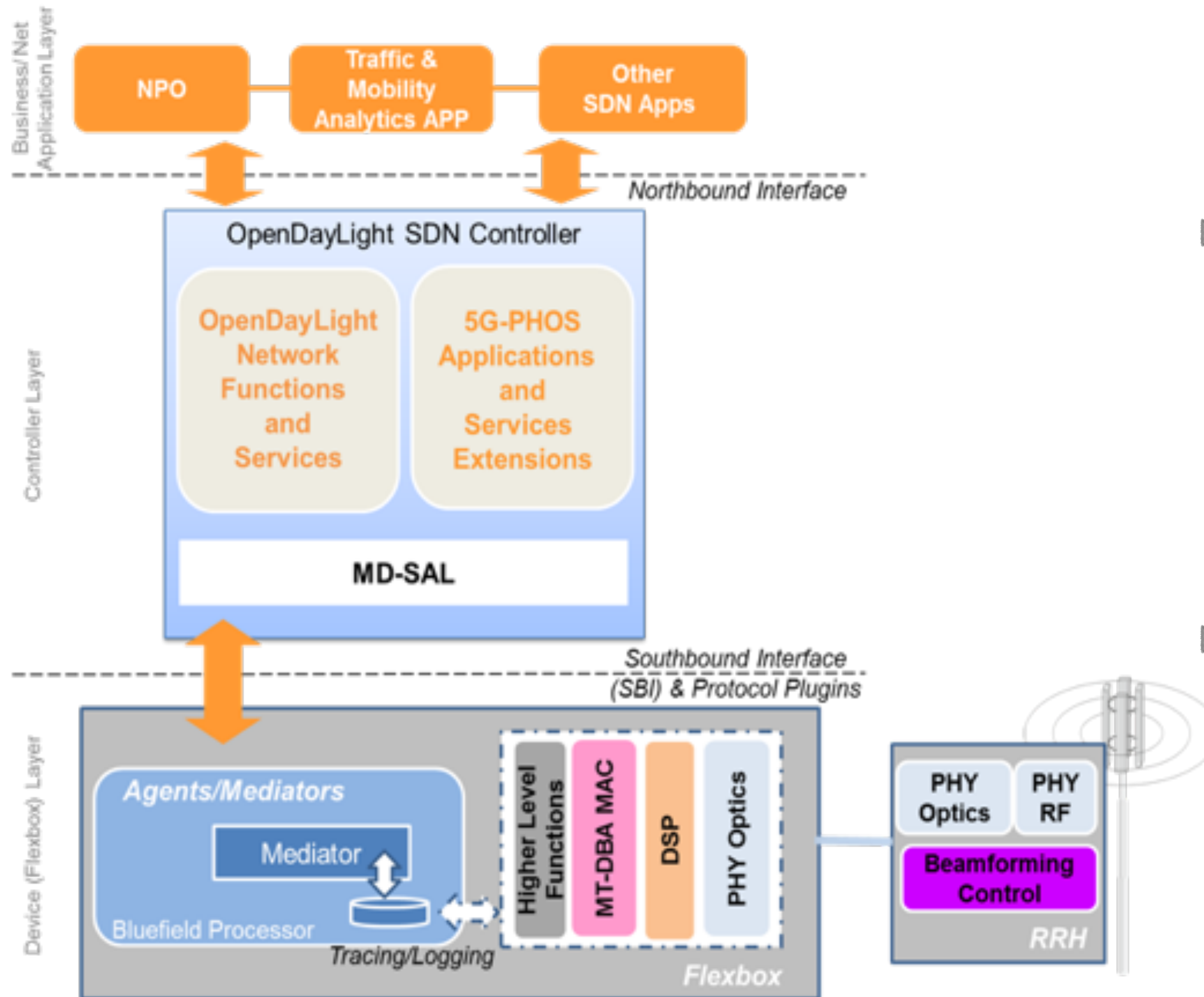
SDN in Dense 5G Environments

The **5G-PHOS** project & overall objectives

The overall goal of the 5G-PHOS project is to architect 5G networks offering a unified solution for **dense, ultra dense and hotspot areas**:

The project incorporates Photonic Integrated Circuits (PICs) in optical mmWave signal generation, DSP-assisted optical transmission, reconfigurable optical add/drop multiplexing (ROADM) and optical beamforming functionalities for the delivery of an **SDN-programmable FiWi 5G network**.

