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5G E2E Architecture Framework Summary

Leveraging the NGMN E2E Architecture Framework for 5G and beyond

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Reference: NGMN E2E Architecture Framework, 11/2020

5G E2E Architecture Framework - *Topics and Theme*

- ❑ Autonomic Networking
- ❑ Network Data Layer
- ❑ AI and ML
- ❑ Virtualization in RAN
- ❑ MEC (Multi-access Edge Computing)
- ❑ DLT (Distributed Ledger Technology)
- ❑ Vertical Market
- ❑ End-to-End security

Autonomic Networking

Autonomic Networking

- Management of complexity in a highly distributed, decentralized ecosystem of virtualized and heterogeneous networks for rendering diverse, innovative services, through embedded and distributed AI and ML models
- Enablement of self-CHOP (Configuration, Healing, Optimization, and Protection) behaviours on a system-wide basis, including the core, edge, transport, radio access and devices (human and machine interfaces)

Usage Scenarios

- Enhanced flexibility of system-wide network slicing orchestration within and across domains
- Context-aware allocation of physical and virtual resources on a system-wide basis, through an application of cognitive awareness
- System-wide automation towards minimized OPEX
- Optimization of service experience and network performance
- Common marketplace for zero-CAPEX service delivery
- Federated partnerships for an optimization of system performance, coverage, capacity, service quality and service experience

Building Blocks of Autonomic Networking

Self C-HOP behaviour

- Self Configuring, Self Healing, Self Optimizing, Self Protecting

Cognitive Service Orchestration, Assurance, Fulfillment

- Orchestration: System-aware management of end-to-end services/resources (Intra-domain or Inter-domain)
- Assurance: Closed-loop network monitoring and data analysis in concert with Orchestration for assuring quality and autonomous provisioning
- Fulfillment: Realization of intra/inter-domain SLAs

Knowledge and Intent

- *Knowledge:* System-wide awareness of slow/fast control loops
- *Intent:* Desire articulated at a high-level for a service tenant to attain a given state, such as a certain KPI of service assurance, or a deployment task, while the 'how' is automated

Virtual Functions

- Distributed, Autonomous Decision Making
- Self-directed Learning and Adaptability
- Cognition enabled through Machine Learning

