IRTF NMRG Virtual Interim

Network Digital Twin : Concepts and Reference Architecture

draft-irtf-nmrg-network-digital-twin-arch-04

February 6, 2024

Open Discussion Items

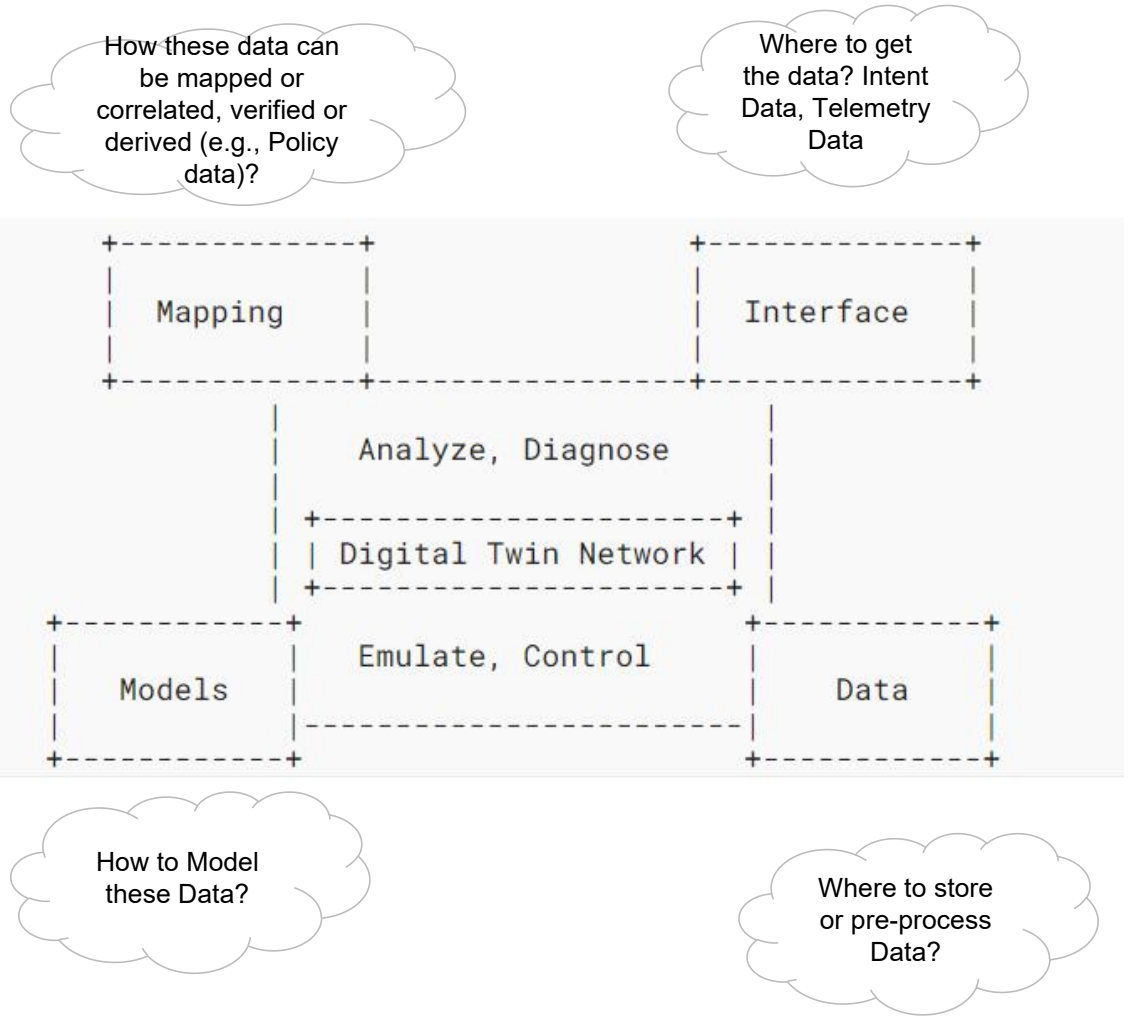
- Definition update: NDT replacing DTN?
- Key characteristics and elements of NDT
- The Scope of NDT
  - Realtime, and bi-directional interaction
- Ucs of NDT
- Relationship with ZSM?
- Future research directions

Definition: Using NDT instead of DTN?

