NIST COMMUNICATIONS TECHNOLOGY LABORATORY

NIST Multi-Domain Knowledge Planes for Service Federation for 5G & Beyond Public Working Group (MDKP-PWG) Kick-Off

AGILITY Initiative and relationship to the GAFB (Deliverable D1)

Knowledge Planes Driven AGILE Service Federation for 5G & Beyond

20th July 2023

Presenters : ***Ranganai Chaparadza, PhD: Capgemini Egineering; IPv6 Forum Research Fellow***

Outlook

- **Autonomic/Autonomous Networking (ANs) and Standards**
- **Knowledge Plane (KP) Concept: What are Knowledge Planes (KPs)?**
- **The Era of Knowledge Plane (KP) Platforms Driven Networking—Anchor for Federation of Autonomic/Autonomous Networks (ANs) Across Industry Sectors**
- **AGILITY Initiative and relationship to the GAFB (Deliverable D1)**

The Knowledge Plane (KP) Concept is defined in **ETSI TS 103 195-2** as adopted from the original KP concept defined by the MIT (USA) SIGCOMM'03 AMC paper (David D. Clark, et al: "A Knowledge Plane for the Internet") and enhanced as:

→ *a construct that exhibits cognitive capabilities and behaviours in performing the management and control of networks and services, and operates on network-wide views (including knowledge continuously gathered about the state and behaviours of network elements/functions) to dynamically program (configure) network resources and parameters, and adaptively and autonomically make changes to the network and services compositions and configurations in order to meet the objectives (e.g. business objectives) desired for the whole network in the best optimal way*.

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MDKP-PWG Deliverables & Planning

3

Introduction to MDKP-PWG Deliverables

1. Produce a **Generic Architecture Framework Blueprint (GAFB)** that articulates the role GANA Knowledge Planes (KPs) Platforms should play as Anchors for the Federation of Autonomic/Autonomous Networks (ANs): ***Early Draft September 15, 2023; Stable Draft December 31, 2023; Final Version February 2024***

2. Describe **Use Cases on the KP-to-KP Federations and on APIs for GANA KP Integrations**: ***Early Draft October 1, 2023; Stable Draft July 31, 2024; Final Version September 2024***

3. Describe **Requirements for Knowledge Plane (KP) Platforms Driven Networking** (including KP Governance and KP-to-KP Federations) within the GAFB: ***Early Draft November 2023; Stable Draft April 2024; Final Version September 2024***

4. Discuss How **Zero Trust Principles (ZTP) can be applied in GANA KP-to-KP Federations**.

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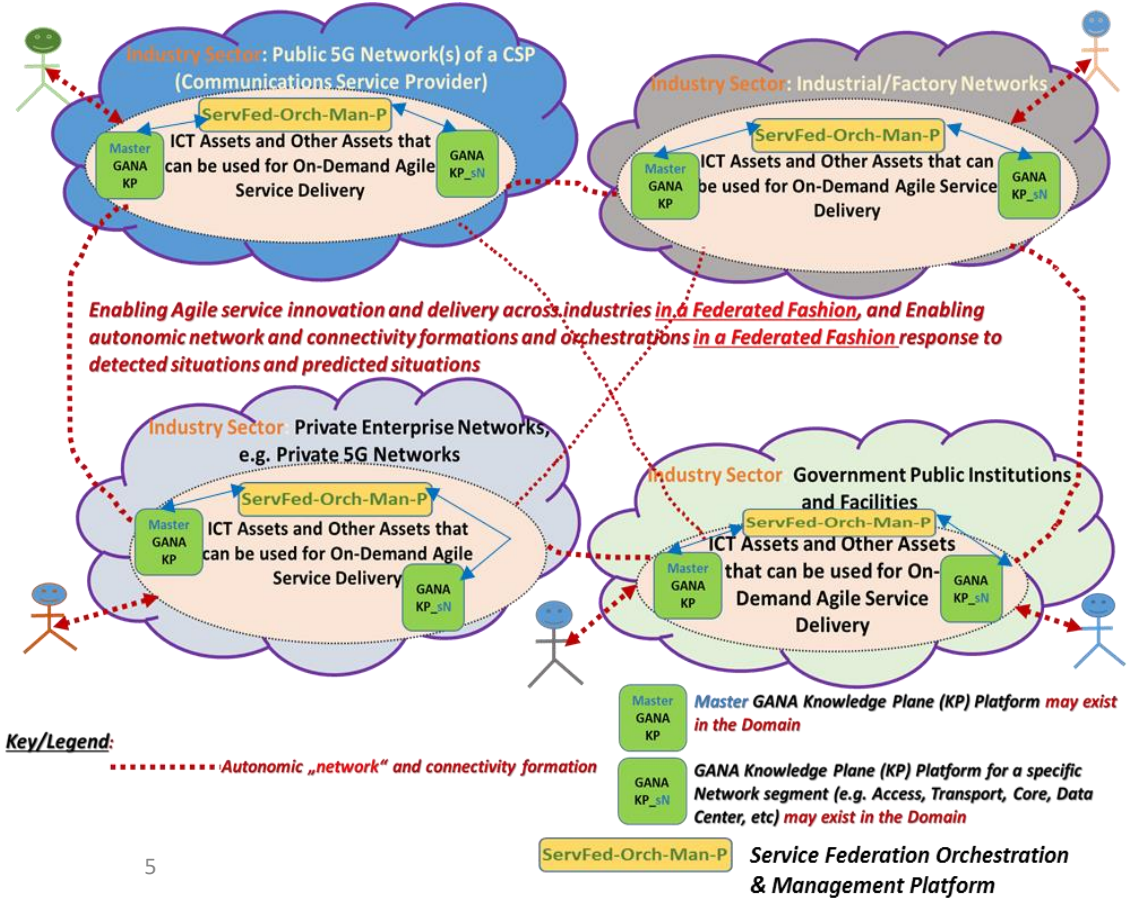
AGILITY Initiative: Generic Architecture Framework Blueprint (GAFB): GANA Knowledge Planes (KPs) Platforms should play as Anchors for the Federation of ANs



→ The NIST PWG will liaise with SDO/Fora such as ETSI TC INT AFI WG, IEEE, ITU-T, NGMN, or other

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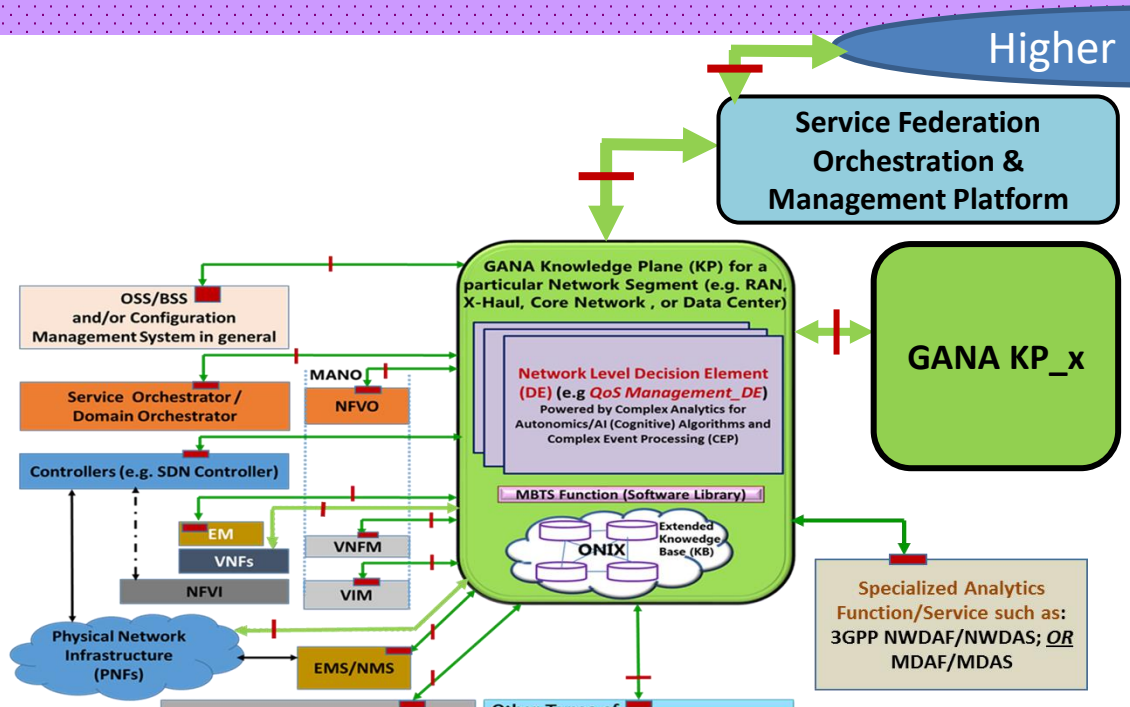
ETSI GANA Knowledge Plane (KP) Platform Integration with other Systems



What the NIST MDKP-PWG should work on:

