Concepts of Digital Twin Network (DTN)

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Cheng Zhou (China Mobile, Presenter)
Hongwei Yang (China Mobile)
Xiaodong Duan (China Mobile)

Agenda

- Background
- Definition of Digital Twin Network
- Benefits of DTN and a simple case study
- Challenges to build DTN
- Next Steps

Background: DT + Network

Digital twin (DT) is becoming a hot technology in industry 4.0. The application of digital twin technology in network field can help realize efficient and intelligent network management and network innovation.

DT is being widely used in Industry

- Aerospace
- Power system and wastewater plant
- Healthcare
- Oil/gas facilities
- Automatic vehicles
- Wind farm
- etc.

[Tao2019] Tao, F., Zhang, H., Liu, A., and A. Nee, "Digital Twin in Industry: State-of-the-Art. IEEE Transactions on Industrial Informatics, vol. 15, no. 4.", April 2019.

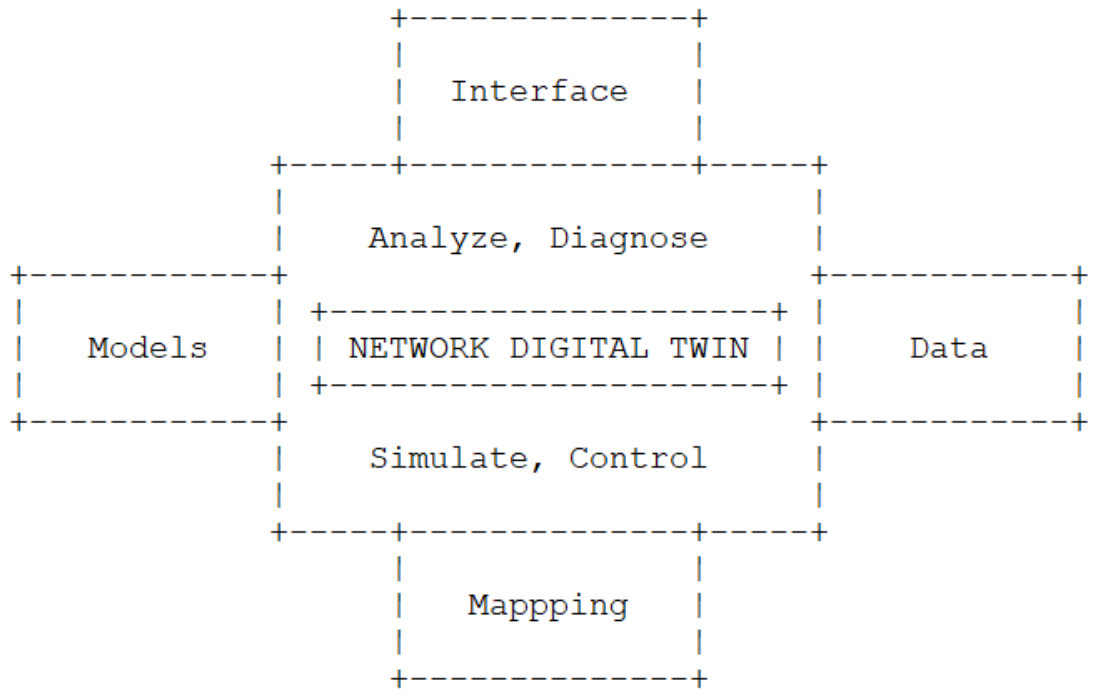
"DT + Network" just started

- **NetBrain/Cisco:** "Dynamic Maps" creates real-time network digital twin.
- **Huawei:** "NCE (Network Cloud Engine, NCE)" creates digital twin between physical network and business intent based on AI, BigData and Cloud.
- **Aria Networks:** "STEP-T" builds digital twin entity based on teleoperator's backbone network.

Definition of Digital Twin Network

- **Reference definition in this I-D:** a virtual representation of the physical network, analyzing, diagnosing, simulating and controlling the physical network based on data, model and interface, so as to achieve the real-time interactive mapping between physical network and virtual twin network.

- **Four key characteristics of DTN**
  - **Data:** cornerstone for constructing a DTN system
  - **Model:** the ability source of DTN
  - **Mapping:** real-time interactive mapping between physical network and virtual twin network
  - **Interface:** key enabler to ensure the compatibility and scalability of DTN