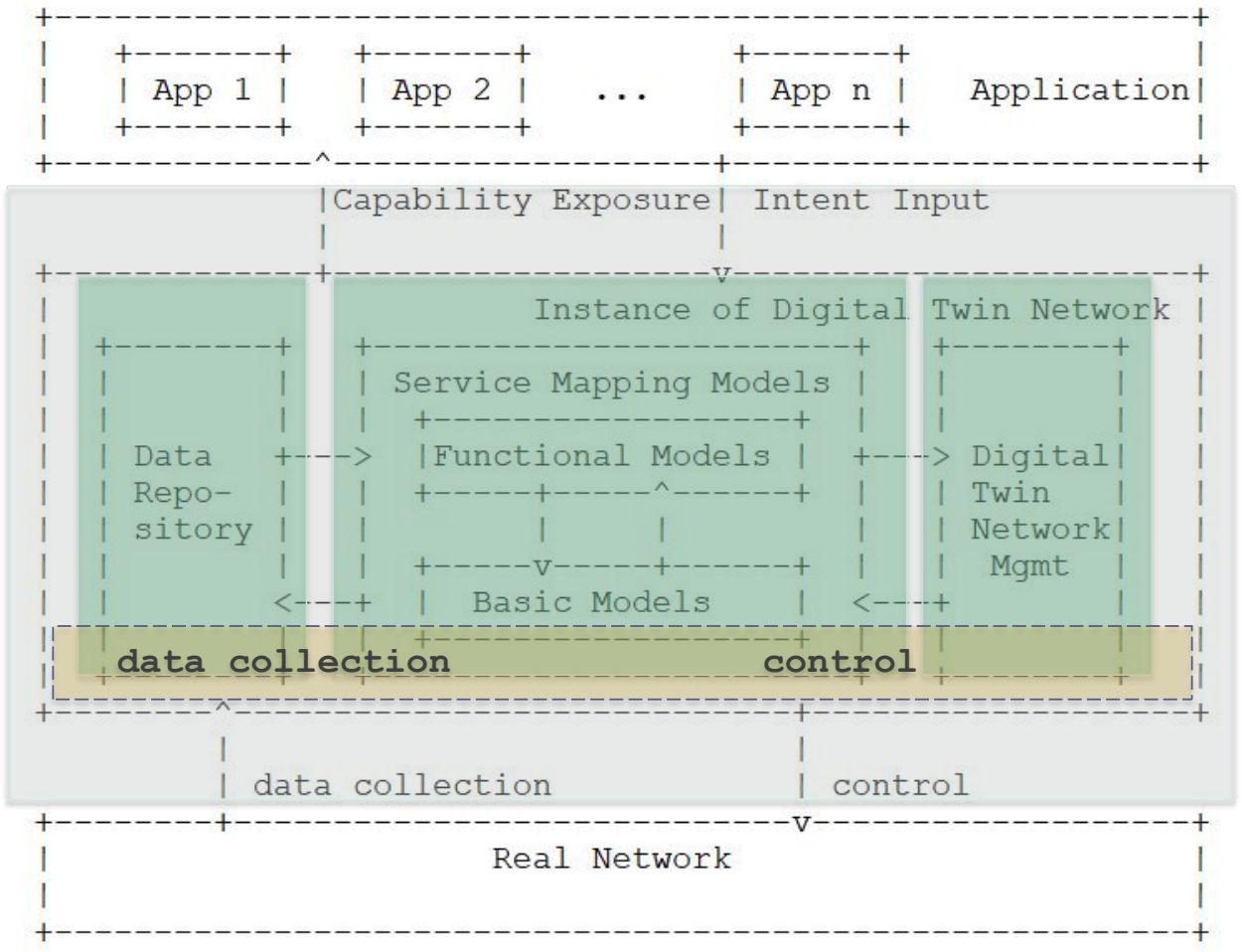
- Update on definition
  - Digital Twin: Digital counterpart of a physical system (twin) that capture its attributes, behaviour and interactions and is continually updated with the latter's performance, maintenance, and health status data throughout the physical system's life cycle.
  - **Network digital twin (NDT)**: A digital representation that is used in the context of networking and whose physical counterpart is telecom network or enterprise network. Such virtual representation is able to analyze, diagnose, emulate, and control the real network via interactive mapping. This is also called, digital twin for networks.
- Key characteristics of NDT: more than a network simulator or emulation platform!
  - **Network Observability:** more than monitoring, it allows you ask why and fix the problem;
  - **Optimal policy generation and pre-verification:** analyze, diagnose with network intelligent modelling; verification
  - **Virtual-real interaction mapping and closed-loop network automation:** two-way interfaces