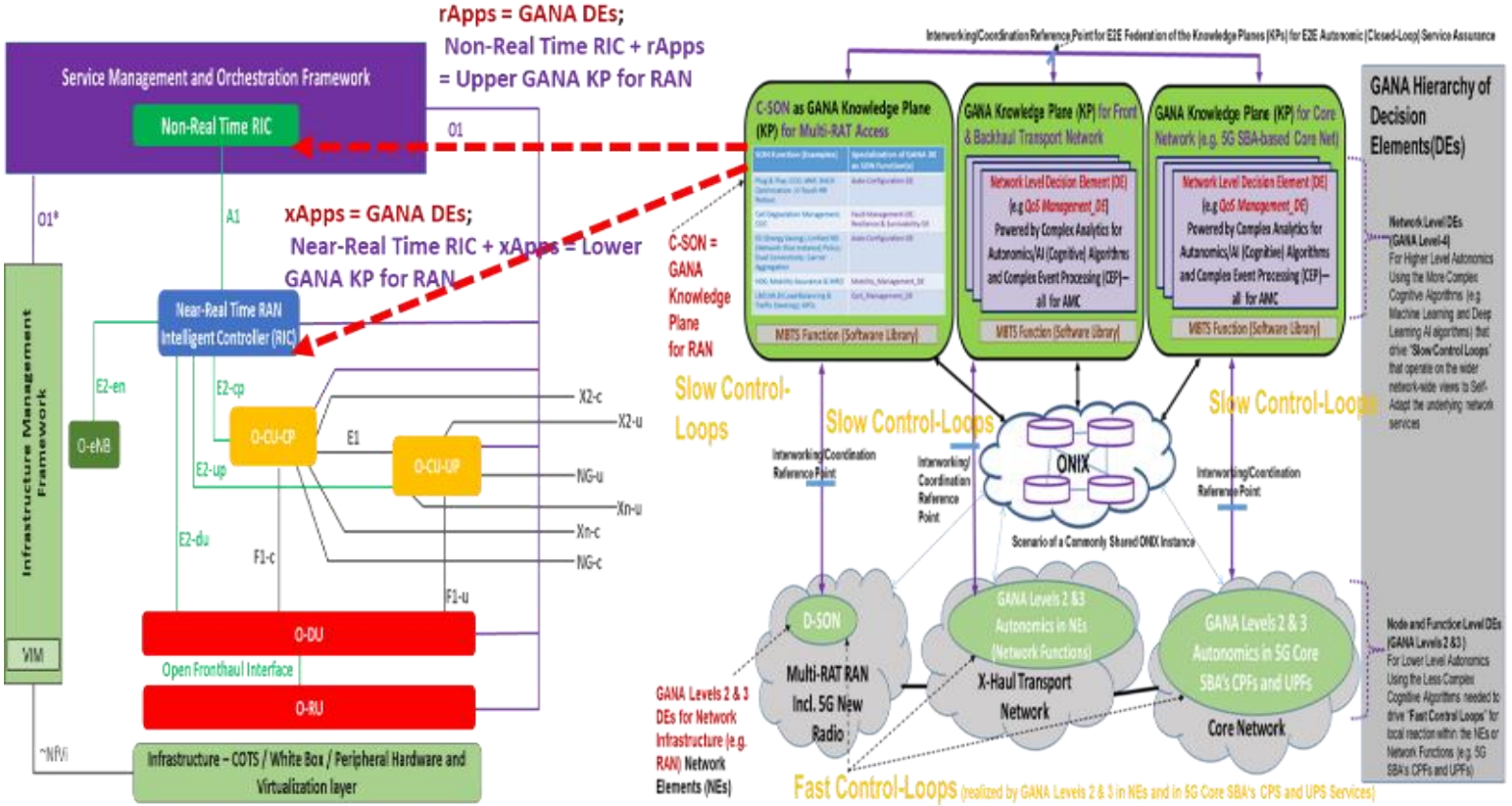
1. Generic Architecture Framework
2. Types of GANA KPs and Integration Interfaces Scope for specific KPs (Selected KPs and Selected Scope)
3. Requirements for Knowledge Plane (KP) Platforms Driven Networking (including KP Governance and KP-to-KP Federations)
4. APIs for GANA KP Integrations with other systems
5. Application of Zero Trust Principles in GANA KP Federations
6. Liaisons with some SDOs/Fora Group

Remark: The NBI **APIs** indicated should be specified and Standardized if no standards exist, including *KP-to-KP Federation* Reference Points. → ***Implies a Call for Action for Joint efforts by Standards SDOs/Fora***

ETSI TR 103 747
Has Insights

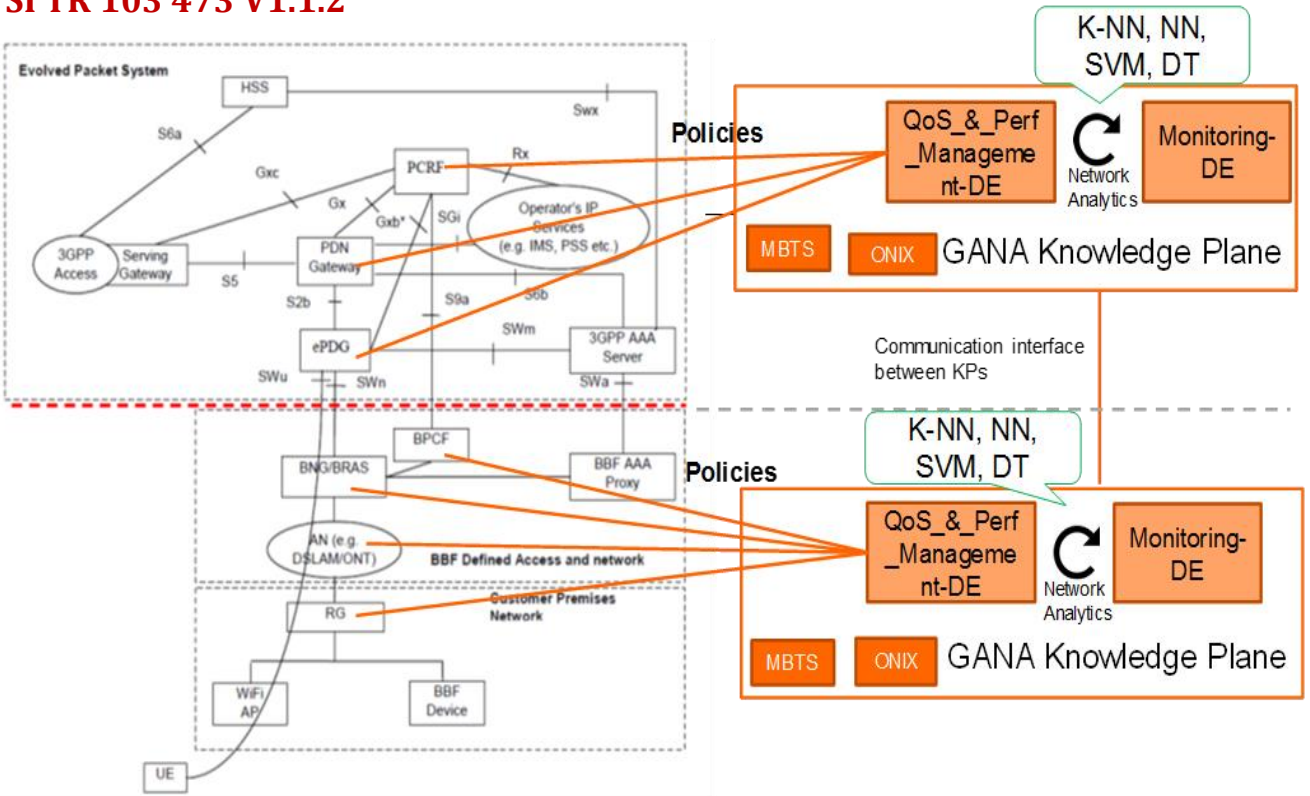
ON NAME

GANA KP, SON; O-RAN RICs/xApps/rAPPs: **Federations for E2E Self-* are Needed**



Federated/Interworking GANA Knowledge Planes (KPs) for BBF (BroadBand Forum) Domain and 3GPP Domain (ETSI TR 103 473 V1.1.2)

ETSI TR 103 473 V1.1.2



Two aspects of Autonomic Management and Control (AMC) Federations that need to be considered in deriving the Requirements for GANA KP-to-KP Federations

Requirements pertaining GANA KP-to-KP Federations we study include the role of GANA KPs federations in *Composable Networks, Composable Services, Enablers such as Cloud Federations APIs, Autonomic Network Formations, How KPs Build Knowledge and can exchange Knowledge and negotiated operations/actions* for *Self-* AMC intelligence* across federated ANs, e.g., *Self-Optimizations, Self-Protection, Self-Diagnosis and Self-Healing, Self-Defense, etc.*

1. **Type-A Federation**: Federations of GANA DEs' Autonomics operations based on DE's Autonomics Algorithms that may have been chosen to be implemented in a Distributed fashion (across NEs/NFs) such that the DEs involved collaborate to configure certain resources (Managed Entities (MEs)) in certain points in the network to achieve a network behaviour that can only be attained through the DEs' collaborations or exchange of information for the benefit of a certain larger scope of the network and services delivered by the portion of the network involved

2. **Type-B Federation**: Federated AMC through GANA KPs across Administrative Domains that host various Technology Domains (such as Access Network, x-Haul Transport Network, Core Network, or Data Center Network) and associated GANA KPs. AMC federation at the level of the GANA KPs is likely to be the only level of AMC federations that may be required across Administrative Domains, e.g., across CSPs.

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Overview of Requirements for Knowledge Plane (KP) Platforms Driven Networking—Anchor for Federation of Autonomic/Autonomous Networks (ANs) Across Industry Sectors

Requirements pertaining GANA KP-to-KP Federations we study include the role of GANA KPs federations in *Composable Networks, Composable Services, Enablers such as Cloud Federations APIs, Autonomic Network Formations, How KPs Build Knowledge and can exchange Knowledge and negotiated operations/actions* for *Self-* AMC intelligence* across federated ANs, e.g., *Self-Optimizations, Self-Protection, Self-Diagnosis and Self-Healing, Self-Defense, etc.*

1. **Type-1 Requirements**: KP support for the industry targeted COPAAN Blueprint' Governance and Federations Interfaces and associated Primitives
2. **Type-2 Requirements**: KP support of Mechanisms for Auto-Discovery by other KPs in a secure and trusted fashion
3. **Type-3 Requirements**: KP support of Mechanisms that enable the KP to collaborate with other KPs by way of federations that involve the KPs working together to instantiate and orchestrate networking resources to create dynamically *Composable Networks* built using various technologies required to deliver services to humans and machines as may be needed *on-demand*, and with the KPs working together to destroy or delete the networks and or services when no longer needed.
4. **Type-4 Requirements**: KP support of Mechanisms that enable the KP to collaborate with other KPs by way of federations that involve the KPs working together to instantiate and orchestrate network services to create dynamically *Composable Services* using network resources or network instances that already exist and are under the management and control responsibility of their respective KPs.
5. **Type-5 Requirements**: KP support for Enablers for Federations such as Cloud Federations API defined by IEEE Std 2302™-2021 that was originally developed by NIST and was further developed into IEEE as a standard. Such APIs are more relevant for *Type-B Federation*.
6. **Type-6 Requirements**: KP role in *Autonomic network and connectivity formations and orchestrations* in response to detected situations and predicted situations, and/or agile service innovation and delivery across industries in a federated fashion
7. **Type-7 Requirements**: KP support for Mechanisms and Techniques for supporting *Type-A Federation*. This implies support for Protocols and APIs for federations

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Overview of Requirements for Knowledge Plane (KP) Platforms Driven Networking—Anchor for Federation of Autonomic/Autonomous Networks (ANs) Across Industry Sectors