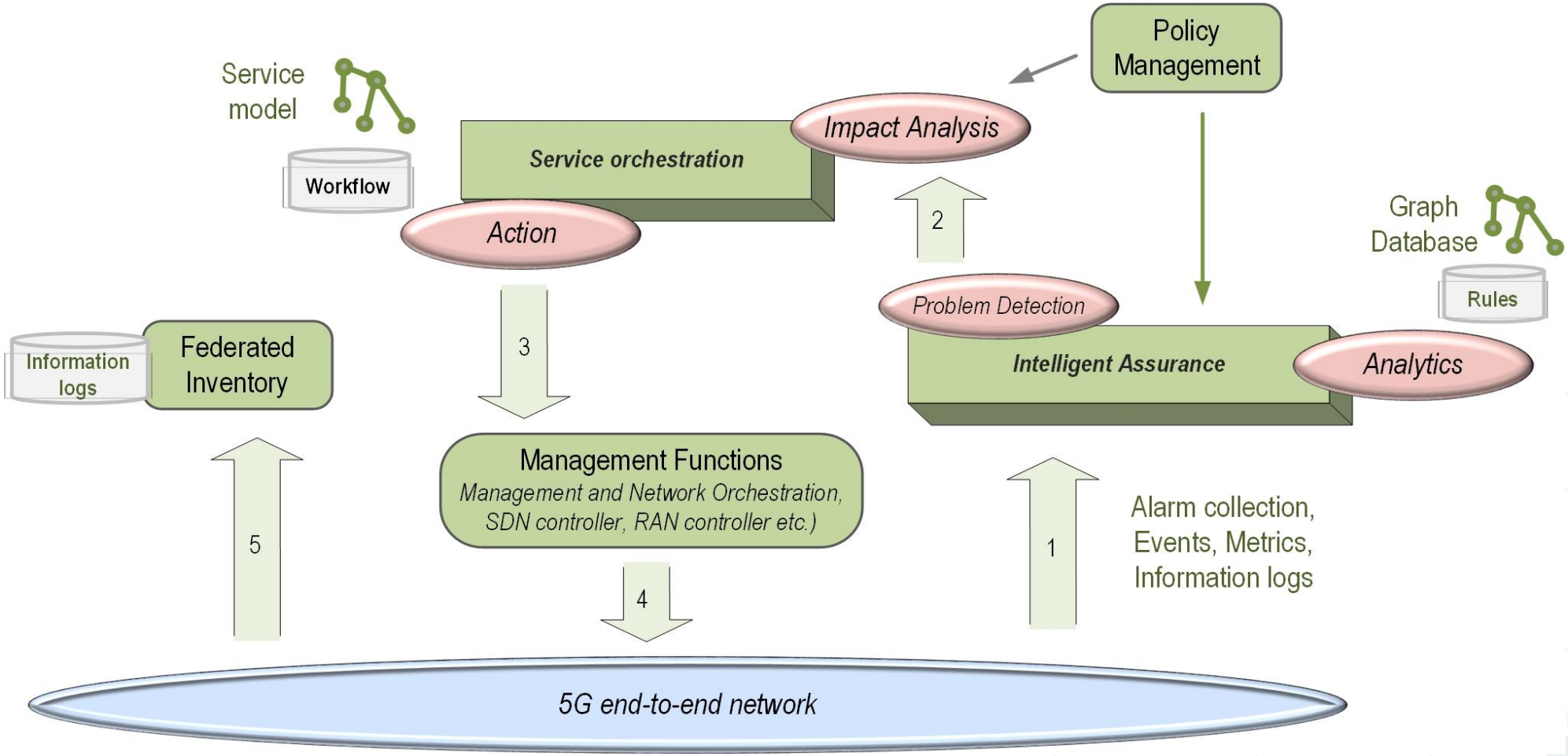
Composable Cognitive Functionality

- Functional composability, enabled through microservices
- Context aware, discoverable, self-adaptive function behavior
- Intelligent sensing/creation of distributed information/analytics

Distribution of Cognitive Decision-Making

- Cognitive function distribution across Core, Edge, Radio networks and diverse form factor Devices
- Intra-domain, Inter-domain, and Federated domain cooperation and coordination

System-wide coordination in autonomic networking



Prominent ML (Machine Learning) models

Prominent ML models

- Enablement of cognitive capabilities in autonomic networking through an application of ML models, within and across domains (e.g. Federated Learning)
- ML model consisting of the following prominent categories for system-wide applicability:
  - Supervised Learning
    - *Structured source data, with learning based on known optimal solutions*
  - Unsupervised Learning
    - *Unstructured source data with learning based on classifying sets of data with similar patterns or attributes, with some desired selection criteria to meet a predefined objective*
  - Reinforcement Learning
    - *Learning technique based on a feedback control system, where the learning progresses iteratively towards a converged transfer function, through a sequence of action, response and reward to meet a desired objective within a probabilistic environment*

System-wide ML Usage Scenarios

System-wide ML Usage Scenarios

- Dynamic resource allocation and optimization for network slicing, channel access conditions, decentralized and distributed resources in edge computing, transport, autonomic networking, dynamic spectrum sharing, beam correspondence, radio-frequency coexistence, radio-frequency interference management, dual connectivity, carrier aggregation, network and user equipment or device resource cooperation and coordination
- Realization of context-aware decision-making in autonomic networking with system-wide scope
- Self-description, and self-advertisement of NE and NF for auto-discovery by other functional entities in a service based framework

Network Data Layer

Network Data Layer

- Enablement of the management of network data as a critical aspect of the Operational Support System (OSS) for an efficient enablement of cloud-native architectural tenets associated with Network Function Virtualization (NFV).
- Enablement of both stateful and stateless services in a service based framework, built on NFV principles with VNFs, and a path for transitioning away from proprietary storage hardware

Usage Scenarios

- Separation of data processing and data storage to suit flexible cloud-native arrangements
- Stateful and stateless services support in a service based framework
- Support for diverse and distributed end-to-end system deployment arrangement, through a unified data management fabric for handling both structured and unstructured data
- Analytics, Orchestration, Assurance, Fulfillment, Autonomic Networking

Virtualization in the RAN

Virtualization in the RAN

- Decoupling of radio layer programmable functions from the underlying hardware platforms through virtualization in terms of network slicing
- Realization of a dynamic and optimized scaling of computing, storage and networking resources through self-CHOP behaviours of autonomic networking with system-wide scope
- Interoperable interfaces between the physical and baseband radio layers for enabling malleable deployment choices

