Digital Twin Network: Concepts and Reference Architecture

draft-irtf-nmrg-network-digital-twin-arch-01

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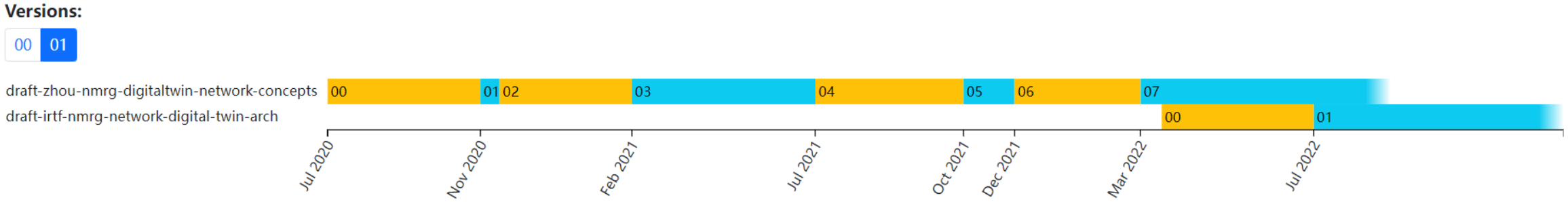
Change Log



- **RG Adoption:**
  - draft-irtf-nmrg-network-digital-twin-arch-00, adopted, Mar, 2022

- **Major changes in -01**
  - Add new section of ‘Enabling Technologies to Build Digital Twin Network’

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  - Closed several open issues and made some editorial changes.

Data Collection and Data Management

- **Data types**
  - Configurations, running status, and service data.
  - Data plane, control plane, and managment plane.
- **Data collection**
  - Target-driven and on-demand
  - Diversified tools for variours types of data
    - Legacy and current tools: SNMP, NETCONF, IPFIX, Telemetry, INT, etc.
    - Innovative tools: sketch-based measurement, iFIT (In-situ Flow Information Telemetry)/iOAM, IFL (Inband Flow Learning), etc.
  - Light-weight with high-efficiency
- **Data management**
  - Data warehouse techs
  - Data services: fast search, batch-data handling, conflict avoidance
  - Unified interfaces for data exchange

Network Modeling

Comparisons between networking modeling methods

Modeling Types		Examples	Pros	Cons
Simulation/Emulation		NS-2, NS-3, OPNET, MiniNET/EVE-NG, GNS-3	•Event/packet driven, •Easy to deploy for small scale network, •Easy for functional evaluation	•High computation cost, •Not suitable for large scale network, •Hardefor performance evaluation
Virtualization Technologies (NFV, Containers, etc.)		MS's CrystalNet, Arista's CVP (Cloud Vision Portal)	•Quick construction for full twin network, •Easy for functional evaluation, •High-fidelity	•Needs virtual OS (low availability of virtual NE system); •Hard for performance simulation; •Huge resource consumption.
Mathematical Modeling	**Formal methods**	Veriflow, Batfish ,DNA, etc.	•Low resource cost •Fast calculation •More suitable for data plane/control plane evaluation	•Limited extensibility •Hard for performance evaluation
	Theory of bottleneck structures	[G2-SIGCOMM]	•Low resource cost •Fast calculation	•Limited extensibility •Hard for functional/protocol evaluation
	Data Driven - AI/ML Algorithms	[RouteNet], [MimicNet], [xNET], [xWeaver], [DeepComNet], etc.	•High efficiency, •High accuracy on performance evaluation	•Hard to validate new protocols, •Data are 'expensive' to acquire, •Low interpretability of AI models