Requirements pertaining GANA KP-to-KP Federations we study include the role of GANA KPs federations in *Composable Networks, Composable Services, Enablers such as Cloud Federations APIs, Autonomic Network Formations, How KPs Build Knowledge and can exchange Knowledge and negotiated operations/actions* for *Self-* AMC intelligence* across federated ANs, e.g., *Self-Optimizations, Self-Protection, Self-Diagnosis and Self-Healing, Self-Defense, etc.*

8. **Type-8 Requirements**: KP support for Mechanisms and Techniques for supporting *Type-B Federation*. This implies KP support for Enablers for Federations such as Cloud Federations API defined by IEEE Std 2302™-2021 that was originally developed by NIST and was further developed into IEEE as a standard; and also KP support for "*Needs*" defined by IEEE INGR Future Networks Systems Optimization Chapter that pertain to Federations across administrative domains.
9. **Type-9 Requirements**: KP support of Mechanisms and Techniques for Building Knowledge and ability to exchange Knowledge and enter negotiations with other KPs on operations/actions that KPs should execute for Self-* AMC intelligence across federated ANs, e.g., *Self-Optimizations, Self-Protection, Self-Diagnosis and Self-Healing, etc.*

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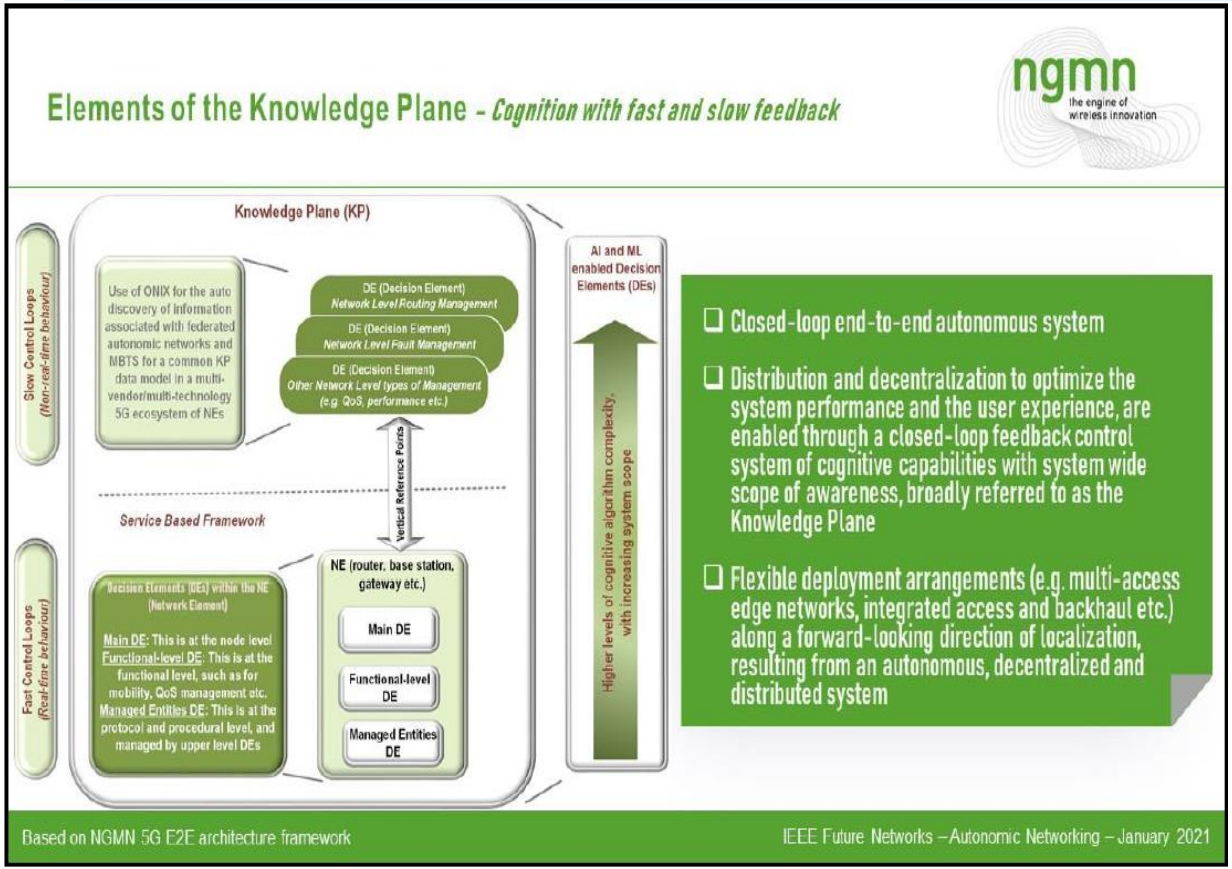
ETSI GANA Model Adoption in NGMN's Autonomic Networking Requirements in E2E 5G Architectures, and ETSI Implementation Fmwk



ETSI has published

ETSI TR 103 747 *on* ***Implementing Federated GANA Knowledge Planes (KPs) Platforms for E2E Multi-Domain Federated Autonomic Management and Control (AMC) of Slices in NGMN E2E 5G Architecture***

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ETSI GANA Model Adoption in BroadBand Forum (BBF)'s AIM Framework

Automated Intelligent Management (AIM) - overview

- In Broadband Forum (BBF)
- Access & Home Network O&M Automation/Intelligence
  - Not necessarily AI/ML
  - Work with Network Functions Virtualization (NFV) & equipment disaggregation
- Project phases
  - Key use cases
  - Logical framework
    - **TR-436,** Access & Home Network O&M Automation/Intelligence
      - Approved for publication
      - Builds on ETSI Generic Autonomic Networking Architecture (GANA) framework, also ML pipelines from ITU-T Y.3172, and TM Forum Open Digital Architecture (ODA)
      - Aligns with Broadband Forum CloudCO specs
  - Data models & interfaces
    - Now starting

IEEE Future NETWORKS

Enabling 5G and Beyond

2nd System Optimization Imperatives, Techniques, and Opportunities for Future Networks Workshop

13 Dec 2022 | Free & Virtual

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FREE Virtual Workshop - Register Today!

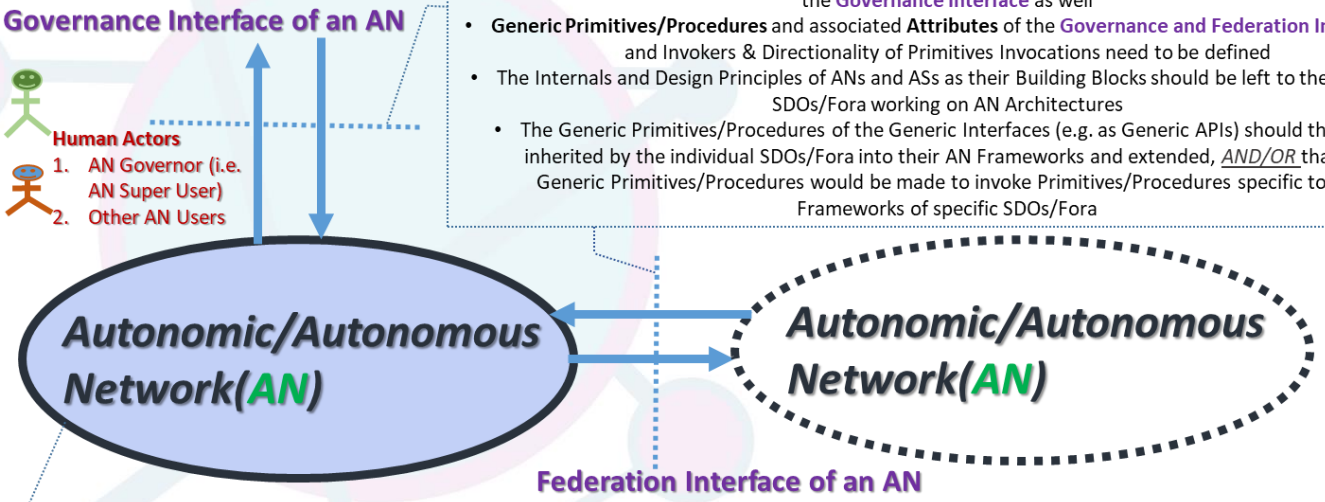
Standards/Interfaces Panel – Interface work needed for AI/ML optimization in the scope of Autonomic/Autonomous Networks (ANs)

Moderator
Ranganai Chaparadza, PhD, Capgemini Engineering/Vodafone Consultant
Jorg Niemoller, Ericsson
Nigel Davis, Ciena
Muslim Elkotob, PhD, Vodafone

13th December 2022

IEEE

IEEE Proposal: Conceptual Model for Developing the COPAAN Blueprint



- The **Human Actors** need to be defined in the Blueprint, including the Types of Actors and Multiplicity on the **Governance Interface** as well
- **Generic Primitives/Procedures** and associated **Attributes** of the **Governance and Federation Interfaces** and Invokers & Directionality of Primitives Invocations need to be defined
- The Internals and Design Principles of ANs and ASs as their Building Blocks should be left to the various SDOs/Fora working on AN Architectures
- The Generic Primitives/Procedures of the Generic Interfaces (e.g. as Generic APIs) should then be inherited by the individual SDOs/Fora into their AN Frameworks and extended, *AND/OR* that the Generic Primitives/Procedures would be made to invoke Primitives/Procedures specific to AN Frameworks of specific SDOs/Fora