Dense Areas (Wide C-RAN) 25 Gb/s wireless — DC/CO — DU — RU

Ultra-Dense Areas (Local C-RAN) 400 Gb/s wireless — DU — RU — Macro-cell — Small cell

Hot-Spot (Private C-RAN) 100 Gb/s wireless small-cell — RU — DU

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5G-PHOS SDN Architecture solution

▷ **Business/Network Application Layer**
   ✳ Network Planning & Operations Tool
   ✳ Traffic & Mobility Analytics App
   ✳ Other SDN Apps & Custom GUIs

▷ **Controller Plane**
   ✳ Support for slicing, traffic and mobility management (and other SDN Apps)
   ✳ Abstraction of resource specific aspects
   ✳ From management commands (from NB) to SB primitives

▷ **Device Layer** (core network, base-stations, switches, routers, etc.):
   ✳ Implementing SDN data paths & forwards the actual traffic
   ✳ Implementing open standards-based programmatic access to infrastructure to enable programming from SDN controllers

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# 5G-PHOS Application - Resource Optimization

Traffic steering

This function **enables network traffic management and optimization of the flows/session in terms of advanced routing policies ensuring specific QoS levels**.

In this context, it balances the traffic load among paths and slices, providing efficient resource utilisation and fairness in the use of these resources. It also handles congestion and faults, avoiding the violation of the service guarantees, prioritises critical applications, based on customer needs.

Traffic/ resources monitoring & analytics

Collecting monitoring information and **analysing** using statistical **and machine learning methodologies**.

In particular, tracking **Key Performance Indicators** (KPI), **detecting events** (e.g. based on faults, rapid changes in traffic) and violations of QoS guarantees, or tracking traffic requirements and changes and analyses traffic flow information, building traffic profiles and predicting.

- Traffic source distribution per class in space and time
- Number of antennas/ carriers
- Access links operating diverse RATs
- Link capacities

Input → **Resource Optimization** → **Output**
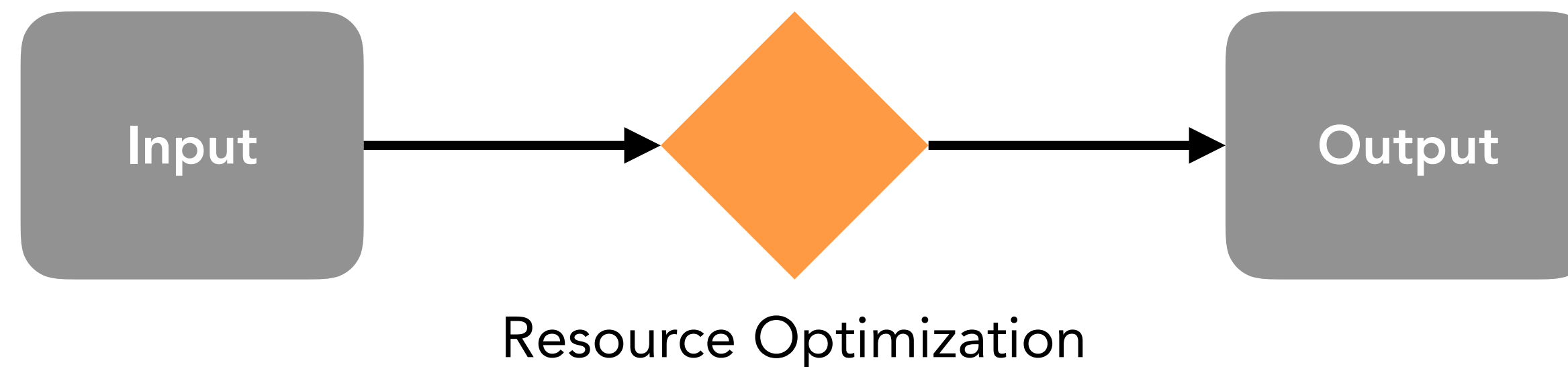
- A set of carriers per link

- Traffic source allocation per access link – antenna capacity slicing (traffic can be allocated to a new RAT or to a legacy one).