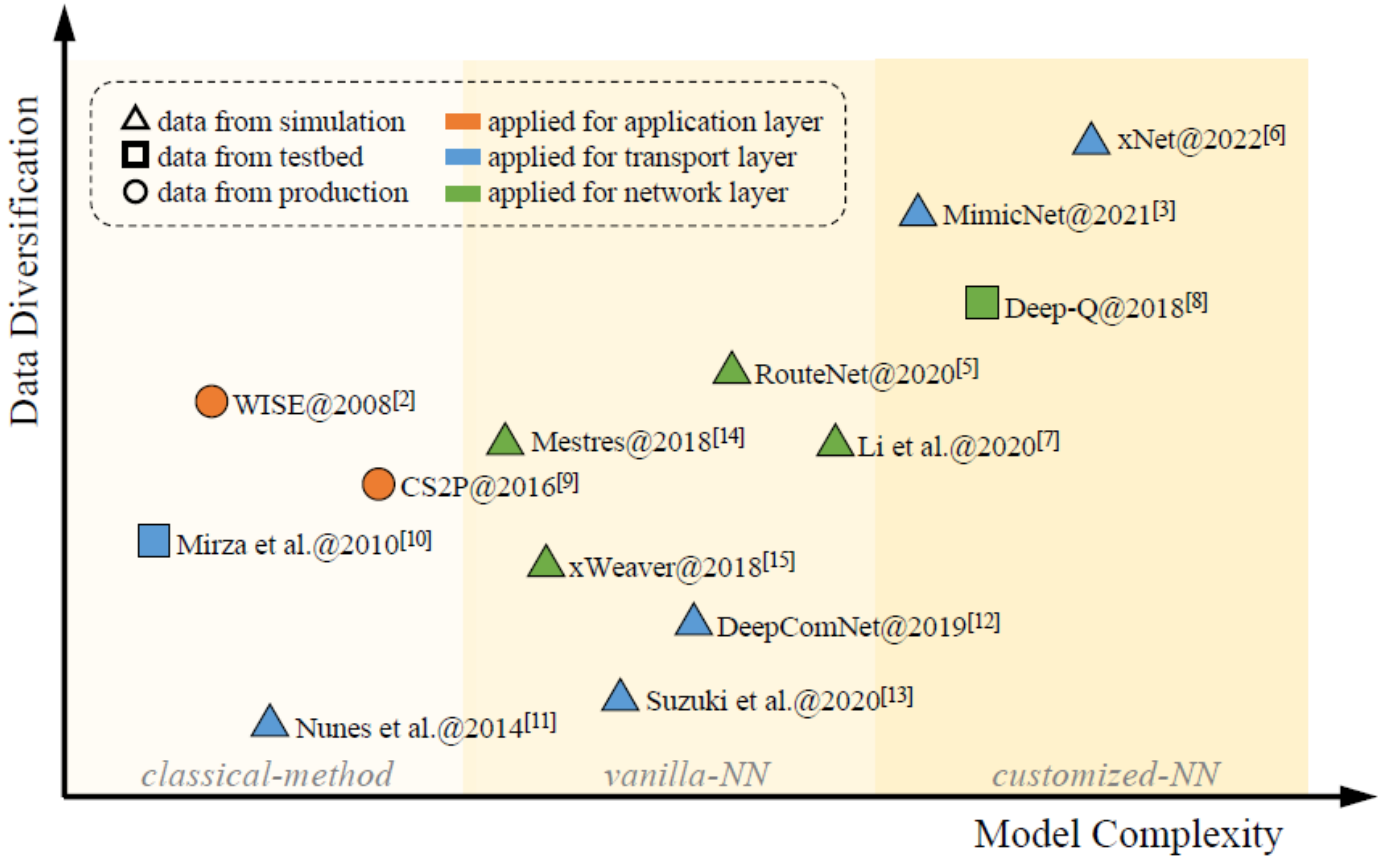
•Notes: YANG modeling can be a common method to describing a network equipment with simple structured language

Recommendation: Multiple methods can be in combination to build a comprehensive DTN system.

Network Modeling - Cont.

Digital Twin for Networking: A Data-driven Performance Modeling Perspective

- For "What-if" performance evaluation, data-driven methods are most promising, comparing with simulation and analytical approaches
- Three requirements (fidelity, efficiency, and flexibility) for performance evaluation
- Present a comparison of selected data-driven methods and investigate their potential trends in data, models, and applications



Hui, L., Wang, M., Zhang, L., Lu, L., & Cui, Y. (2022). Digital Twin for Networking: A Data-driven Performance Modeling Perspective. ArXiv, abs/2206.00310.