Key Elements of NDT

- **Data:** cornerstone for constructing an NDT system
  - Target driven and on-demand collection
  - Including data from 3rd-party sources (NMS, Data lakes, Simulator, etc.)
- **Model:** the ability source of NDT
  - Various modelling methods for decision making
  - Pre-verification before implying the decisions
- **Mapping:** between physical and twin network
  - real-time interactive
  - one to one, or one to many
- **Interface:** ensure the compatibility and scalability
  - between physical and twin network
  - between twin network and applications



Scope of NDT



- **A complete NDT system including three layer:** real network, twin network and applications.
- **NDT focuses on twin layer and interfaces** (grey part); real network and applications are out of research scope of this document/draft.
- **Enhance points:**
  - ① Inner closed-loop: iterative simulation and verification in twin layer.
  - ② Outer closed-loop validation and optimization.
  - ③ Orchestration for models and resources should be included in NDT mgmt module
  - ④ Optional sub-layer: for data collection and control; or embedded in NDT mgmt module.

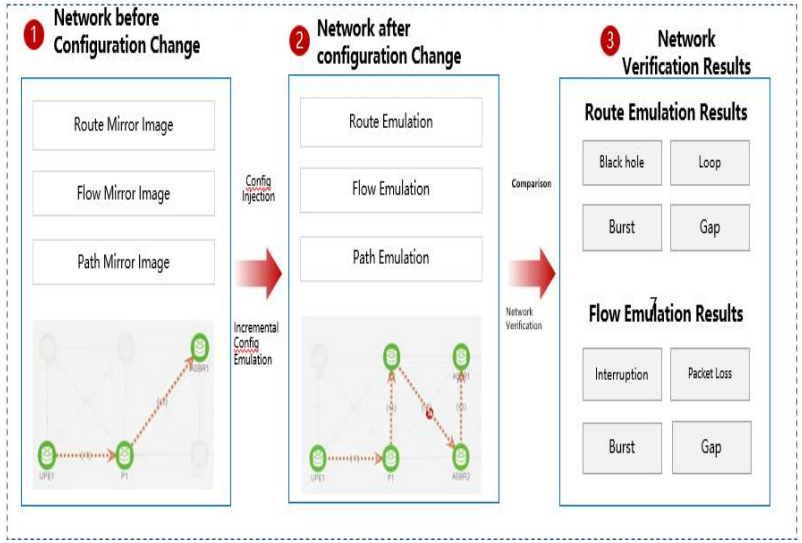
Realtime, and Bi-directional interaction

- **Realtime**
  - Not always required for all scenarios
  - **Online NDT：** Continuous data exchange occurs between twin network and physical network
    - only for scenarios requiring real-time decisions;
    - nearly real-time, second, and minute can also be options.
  - **Offline NDT:** offline simulate/analyse/predict, utilizing historical data, simulations, and pre-built models of the physical network

- **Bi-directional interaction: same meaning as ‘two-way’ interaction**
  - Not always required for all scenarios, only required for online NDT
  - Physical to Twin: network data
  - Twin to Physical: mostly network control, and sometimes network data (e.g. injecting defensive data or packets)