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5G-PHOS Application - Mobility Analytics

Mobility prediction

Supporting mobility and maintaining user's quality of services is an important feature of wireless networks. With accurate mobility predictions we can identify future targeted base stations in advance an enhance handover performance in wireless networks.
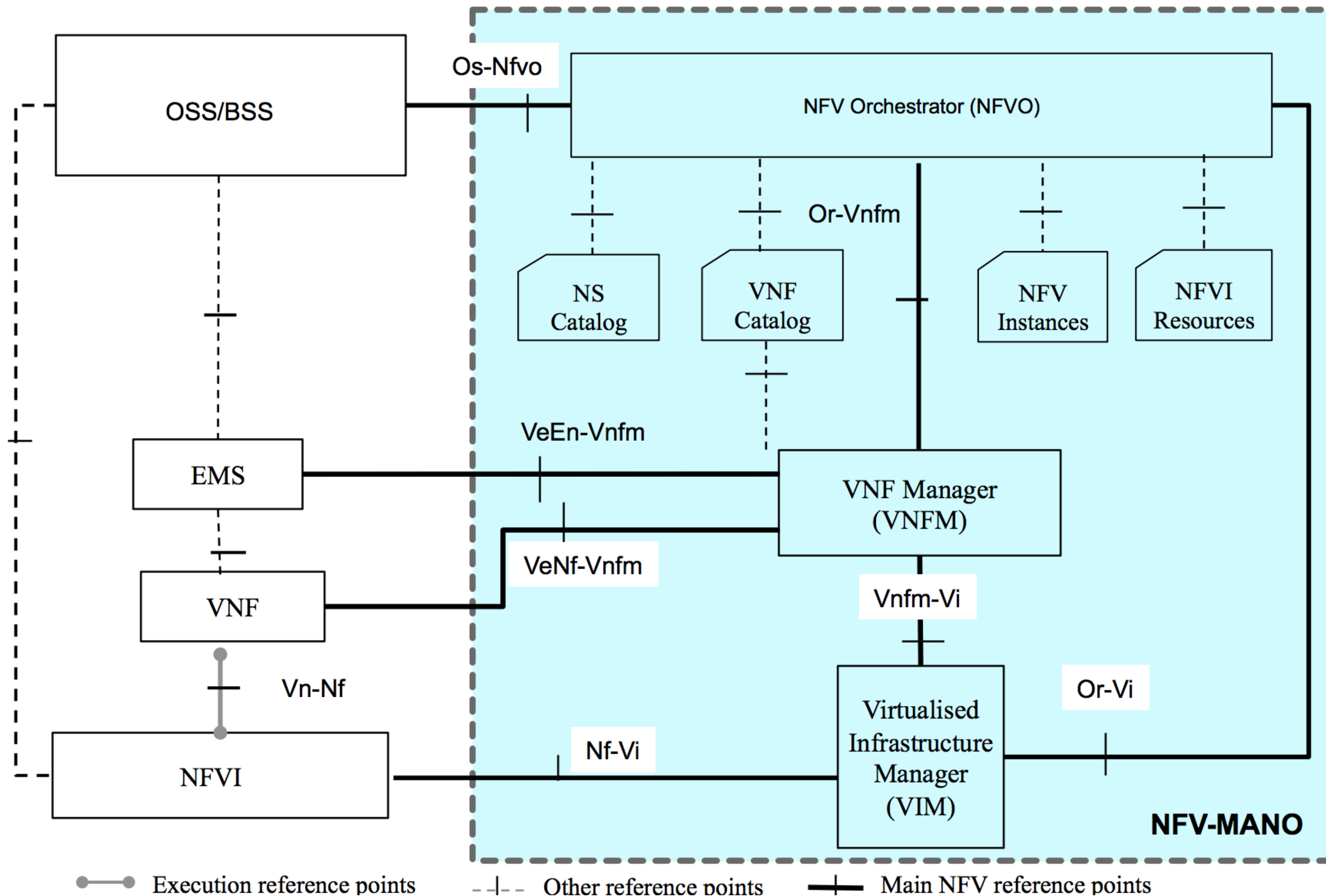
- The points of attraction in a smart venue
- The mobility behaviour of the users
- The traffic behaviour