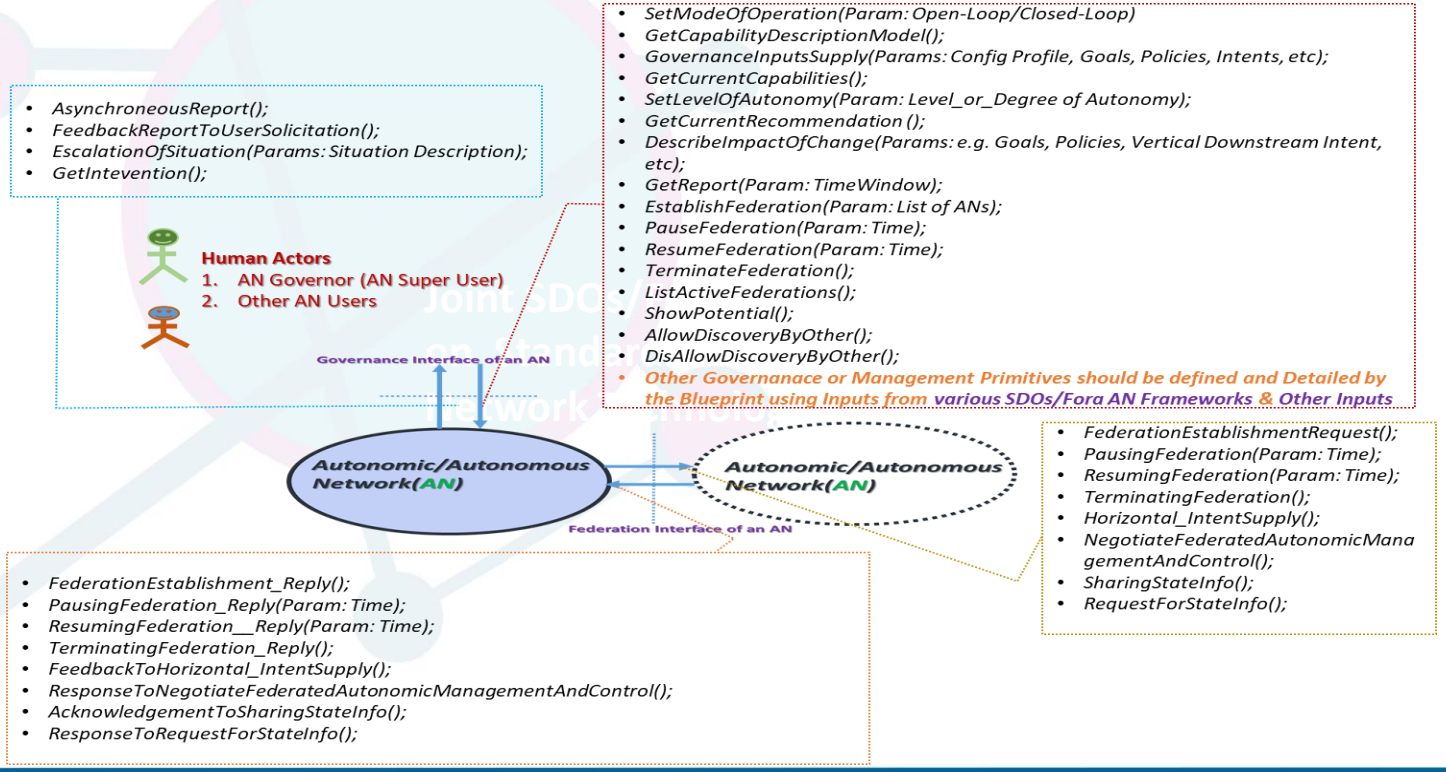
- **There are different Classes of ANs** and the Industry now need a Blueprint that describes the various Classes of ANs and Characterizations of the AN Operational Principles that are **Common across AN Classes** and those that are **Common across ANs that belong to the same Class**

Benefits of the Blueprint of Common AN Ops Principles:

- Enable Test and Certifications of ANs based on the Common Operational Principles
- Enable Integrability and Interopearbility among ANs
- Provide for Differentiating Factors for ANs, to aid Procurement of ANs

Facts regarding AN Framework Standardization in various SDOs/Fora: There are already a number of SDOs/Fora working on their AN Architectures: There is a way to achieve some level of harmonization that enables Integrability and Interoperability of AN Architectural Frameworks from various SDOs/Fora and Implementations thereof, without disrupting the roadmaps of the SDOs/Fora

IEEE Proposal: Examples of Primitives of the Conceptual Model of an AN that would need to be specified and detailed in the Blueprint



Backup

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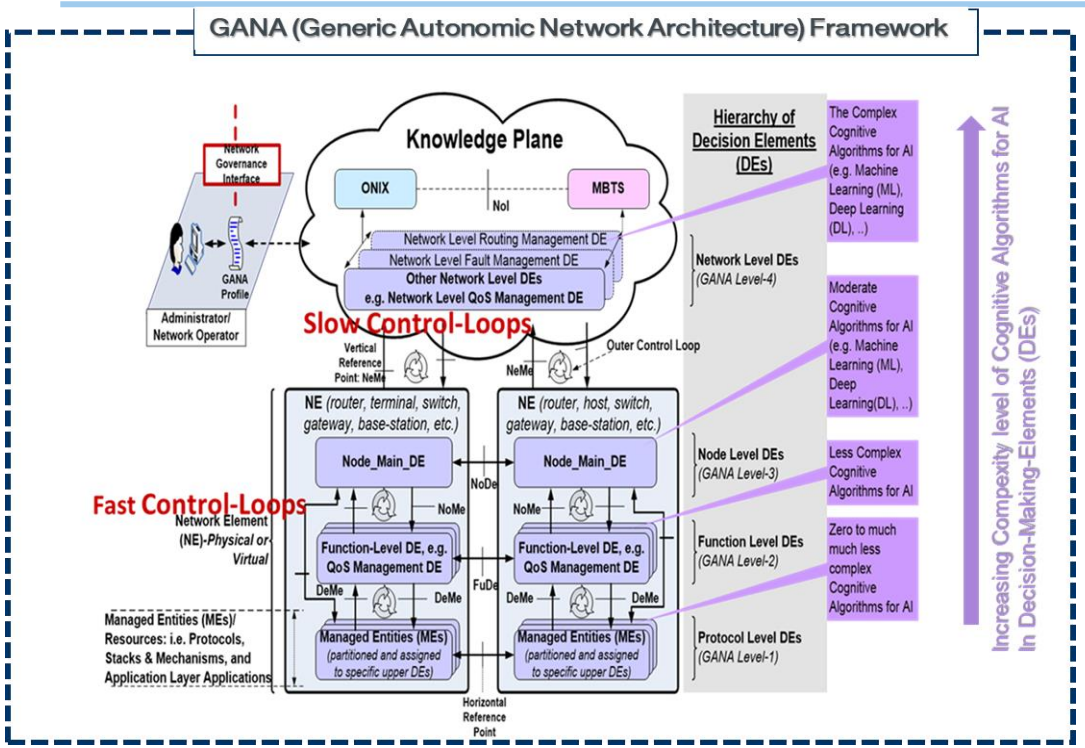
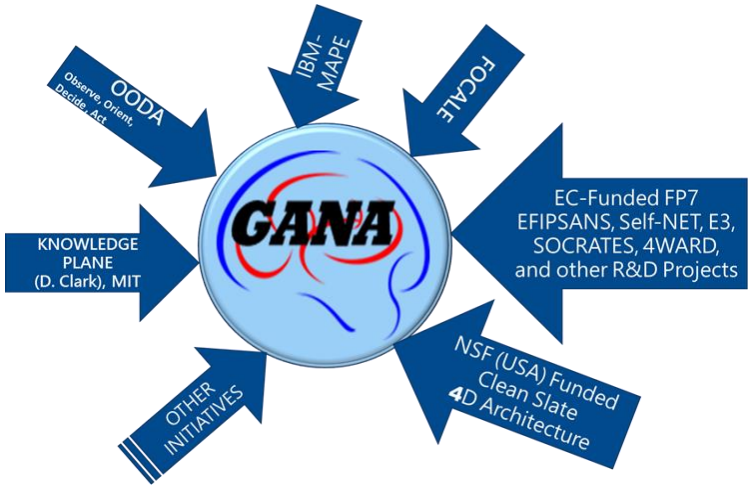
ETSI GANA (Generic Autonomic Networking Architecture)
Reference Model / Functional Architecture (**ETSI TS 103 195-2**) for **Multi-Layer AI/ML & AMC**



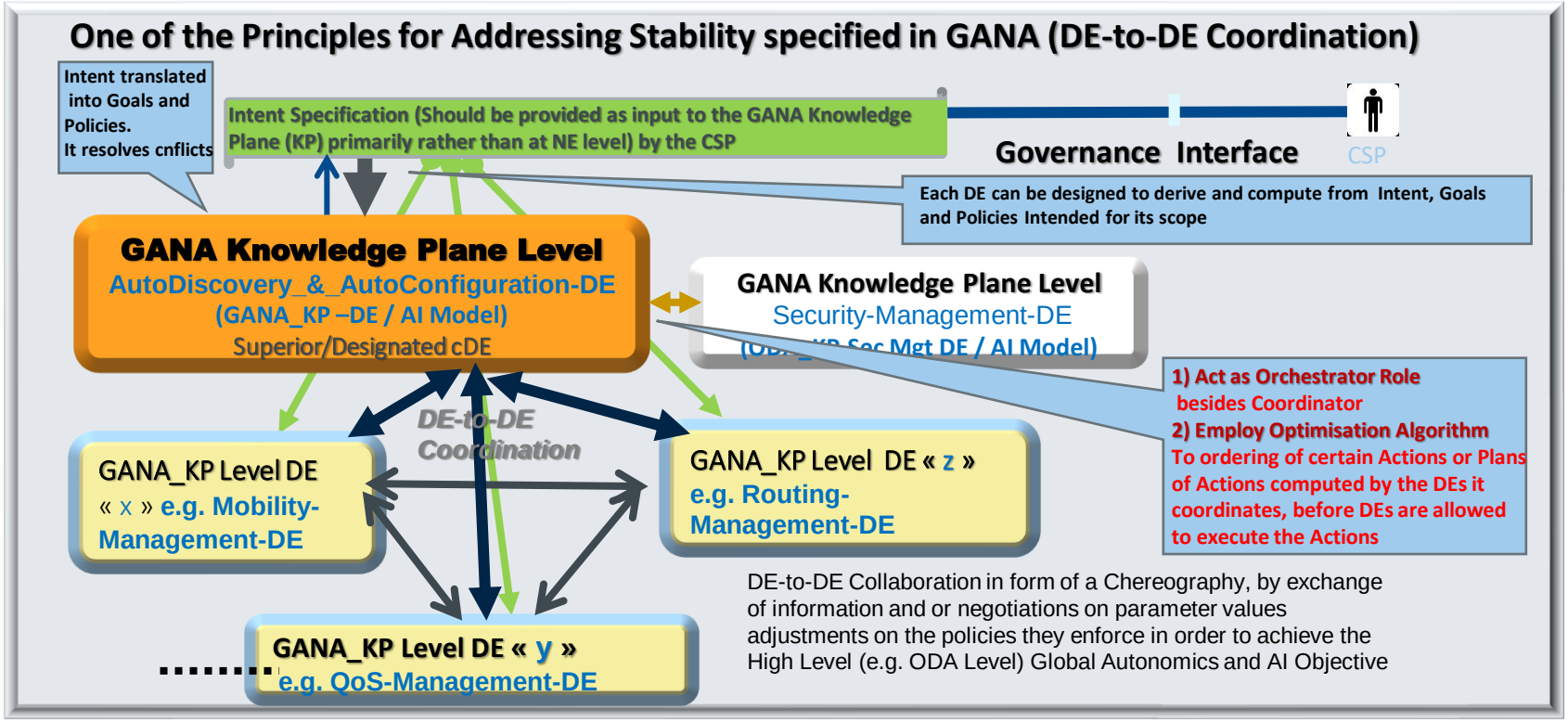


GANA is Framework for Multi-Layer Autonomic Management & Control (AMC)/Autonomics & Multi-Layer AI/ML for AMC