UCs of NDT

UC 1: Network Configuration Change Evaluation

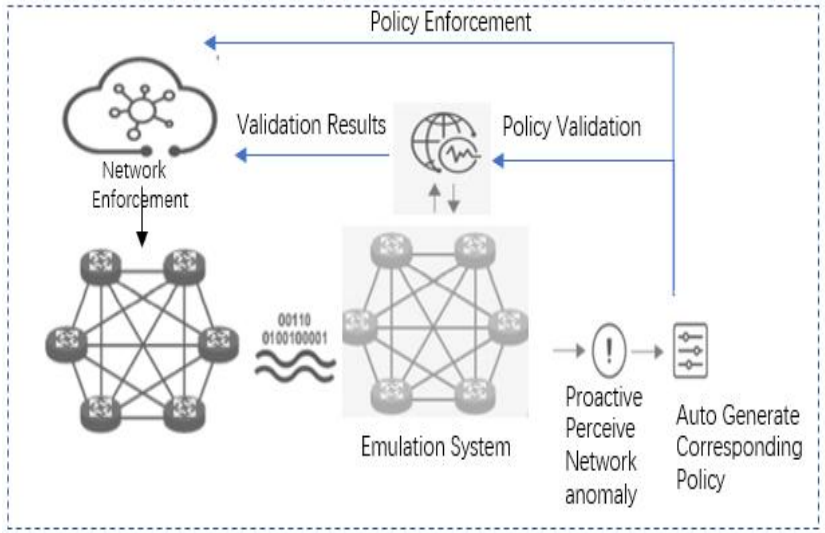


Route Correct Verification

Network Connectivity Verification

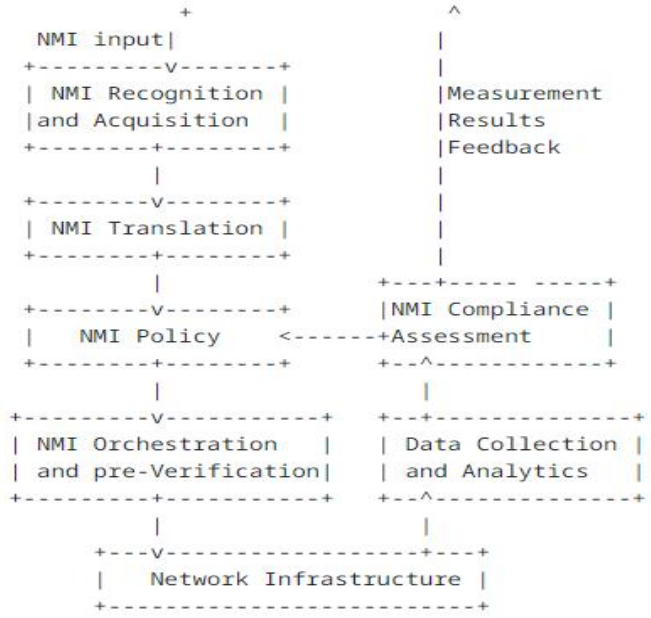
Configuration Consistency Verification

UC 2: Network Policy Verification and Network Optimization



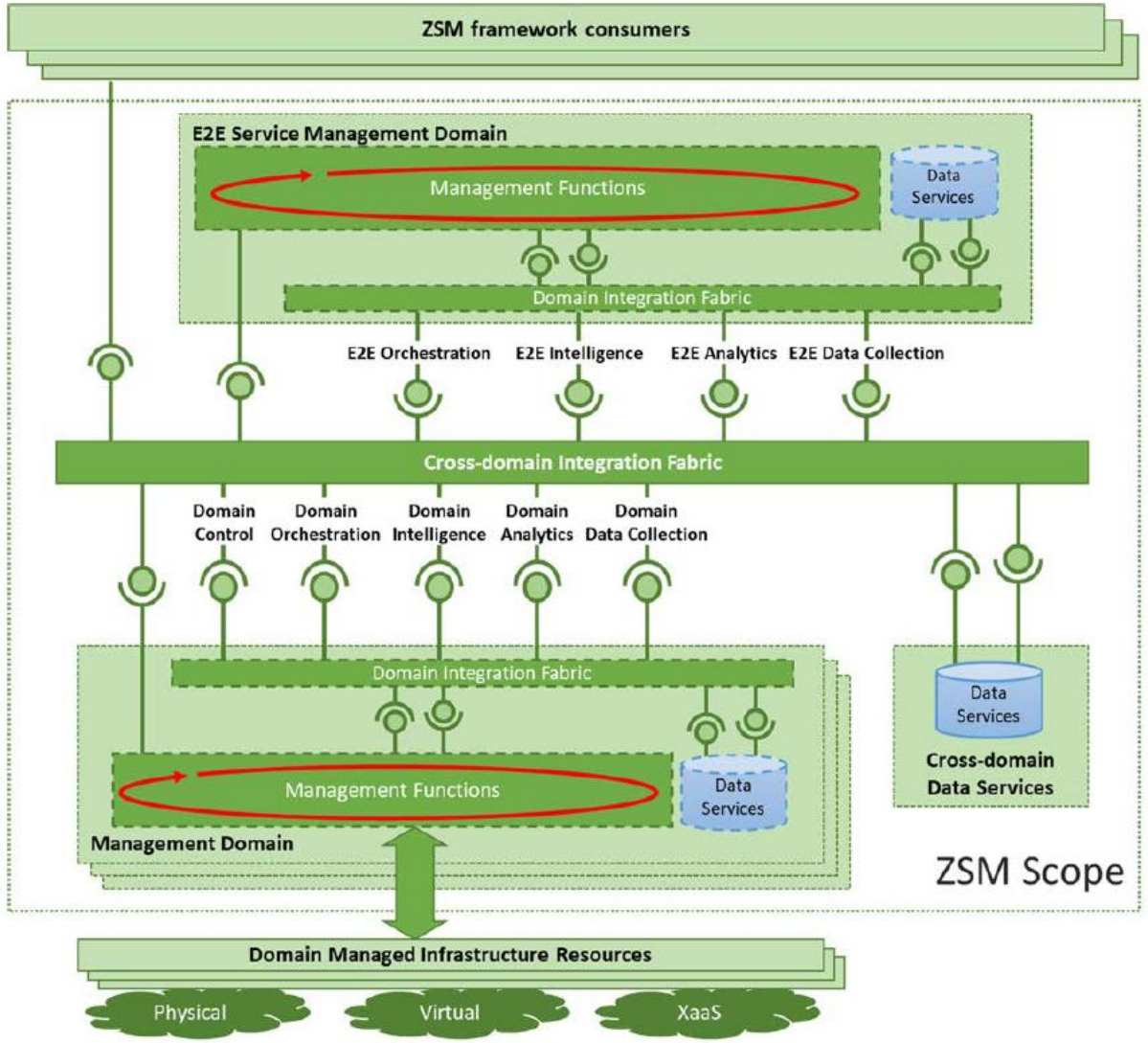
Automatically adjust the speed of low-priority service path, and relieves partial congestion when Link traffic exceeds the limit

UC 3: Measurement Intent Verification



Source: https://datatracker.ietf.org/doc/draft-yang-nmrg-network-measurement-intent/

Relationship with ZSM?



- Both ZSM and NDT are candidate solutions to achieve autonomous network
- ZSM for NDT
  - Data, data collection/control and orchestration can server for building NDT
- NDT for ZSM
  - integrating more NDT capabilities, including simulation/emulation, high fidelity of modelling, pre-validation, ‘real time’ decision making