Input → **Mobility Prediction Algorithms** → **Output**
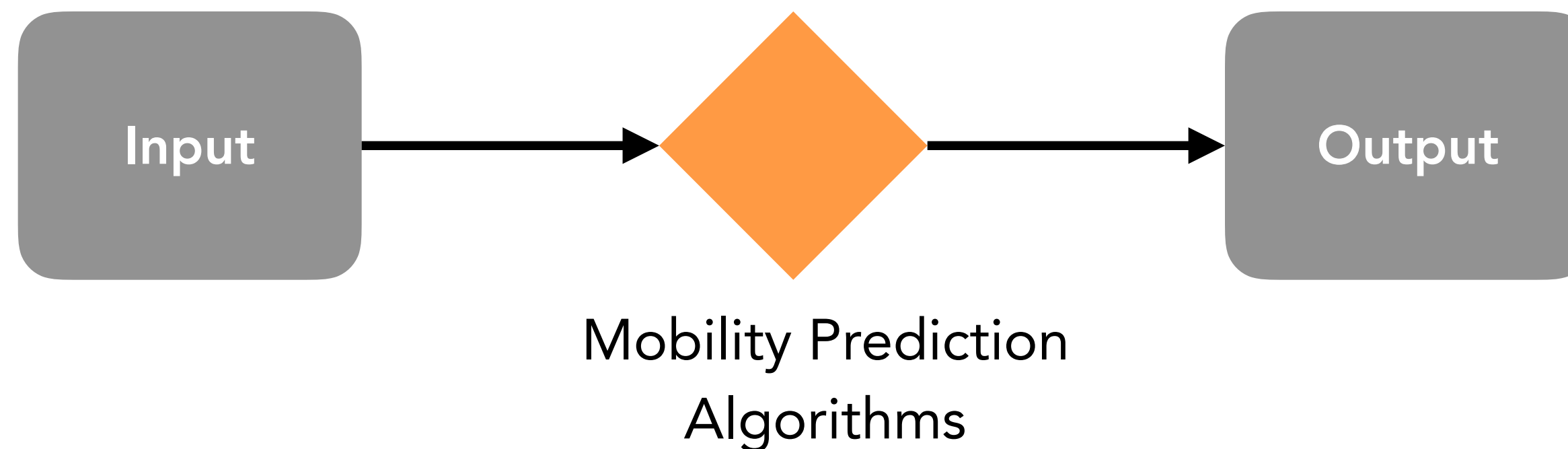
- Probability of being located in a point of attraction at a certain timeframe
- Prediction of network needs

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NFV

NFV MANO Reference Architecture

NFV Orchestrator:
▷ On-boarding of new Network Service (NS), VNF-FG
▷ NS lifecycle management

VNF Manager:
▷ Lifecycle management of VNF

Virtualised Infrastructure Manager (VIM):
▷ Controlling and managing the NFVI compute, storage and network resources
▷ Collection and forwarding of performance measurements and events

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MATILDA: Deploying Cloud-Native Apps on a 5G Infrastructure

MATILDA aims to provide a next-generation design, development and operational environment of **5G-ready** applications.

A **5G-ready app** is a distributed-by-nature application consisting of **cloud native** components that rely on a **service mesh** as a means on **network abstraction**

Innovation Aspects

▷ MATILDA provides an **interplay** between a Vertical (L7) Orchestrator and Telco's NFVO

▷ **Intelligent orchestration mechanisms** for vertical slice monitoring (network + app), data fusion & machine learning mechanisms, real-time profiling, context awareness, policy enforcement

▷ Based on the models, MATILDA will offer sophisticated mechanisms that will infer and manage the **optimal Vertical Slice** based on the requirements of the Vertical App

▷ MATILDA will combine **NFV and Edge resource management** in order to facilitate the operation of Service Meshes