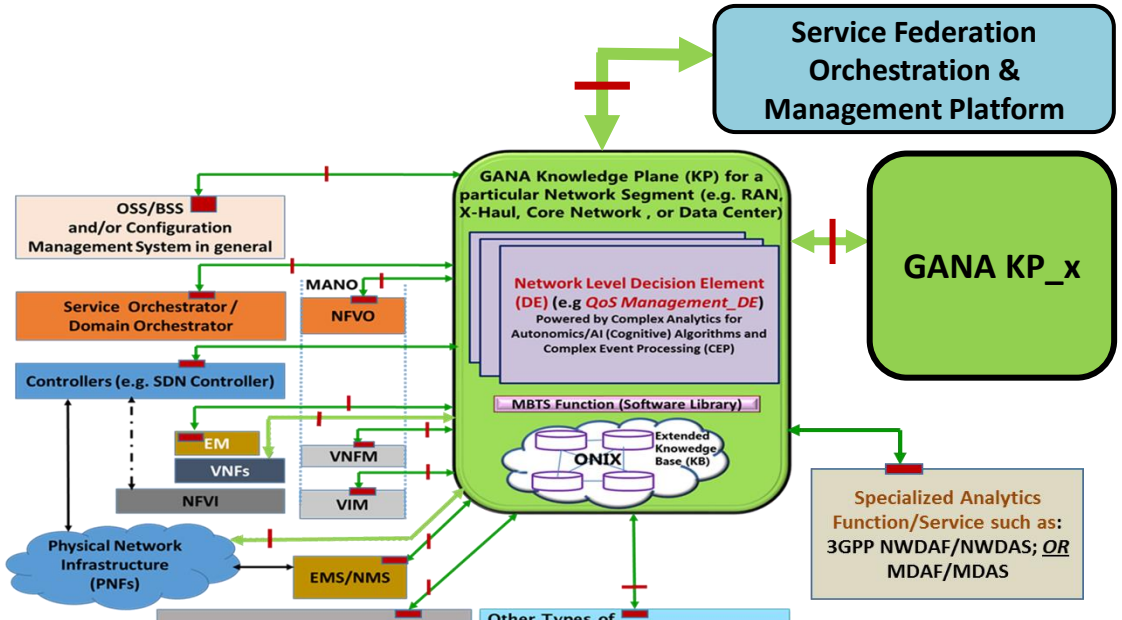
Remark: ETSI White Paper No.16 and ETSI TS 103 195-2 describe the Recommendation to focus on GANA levels 2 to 4 when introducing autonomics in architectures and Why

Intents Handling & Addressing Stability of Control-Loops in GANA:

Design for Stability Principles and Run-Time Stability Principles for *Coordination / Synchronization / Orchestration among DEs*



ETSI GANA Knowledge Plane (KP) Platform Integration with other Systems



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ETSI TR 103 747 Has Insights

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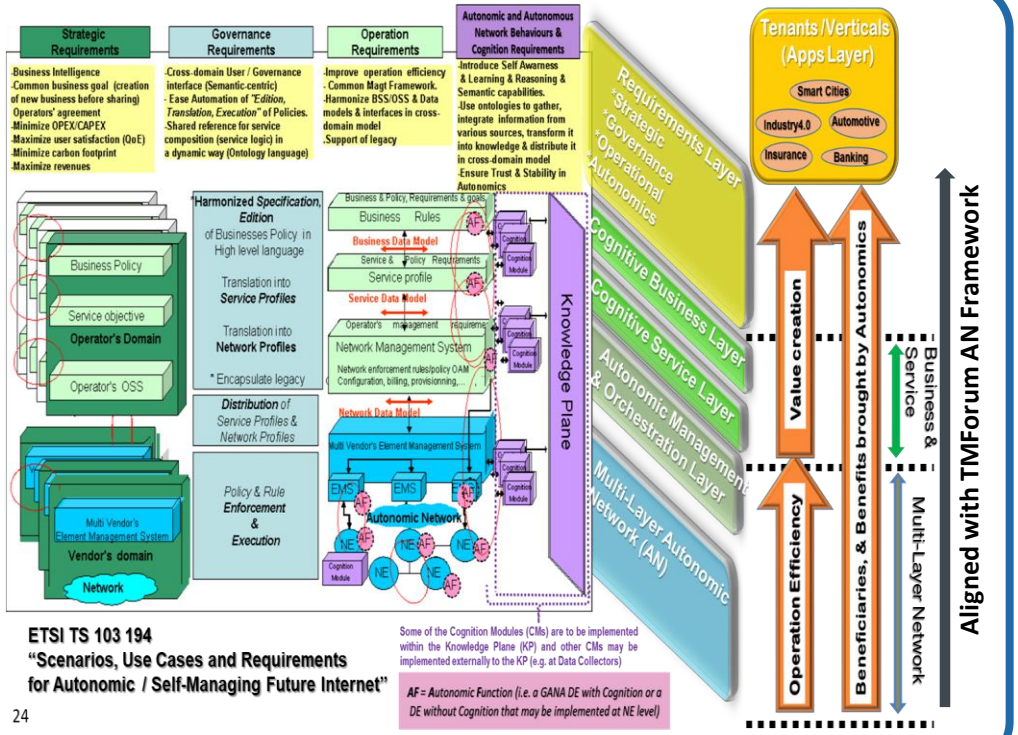
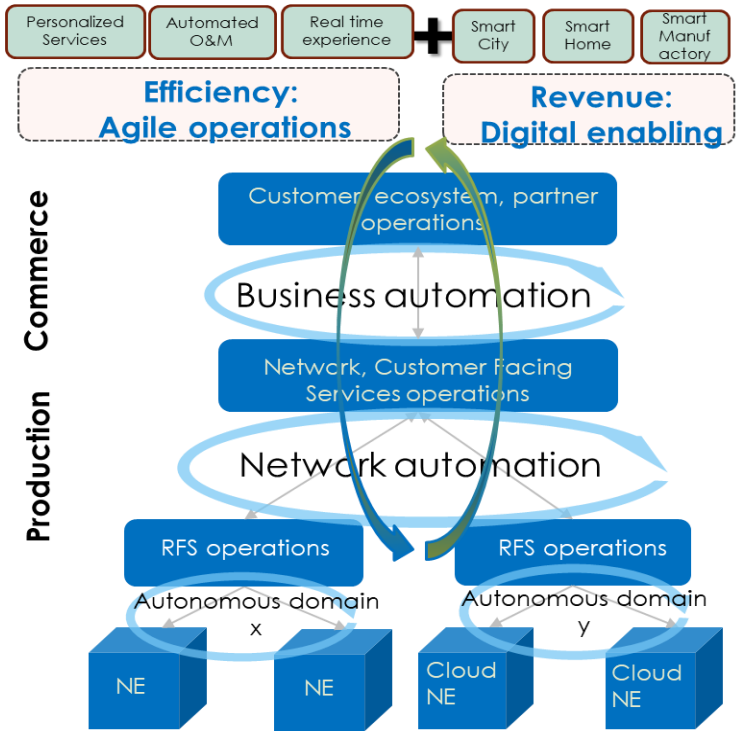
ETSI GANA Framework alignment with TMForum Autonomous Networks (ANs) Framework (comparison performed during TC INT#44, Sept 4th 2019, Paris).