Usage Scenarios

- Radio network resource sharing across multiple tenants, through network slicing (e.g. flexible disaggregation of the radio network)
- Enhanced feasibility in terms of the development and deployment of innovative services to create and serve new markets, as well as to adapt to changing and evolving market demands.
- Intelligent, open, virtualized and fully interoperable mobile networks with dynamic spectrum sharing to optimize coverage and capacity for NSPs and SPs, leveraging cognitive capabilities in autonomic networking
- Leveraging of decentralized SDN controllers in the control layer for a programmable

Multi-Access Edge Computing

Multi-Access Edge Computing

- *Multi-access Edge Computing (MEC):* Enablement of computing, storage, and networking resources at the network edge consisting of terrestrial, non-terrestrial, fixed-wireless categories of technology access for a virtualized, distributed, and logically distinct sub-networks between the core network and human or machine type devices/equipment.
- Leveraging of microservices for a virtualization of deployment-specific collection of converged radio-access technologies for a realization of customizable and interoperable levels of flexibility and granularity of network slices
- Alleviation of the overhead associated with the utilization of computing, storage, and networking resources that are located in a centralized or a remote cloud, for an optimized resource utilization and an augmented service quality and experience, associated with diverse KPI demands

Usage Scenarios

- *Personalized quality of experience:* Rendering over human and machine interfaces, and distributed resources
- *Automotive:* Navigation, diagnostics, real-time situational awareness
- *Retail:* ML based analytics for an engaging customer experience
- *Security:* ML based security solutions (e.g. business, public services
- *Gaming eXtended Reality (XR):* Immersive AR/VR platforms
- *Smart City:* Vehicular traffic optimization, clean environment, safety

Distributed Ledger Technology

Distributed Ledger Technology

- *Distributed Ledger Technology (DLT):* Enablement of a secure, decentralized, and distributed database for accessing and modifying entries associated with virtual or physical resources associated with a given distributed ledger.
- DLT utilizes distributed cryptographic data processing techniques, broadly classified as a blockchain protocol, in a permissioned (private or known entities) or permission-less (public) mode, where trust is established in both modes as an implicit aspect of the process. The permissioned mode is simpler and adaptable for practical applications, as well as being compatible with system-wide autonomic networking for automation.
- Facilitation of an avoidance of overhead associated with brokers or intermediaries for the oversight of transactions between any two entities or among a defined group of entities that share a distributed ledger.

Usage Scenarios

- Enablement of a zero-CAPEX environment via a Common Marketplace platform consisting of a secure distributed environment for engaging multi-domain (e.g. NSPs and SPs) partnerships and collaboration for service innovation (e.g. services over MEC).
- Minimization of latencies and the costs associated with data access or exchange, through the use of a Smart Contract (SC), which automatically adapts and executes configured actions and service level agreement among different domains in a federation of partners.

Vertical Market

Vertical Market

- Enablement of seamless service experience through a common API framework, whether the service usage utilizes connectivity over a home network domain or over a roaming network domain
- Coordination of resources across multiple cooperating domains, where network slicing serves as a logical scheme that harnesses a dynamically or statically configured set of distributed resources, to enable a realization of diverse and innovative services
- Leveraging of autonomic networking capabilities for service orchestration and fulfillment of KPIs across diverse, cooperating domains to support an emerging Vertical market

Usage Scenarios

- Few example categories among a myriad of emerging Verticals:
  - *eHealth, Autonomous Vehicles, Industrial Automation, Food and Agriculture*
  - *Energy, Utilities, Learning, Media, Government, Public Transportation*
  - *Entertainment, Public Safety, Weather*
  - *Services aligned with the vision of the UNSDGs (Sustainable Development Goals) over human and machine interfaces*

End-to-End Security

End-to-End Security

- The enablement of security in a 5G system consists of different components of security that include network access security, network domain security, user domain security, application domain security, visibility, and configurability of security.
- Leveraging of 4G cryptographic algorithms for a 5G system, with the use of the same key length of 128-bit for the protection of the control plane, user plane and RRC signalling.
- Studies are in-progress to extend the key length for 256-bit protection over the air interface in the future.

Usage Scenarios

- Applicability across the features and capabilities in the end-to-end architectural framework:
  - *Autonomic Networking*
  - *Network Data Layer*
  - *AI and ML*
  - *Virtualization in the RAN*
  - *MEC*
  - *DLT*
  - *Vertical Market*
  - *Privacy*


THANK YOU