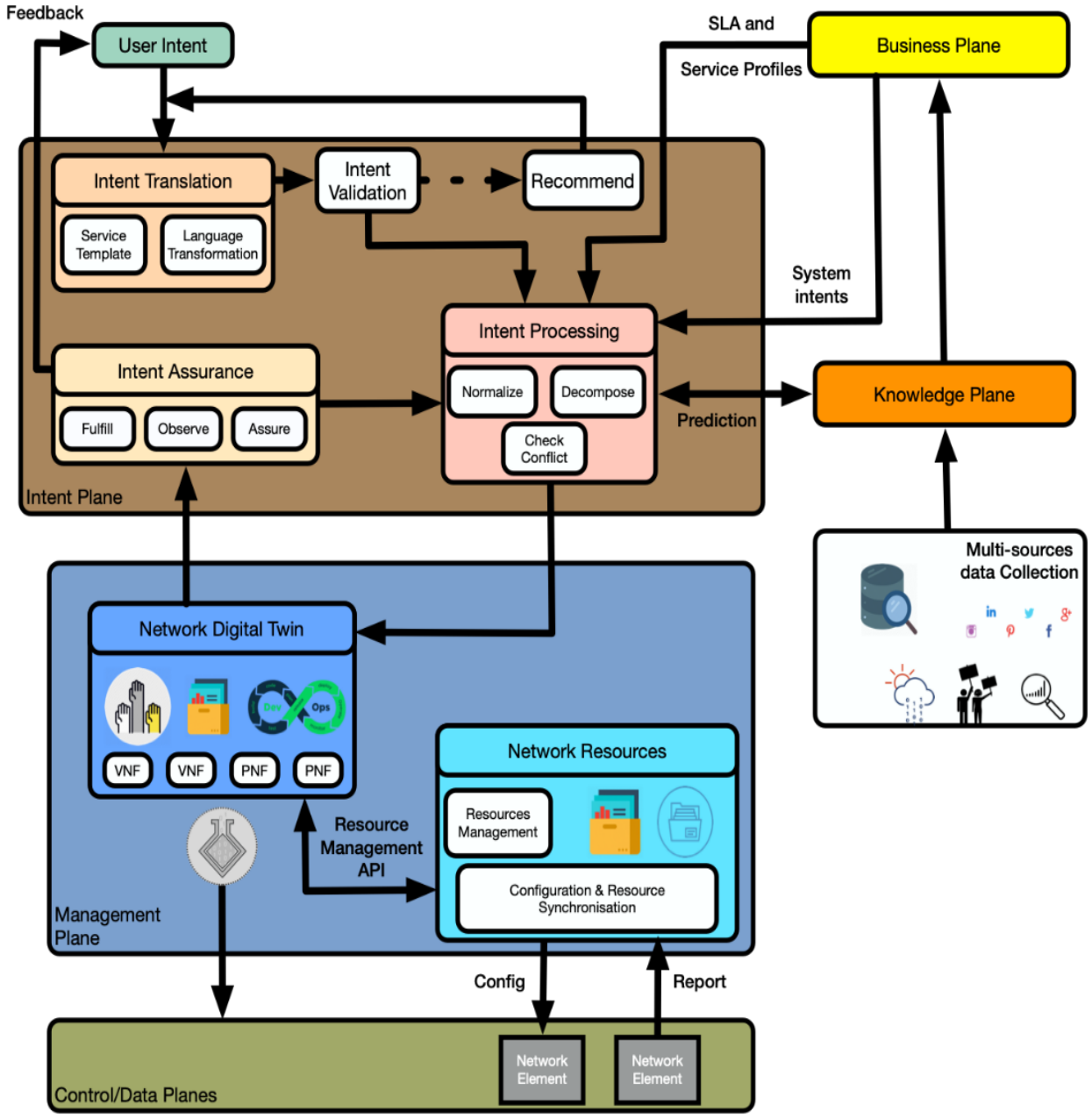
Benefits of Digital Twin Network

DTN can help enable closed-loop network management across the entire lifecycle, from digital deployment and simulation, to visualized assessment, physical deployment, and continuous verification.

Key Benefits	Without DTN (As is)	With DTN (Will be)
#1: Lower the cost of network optimization	• No interactive platform for simulation • Longer time cost and higher OpEX • Higher service impact on real network	• Effective platform for simulation • Lower time cost and lower OpEX • Lower service impact on real network
#2: More intelligent for network decision making	• Focus on managing current data • passive and protective maintenance	• Using AI, BigData to analyzing past data, current data as well as predict future status. • provide more comprehensive decision support to achieve predictive maintenance
#3: High efficient for network innovation	• Higher trial risk due to lack of real network environment; • Slow on deploying new innovations (e.g. IBN, Network AI, etc.) on risk-averse network operators.	• Effective virtual twin network is more easier to access for researchers; • Speed up network innovations from prototype to deployment.

A Case Study
- DTN as Enabler for IBN

- IBN is being discussed in many SDOs (IETF, ITU-T, ETSI, etc.).
- IBN system requires that user's intent can be assured automatically via continuously adjusting the policies and validating the real-time situation.
- Intent assurance and policy validation can be simulated in Network Digital Twin entity, as suggested in IBN framework of ITU-T FG Network 2030.



ITU-T FG Network 2030: Framework of Intent-Based Networking
https://www.itu.int/en/ITU-T/focusgroups/net2030/Documents/Network_2030_Architecture-framework.pdf
From Technical Specification "Network 2030 Architecture Framework" , June, 2020.

Challenges to build Digital Twin Network

- **Large scale challenge:** The digital twin entity of large-scale network will significantly increase the complexity of data acquisition and storage, the design and implementation of model. And the requirements of software and hardware of the system will be very high.
- **Compatibility issue:** It is difficult to establish a unified digital twin platform with unified data model in the whole network domains due to the inconsistency of technical implementation and supporting functionalities of different manufacturers' devices in the network.
- **Data modeling difficulties:** Based on large-scale network data, data modeling should not only focus on ensuring the richness of model functions, but also need to consider the flexibility and scalability of the model. These requirements further increase the difficulty of building efficient and hierarchical functional data models.
- **Real-time requirement:** The processing of model simulation and verification through DTN system will increase the service delay, so the function and process of the data model need to design efficient and timely mechanism to handle various network applications.
- **Security risks:** Network digital twin entity synchronizes all data of physical network in real time, which will increase the security risk of user data, such as information leakage or more vulnerable to attack.

Next Steps

- To investigate more use cases and requirements of DTN.
- To work on a reference framework of DTN system.
- To study key enabling technologies (e.g. data collection, data modeling, network visualization, etc.) to build DTN system.

- **Welcome to join our work, and any comments are welcome!**