?? Invitation to ETSI TC INT meeting.msg

GANA Scenarios, Use Cases & Requirements



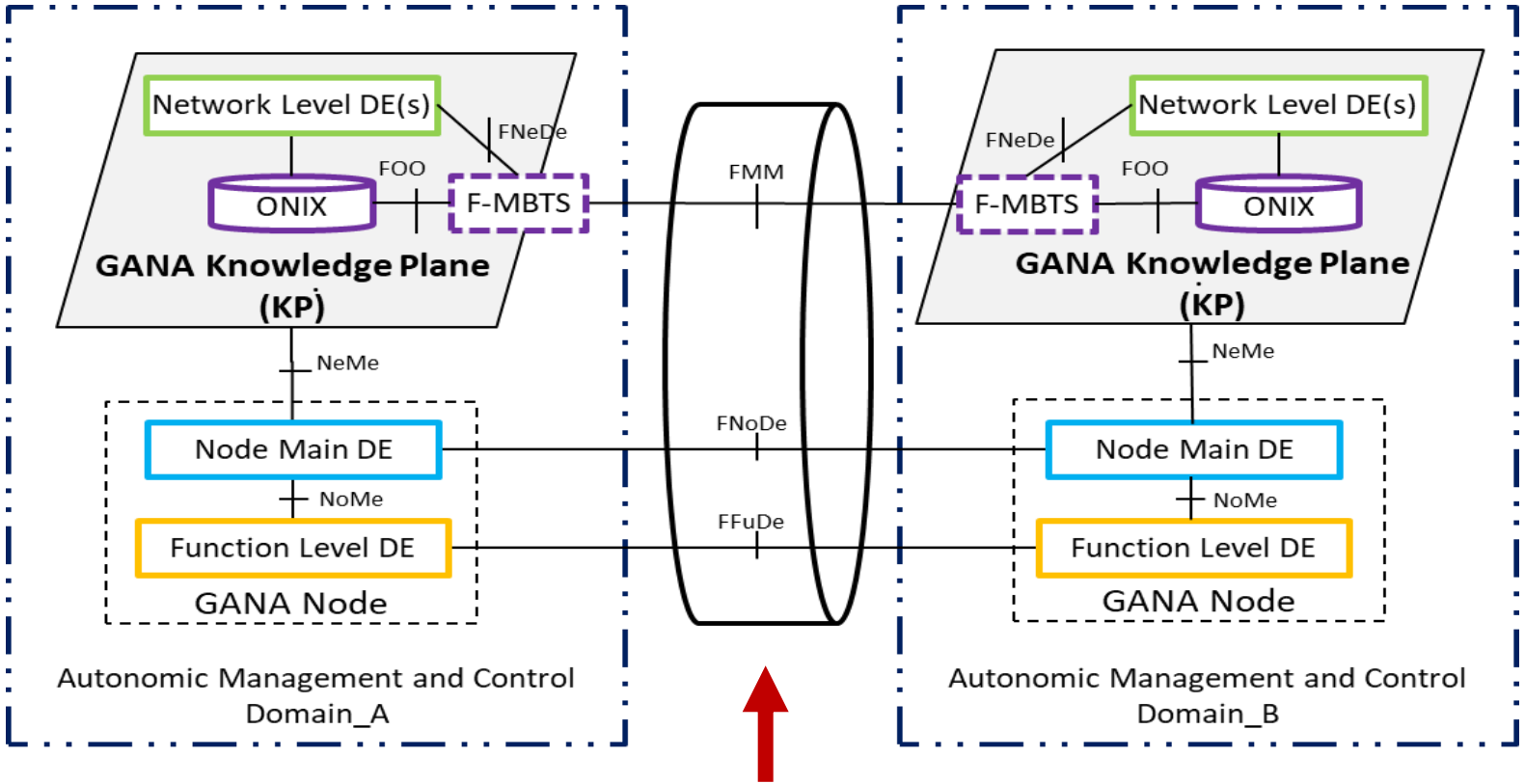
TMForum Autonomous Network Framework



ETSI GANA Framework and TMForum ODA & AN Framework are aligned

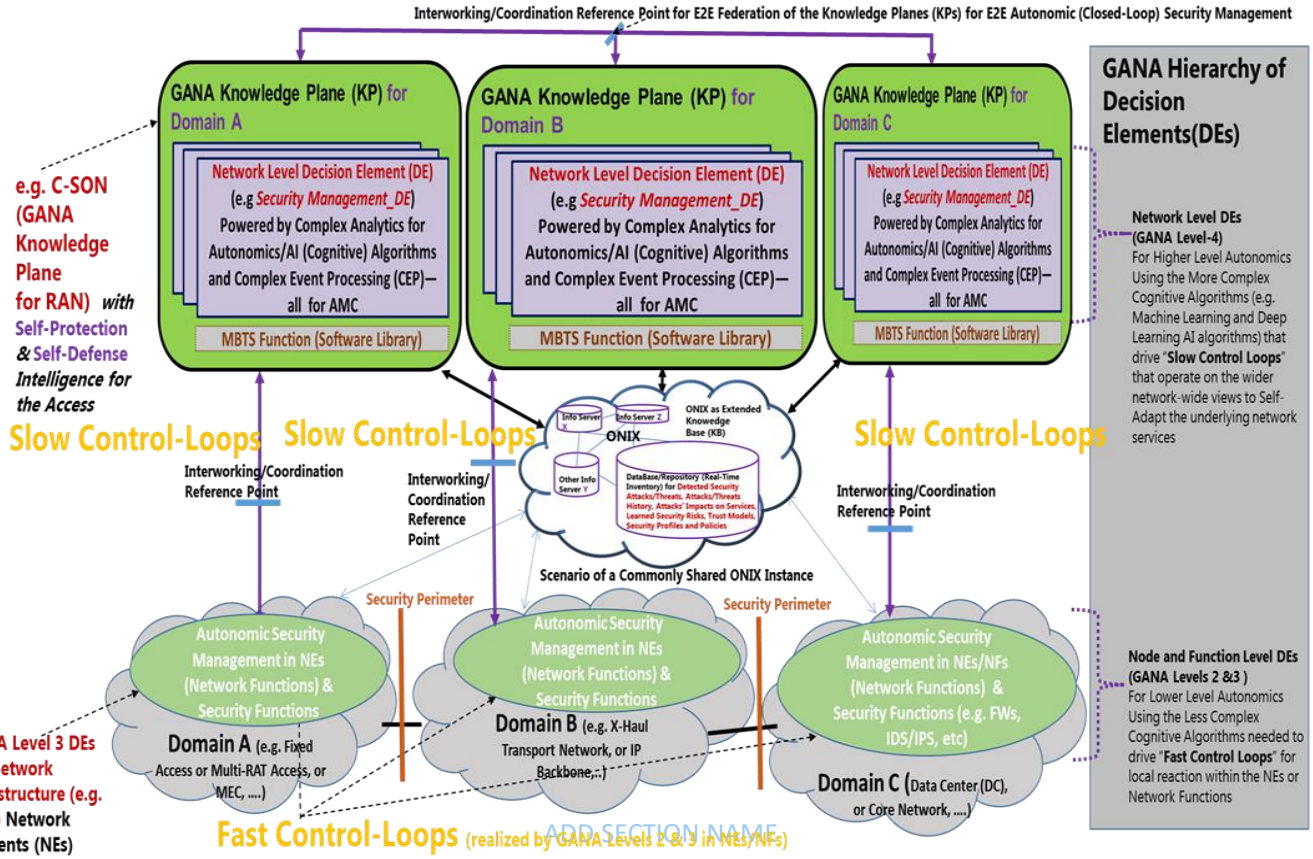
KP to KP Federations

Federation of GANA Knowledge Planes (KPs) Framework (ETSI TS 103 195-2)

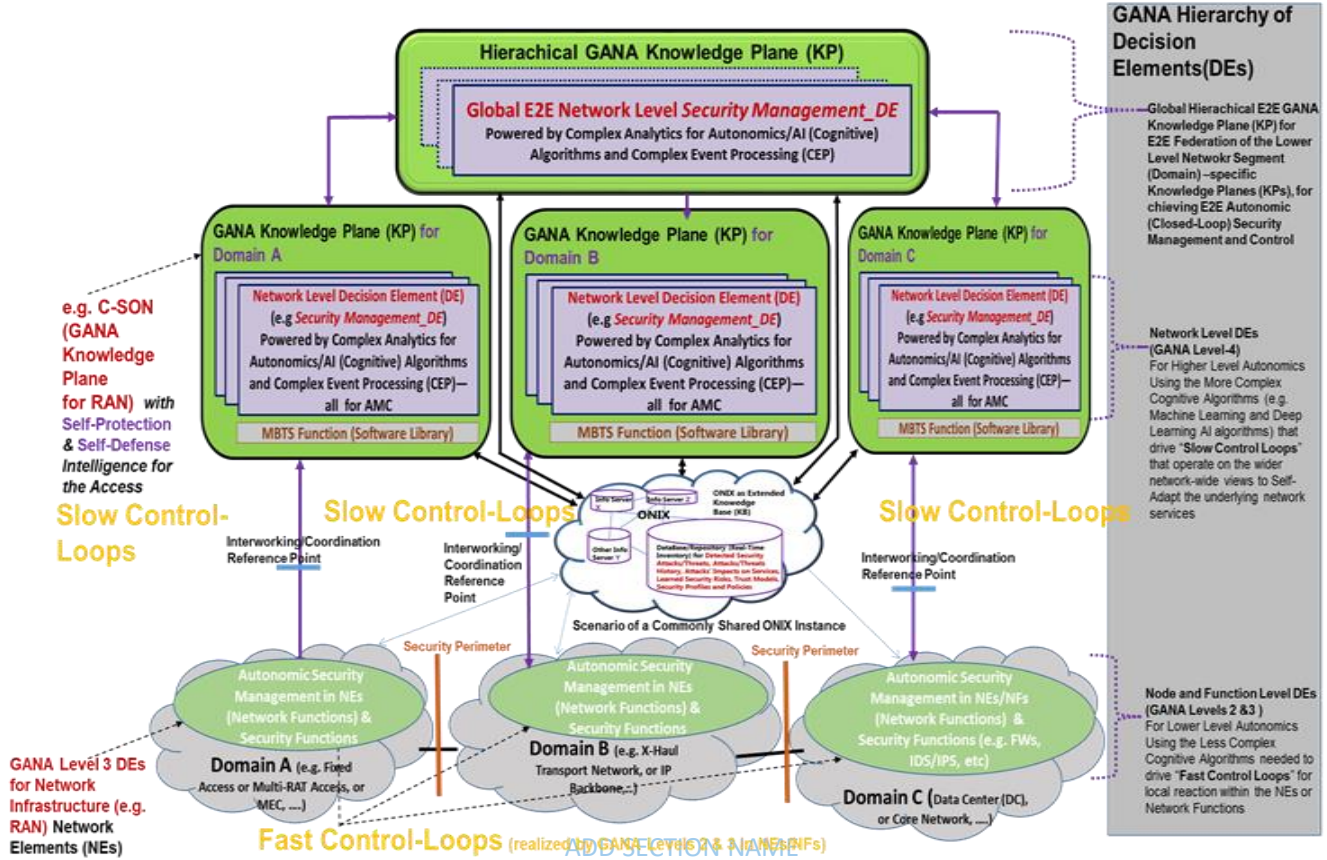


The **Protocols** and **APIs Required. Joint efforts needed to define**

Federation of GANA Knowledge Planes (KPs), e.g. for E2E Autonomic (Closed-Loop) Service & Security Assurance of 5G Slices – **Horizontal Federation of KPs**



Federation of GANA Knowledge Planes (KPs), e.g. for E2E Autonomic (Closed-Loop) Service & Security Assurance of 5G Slices– **Vertical (Hierarchical) Federation of KPs**



