Coherent: introducing a reference architecture for Digital Twin Networks

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Coherent project summary

The Coherent project, under the scope of S1 "Disruptive Architectures and Platforms" - SPOKE 6, aims to develop an integrated architecture from both technical and business perspectives [1], collaborating with RESTART initiatives such as S8, S9, and S14. It utilizes Digital Twins (DTs) for predictive network management, ensuring dynamic behavior aligned with strategic goals, including ethical considerations measured through Key Value Indicators (KVIs) [2]. Coherent commits to defining and managing KVs and KVIs within the network ecosystem, facilitating communication between different actors and domains, aiming to develop methodologies to achieve KVs at both local and global levels. Additionally, it aims to implement serverless computing and deviceless operations, emphasizing network autonomy. Beyond these goals, the project seeks to implement Service Level Agreements (SLAs) [4] and develop an integration platform to achieve these objectives, ensuring efficient and cohesive management of network resources and processes.

Abstract

The poster outlines the proposed reference architecture for Digital Twin Networks (DTNs) developed within Coherent projects, that aims to manage the lifecycle and interactions of Digital Twins representing a communication network, creating a comprehensive digital representation of telecommunication networks. This architecture aspires to enhance network adaptability and responsiveness through intent-based communication and advanced functionalities like reliability management and Key-Value evaluation.

Integration Platform

NS Controller:
- ❑ The **Digital Twin Manager** oversees the lifecycle of digital twin instances, handling their creation, removal, and providing detailed lists of pods and deployments within namespaces.
- ❑ The **Network Manager** is responsible for managing connections between digital twins.
- ❑ The **Platform Manager** performs key tasks such as retrieving lists of available nodes and services, managing links between digital twins and real-world objects, and handling resource lifecycle and configurations.

NS DT:
- ❑ **Digital Twins** are representations of specifically modeled physical network devices, using an Asset Administration Shell.
- ❑ **Configurations** within this namespace handle settings for connecting Digital Twins, maintaining persistent data, and linking with their physical counterparts.