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MATILDA Architecture / NFV
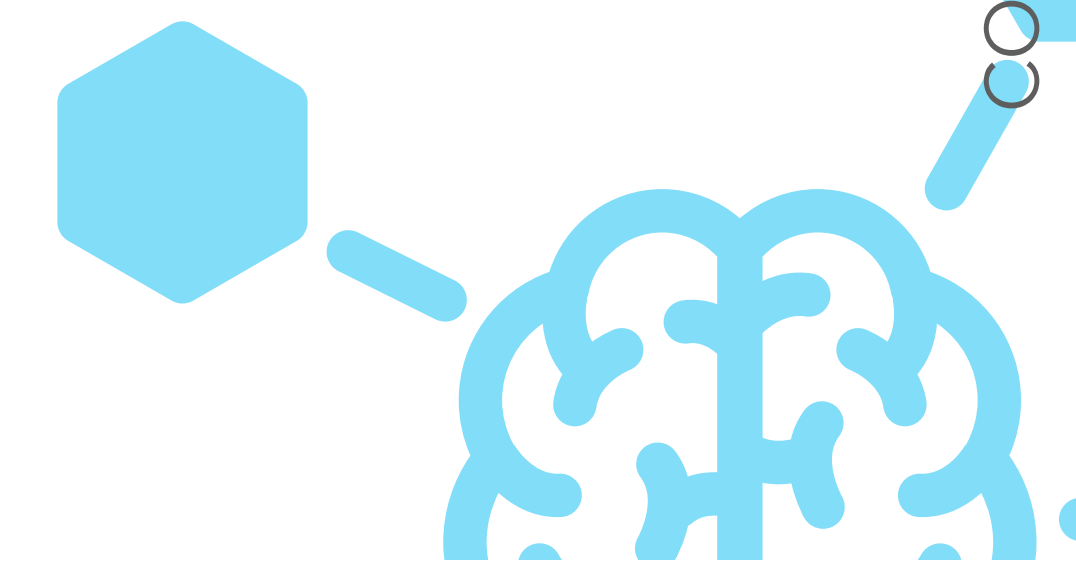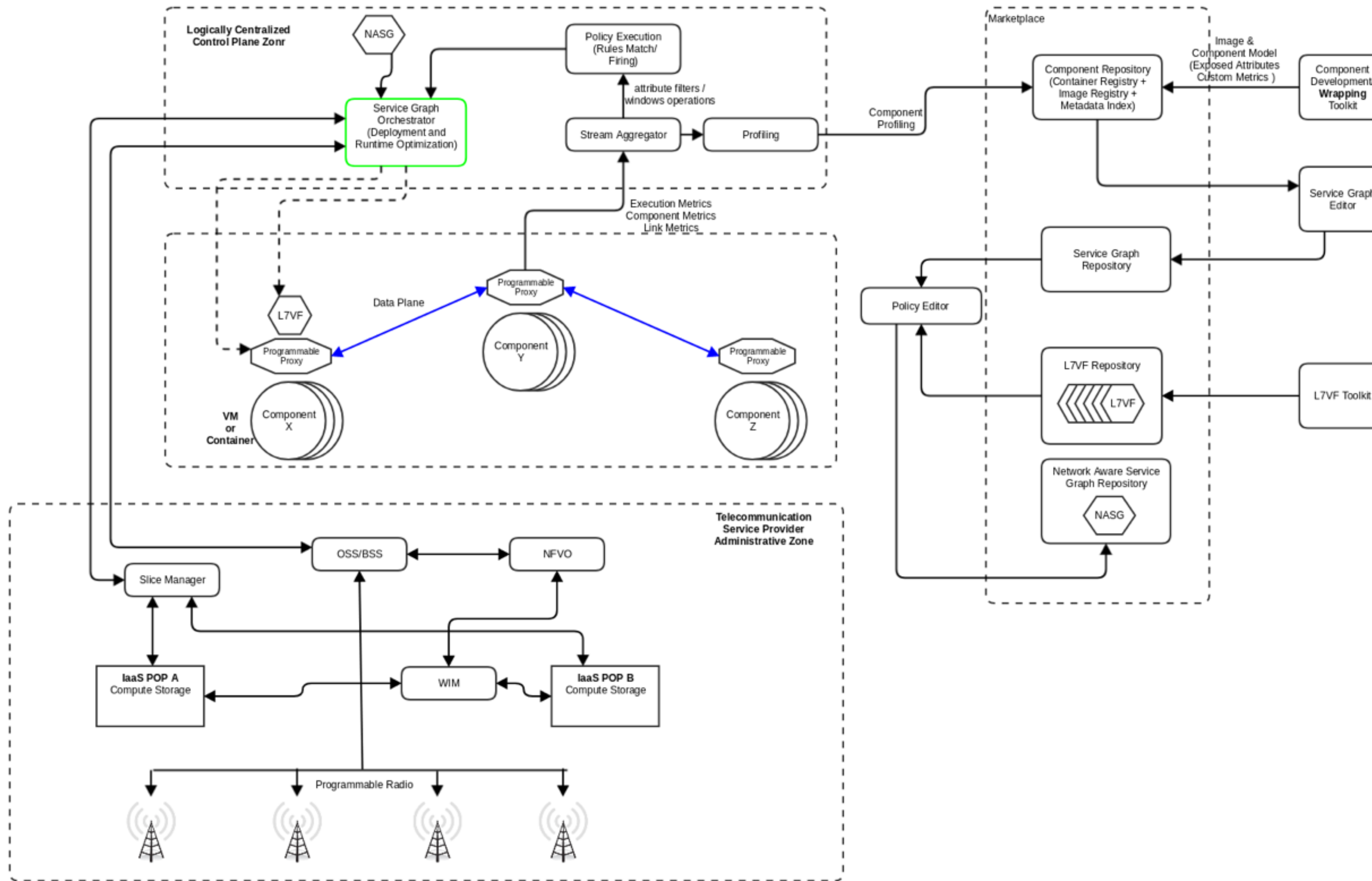
The Analytics Engine in MATILDA
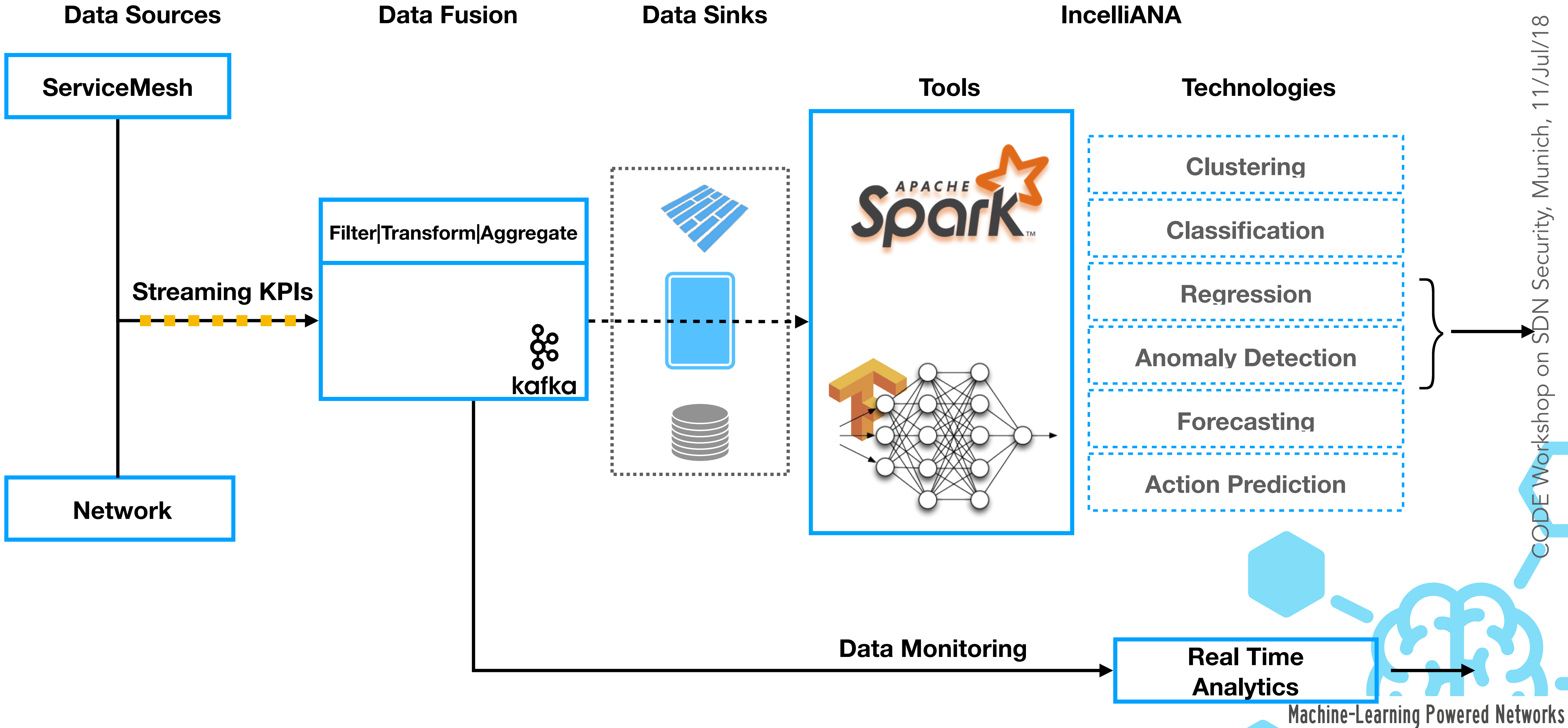
Acknowledgements

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Thank you
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Nikos Stasinopoulos

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