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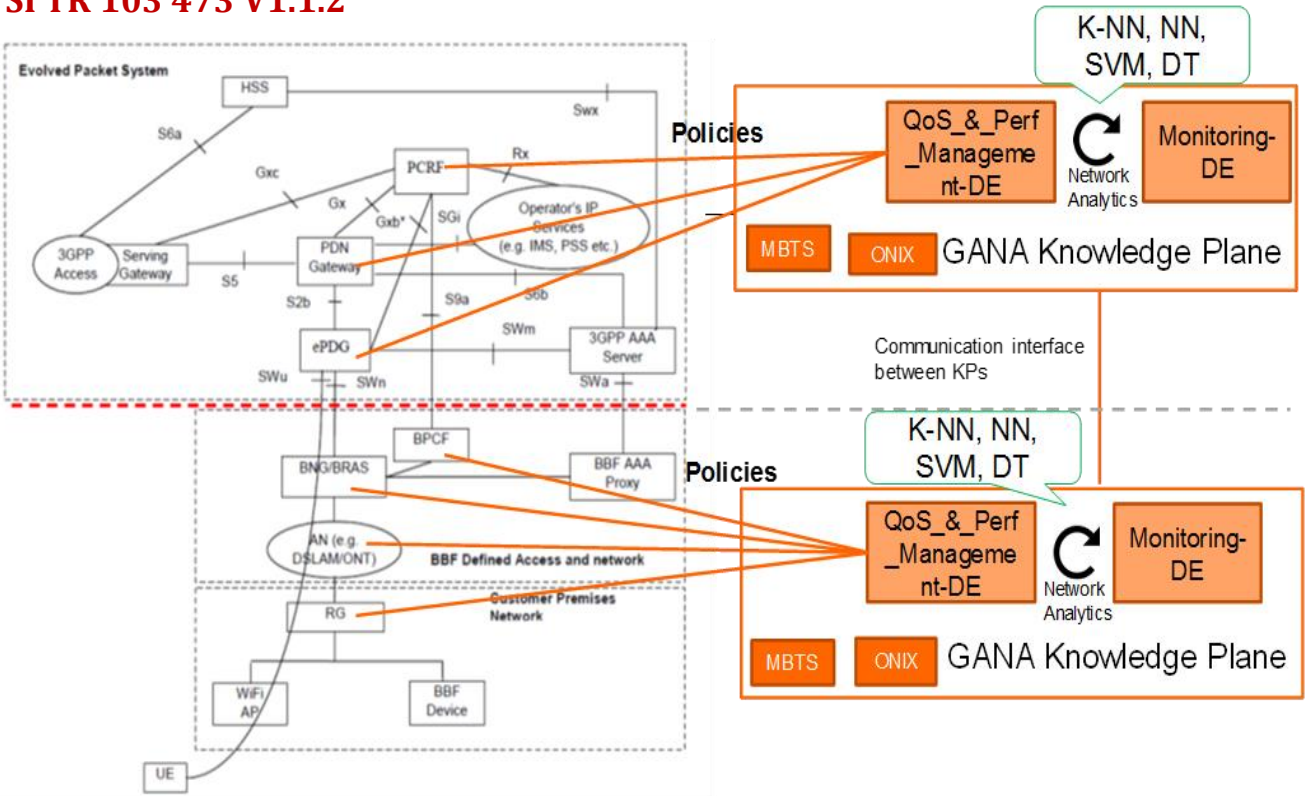
ETSI TR 103 473 V1.1.2



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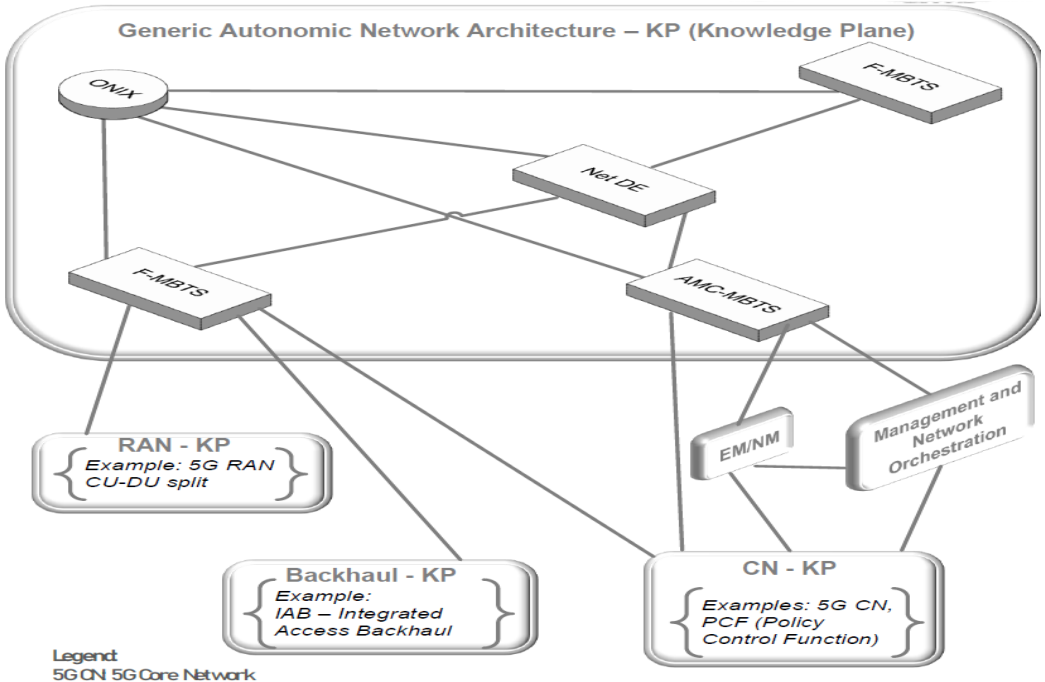

ETSI has published

ETSI TR 103 747 *on*

Implementing Federated GANA Knowledge Planes (KPs) Platforms for E2E Multi-Domain Federated Autonomic Management and Control (AMC) of Slices in NGMN E2E 5G Architecture

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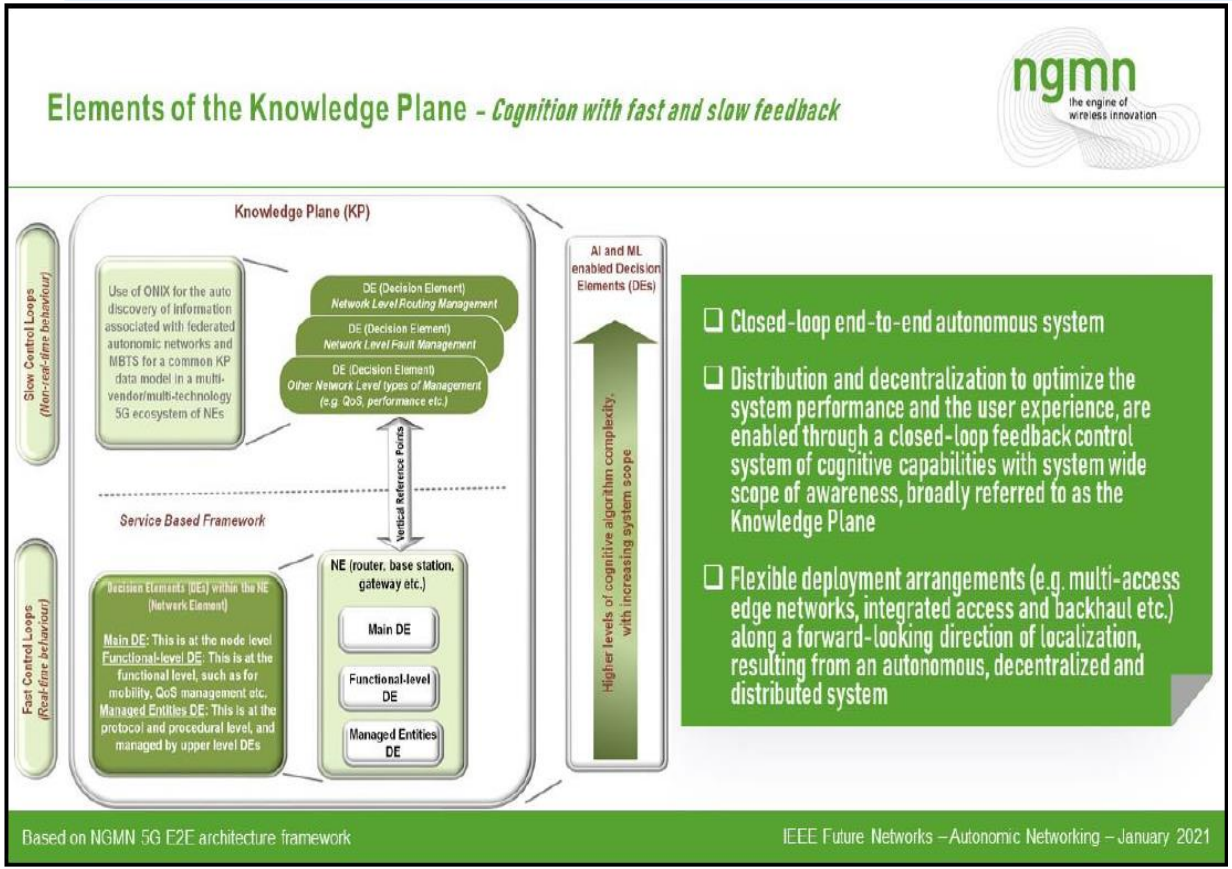

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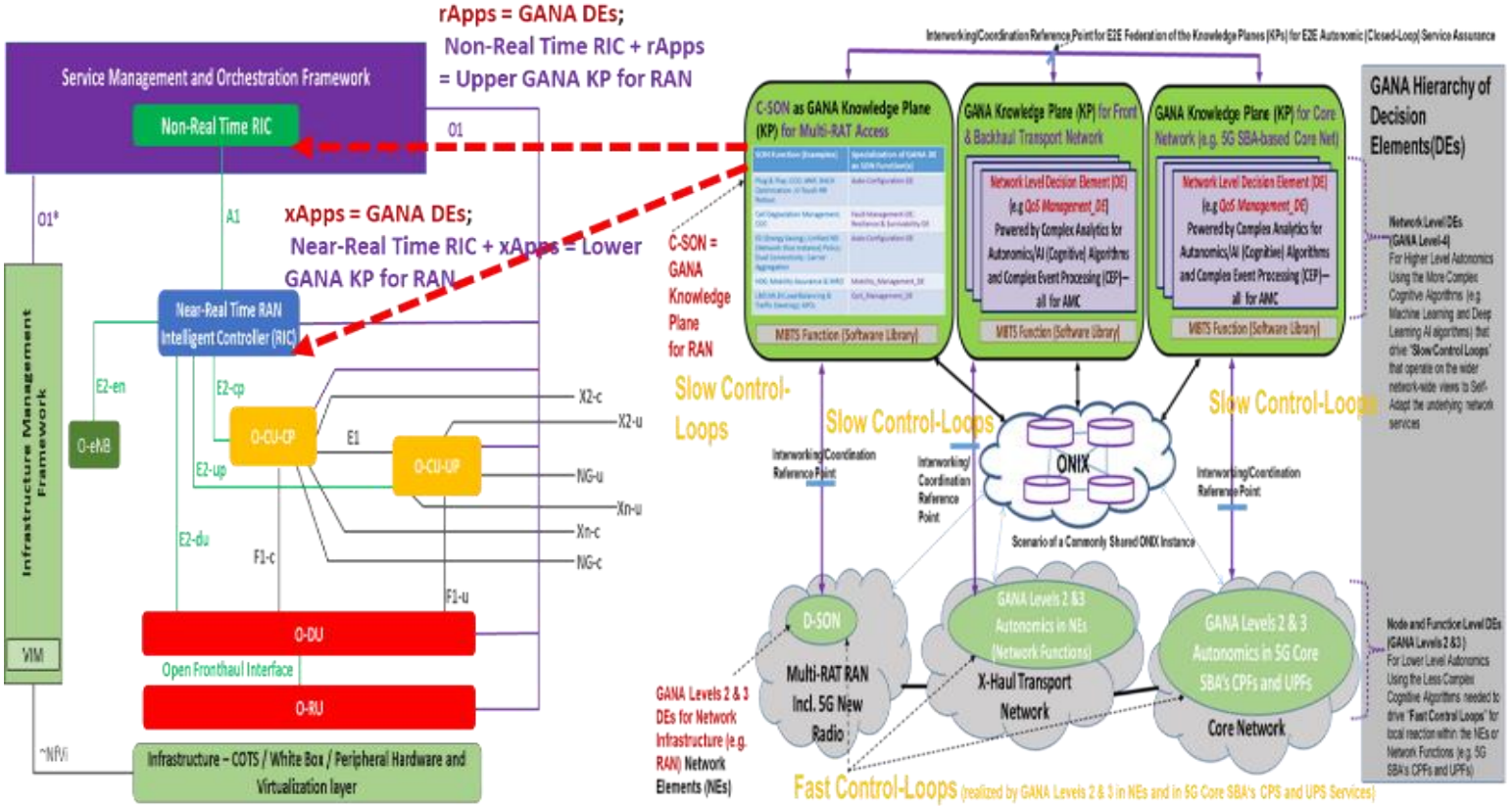
GANA KP, SON; O-RAN RICs/xApps/rAPPs: **Federations for E2E Self-* are Needed**