NS SLA:.
- ❑ The **Intent Mapping** module translates a customer's service request into an intent, aligning high-level demands with network objectives to enhance automation and agility.
- ❑ The **SLA Module** interprets customer service requests and facilitates the establishment of Service Level Agreements (SLAs) between customers and network providers.
- ❑ The **DTN Service Marketplace** module provides a platform for accessing solutions aimed at value indicators. It offers diverse services accessible publicly or based on specific criteria.
- ❑ The **Active Service Manager** oversees the instantiation of digital twin instances
- ❑ The **Service Orchestrator** component optimizes resources and identifies optimal configurations to meet customer demands by utilizing network digital twin instances.
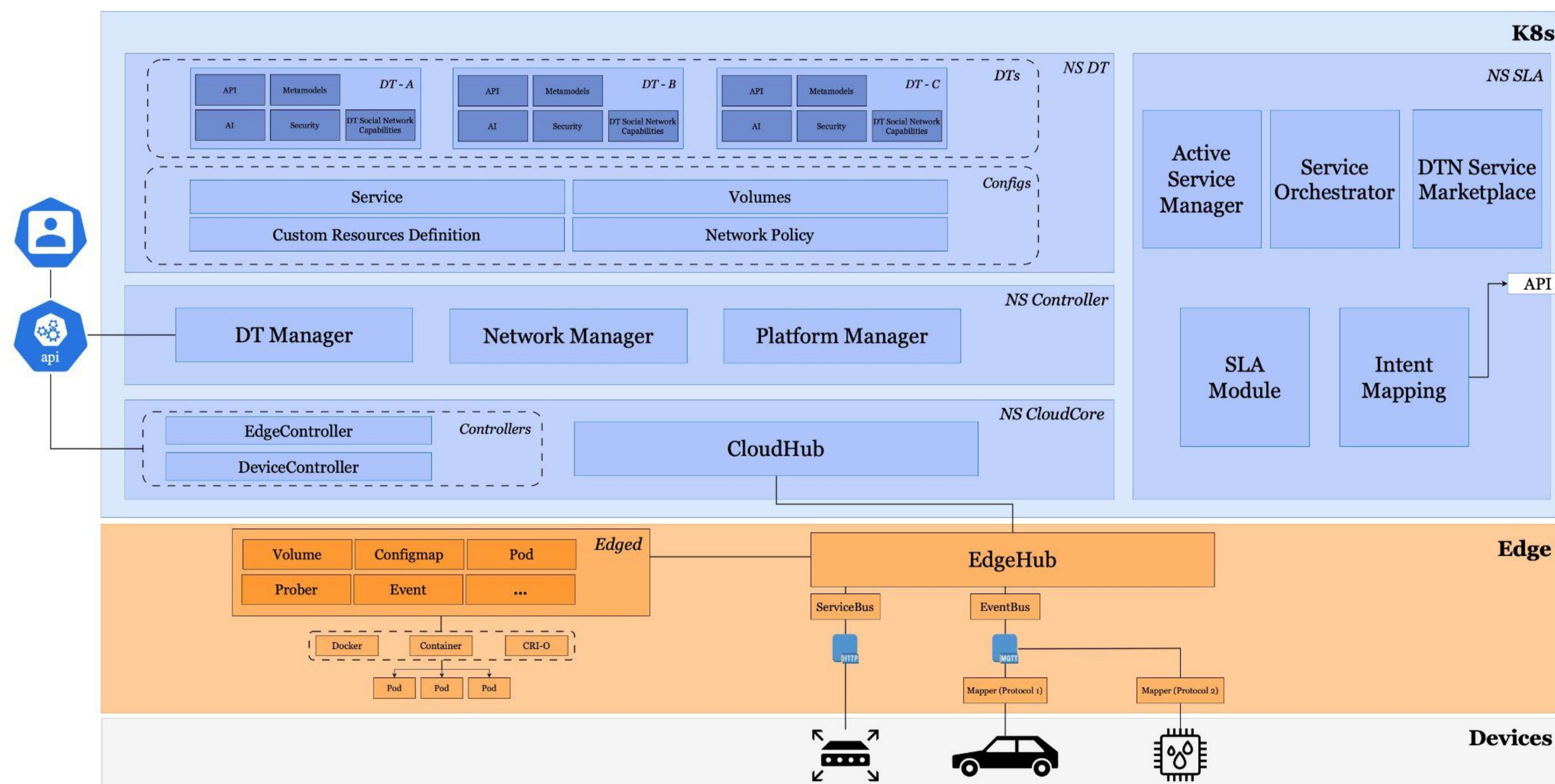
NS CloudCore:
- ❑ The **Cloud Hub** serves as the main communication hub between the cloud and edge.
- ❑ The **Edge Controller** manages and orchestrates edge nodes and devices.
- ❑ The **Device Controller** manages individual network-connected devices, handling registration, configuration, and communication.

Edge layer :
- ❑ The **Edge Hub** for local edge node management.
- ❑ The **Edge Bus** for communication with the cloud.

Service Bus and Event Buses with specialized connectors ensure seamless communication across diverse devices by translating data formats and protocols. This strategic deployment bridges cloud and edge environments, synchronizing Kubernetes functionalities and optimizing performance and scalability for edge computing applications.

Future Work

The next steps following the definition of the integration platform involve implementing a use case to test it, thereby integrating all key project components. This architecture will focus on Digital Twins and require multi-level and federated orchestration of computational and communication resources. Therefore, network components and services will be modeled and federated to ensure the required level of service. Additionally, Coherent will collaborate with other RESTART projects by participating in and organizing dissemination events and conferences.

References

[1] L. Atzori, C. Campolo, A. Iera and G. Morabito, "Toward the EthicNet: Challenges and Enablers for Ethics-Aware Networks," in IEEE Communications Magazine, November 2023.
[2] L. Pintor, L. Atzori, A. Iera, "Building the Foundations of Ethical Networks: Integrating Key Value Indicators for Social, Economic, and Environmental Impact", accepted at IEEE PIMRC'24.
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[4] F. de Trizio, G. Sciddurlo, I. Cianci, G. Piro, G. Boggia, "Optimizing Key Value Indicators in Intent-Based Networks through Digital Twins aided service orchestration mechanisms", submitted to Computer Communications (Elsevier).