Backup

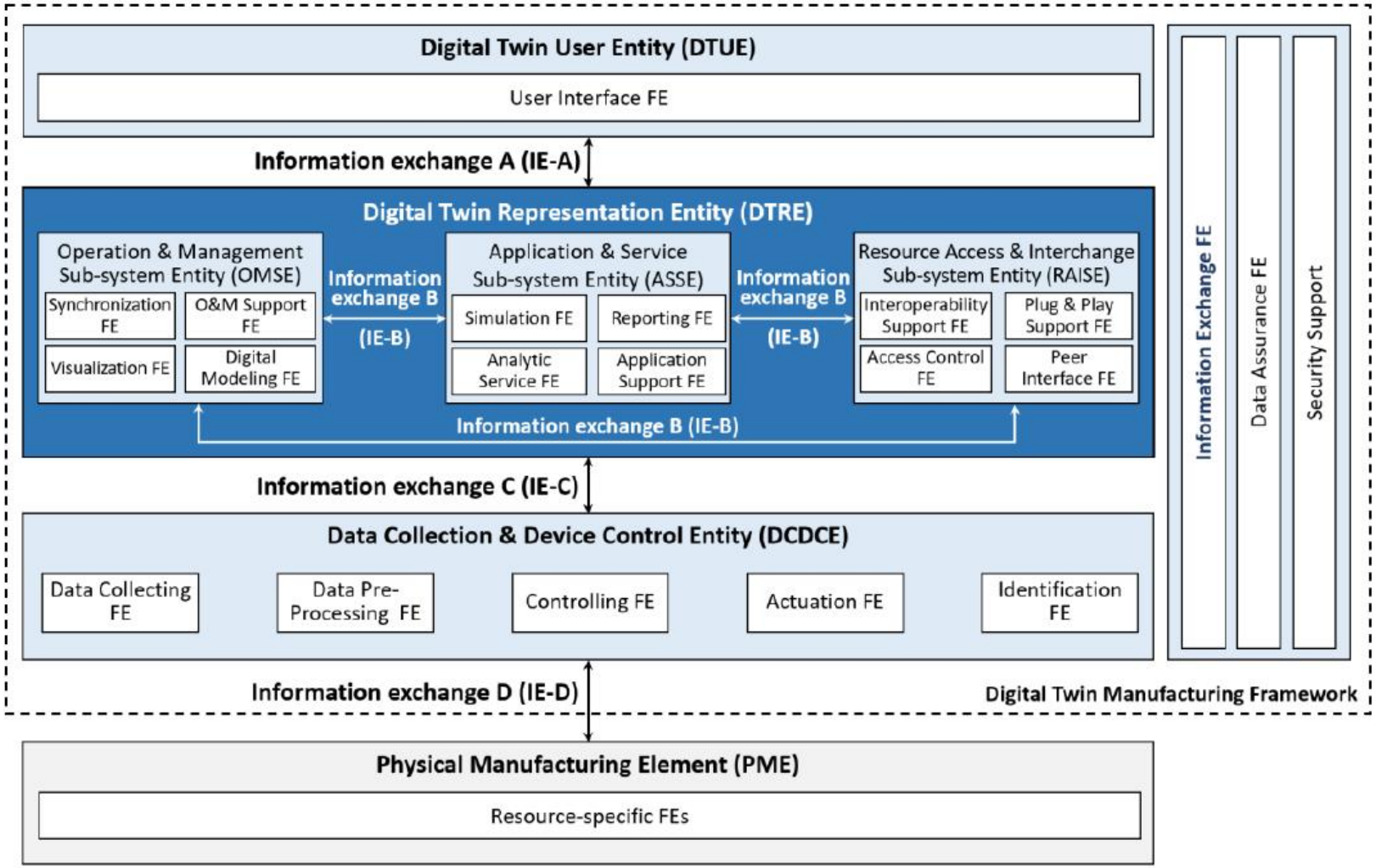
Next Steps

- **Research Directions**
  - How can DTN integrate and evolve with legacy network management system?
  - How can ‘knowledge’ be injected to network digital twin to help achieve vision of ‘autonomous network’ ?
  - More assessment to quantify the gain brought by DTN to Network management?
  - etc.

- **Goals**
  - **Record all open issues (Prioritize the Arch-draft related ones) and track them on GitHub?**
  - **By IETF #120,** enhance the document via fixing all issues, then promote for informational RFC

Backup

DTM Framework - for reference



ISO/CD 23247: *Digital Twin manufacturing framework - Part 2: Reference architecture*