Network Visualization

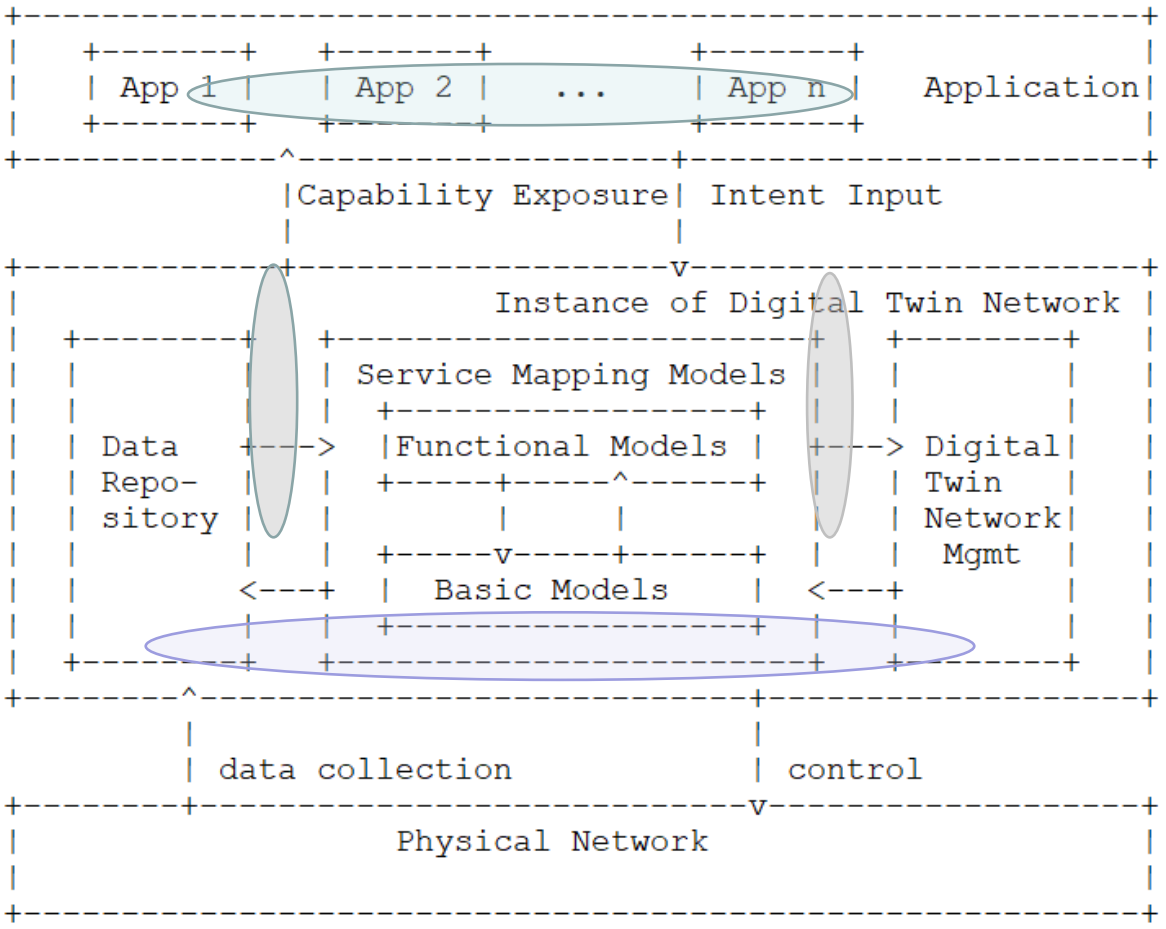
Help users better understand the internal structure of the network, and mine valuable information hidden in the network.

- **Network topology visuability**
  - Acquire topology data using solutions provided in [RFC8345], [RFC8346], [RFC8944]
  - Hierarchical layout, heuristic layout or force-oriented layout
- **Modelling visuability**
  - Increace the interpretability of AI models.
  - Present the creation of model instances, data loading, simulation process, and verification results of the models
- **Interaction methods**
  - The data query technology such as SPARQL to express queries across diverse data sources
  - Visual dynamic interation: direct interaction, focus plus context interaction, relevance interaction and immersive simulation; XR (AR, VR and MR) etc.

Interfaces

- **Candidate options for three types of Interfaces on building DTN system**

Types	Requirements	Candidate options
Northbound	Open, Standardized, Extensible	RESTFul, RESTCONF
Internal	Open, Standardized, Fast and efficient	XMPP (RFC7622), and HTTP/3.0 (RFC9114)
Southbound	Open, Standardized, Light weighted	SNMP, NetConf



Next Steps

- To dig deep on each enabling technology
- To build a digital twin network system on trial network, and validate the gains against specific use cases.
- We also welcome proposals to enhance the document.

- **Your comments are always welcome!**