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  - Data models & interfaces
    - Now starting

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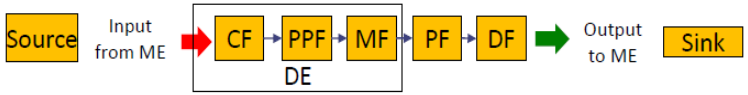
GANA DE Design in BroadBand Forum (BBF)'s AIM Framework, using ITU-T Y.3172

AIM pipeline

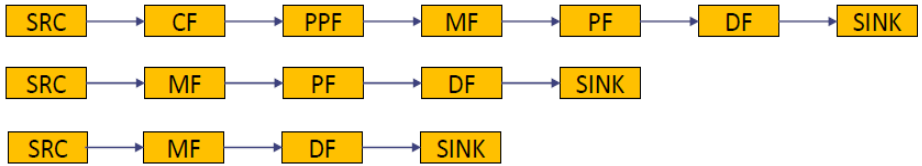
- Inspired by ITU-T Y.3172, Architectural framework for machine learning (ML) in future networks including IMT-2020

AIM pipeline representation



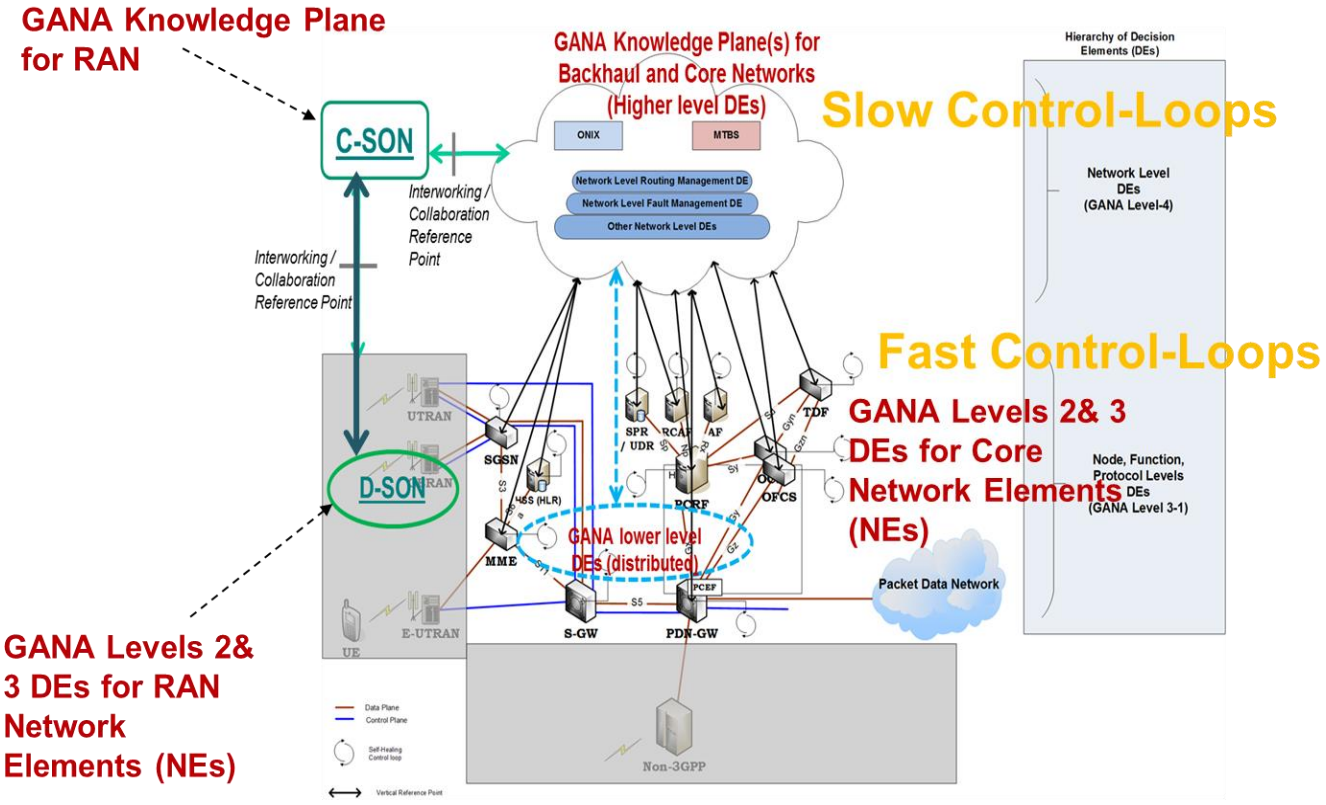
- Collection Function (CF): responsible for data collection
- Pre-processing Function (PPF): responsible for data processing
- Model Function (MF): responsible for knowledge handling, can use AI / ML
- Policy Function (PF): responsible for the application of policies to the MF outputs
- Distributor Function (DF): responsible for distributing the outputs of the MF

- Other pipelines examples:

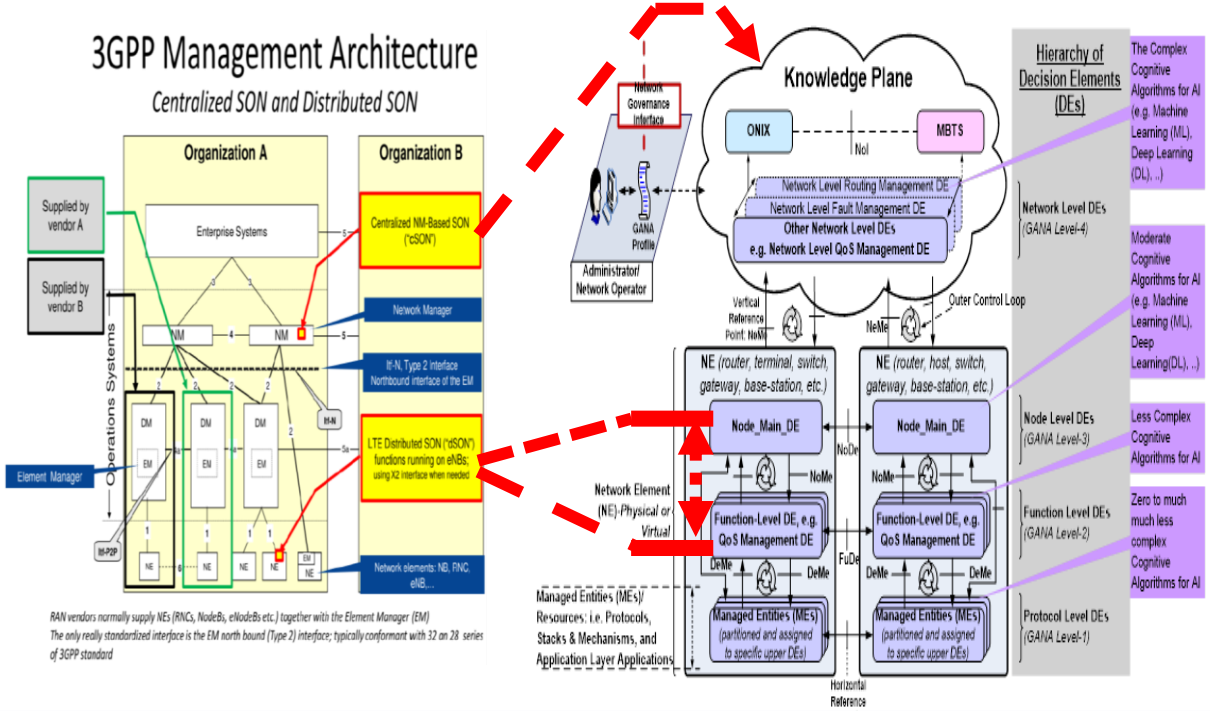


Example of a GANA Instantiation onto a particular Network Architecture and its associated Management & Control Architecture

Instantiation of GANA onto 3GPP EPC Core & Backhaul Network (ETSI TR 103 404); and Federated/Interworking GANA Knowledge Planes for RAN-, Backhaul- and 3GPP EPC Core Networks complemented by low level autonomics



Hybrid-SON Model Mappings to the ETSI GANA Model (PoC on Autonomics in 5G Slices Service Assurance)



- **NOTE: Hybrid SON Model as specified by NGMN is compatible with GANA**
  Hybrid SON (C-SON(Centralized SON) & DSON(Distributed SON)) are considered as an implementation of the GANA Model for the RAN

GANA for the RAN is realized by Hybrid SON (C-SON (cognitive) complemented by D-SON in eNBs)

SON Function = GANA Decision Element (DE)

C-SON with Cognitive SON Functions = GANA Knowledge Plane for the RAN

https://intwiki.etsi.org/images/ETSI_GANA_in_5G_PoC_White_Paper_No_1_v1.28.pdf