# IRTF NMRG Meeting

## Network Digital Twin : Concepts and Reference Architecture

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

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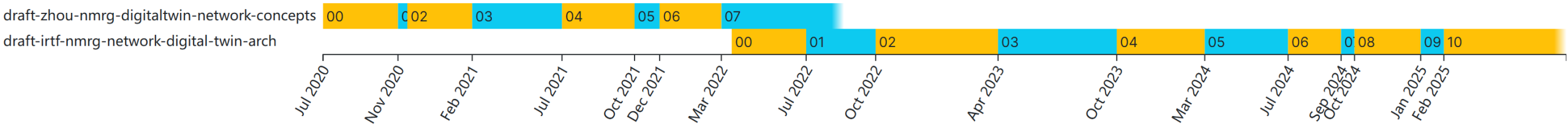
# Recap



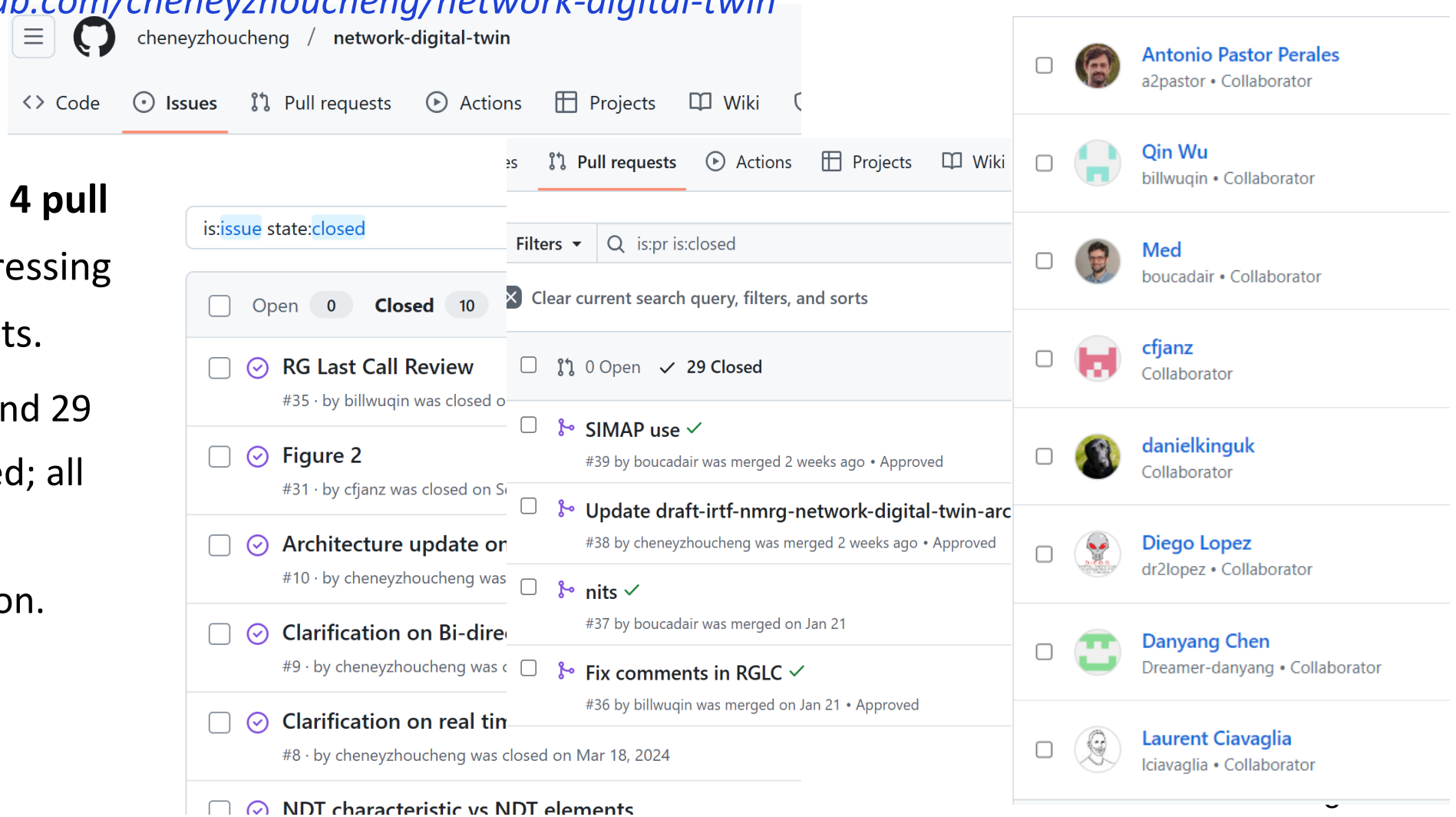

- The publication process started via Last Call in November 2024, after fixed all open issues raised in NMRG meetings, mailing list and github.
  - Specifically, collaborated with ETSI ZSM to align the concept, definition and reference architecture of NDT.

- **RG Last Call.**
  - From Nov 11 to Dec 20, 2024
  - Thanks Wei Wang, Ziyang Xing, Jinjie Yan, Gao Xing for the support and comments.
  - Comments are of citations, NDT elements clarification, spellings, etc..

- Discussions and cooperations (via mails and Github) between authors and contributors to address the call comments.

# GitHub Activity

- Github Repository for NDT co-design
  - *https://github.com/cheneyzhoucheng/network-digital-twin*




- **1 open issue and 4 pull requests** for addressing Last call comments.
- Totally 10 issues and 29 pull requests raised; all were closed after sufficient discussion.

# Latest Updates

- The latest update is v-(10), changes compared to the previous version:
  - Added more citations on Digital Twin and Network Digital Twin
  - Refined Elements in **Section 4**
  - Numerous editorial and general readability updates

# Section 3&5&9: Added more citations

- More citations on digital twin and NDT
  - **ISO** Concepts and terminology on DT
  - **Papers:**
    - Digital twin applications toward industry 4.0: A review
    - Digital twin-based anomaly detection for real-time tool condition monitoring in machining
    - Digital Twin Empowered Wireless Healthcare Monitoring for Smart Home
    - etc.
  - **Academic workshops:** IEEE NOMS – TNT2023&2024 workshops
- Citation on SDN
  - RFC 7149 and 7426
- Citation on network modeling
  - ietf-nmop-simap: multi-layered data models on operator's networks and service and Infrastructure.

*Citation comments from Ziyang Xing – last call*

1.In section 3.1
It is recommended to use the latest version of ISO (ISO-2023) and avoid using older versions (ISO-2021) for Digital twin.
https://www.iso.org/standard/81442.html
2.In section 3.2
Suggest the authors to further summarize some of the latest literature, such as 2023 and 2024. And it is necessary to classify the literature.
https://www.sciencedirect.com/science/article/pii/S2667241323000137
https://www.sciencedirect.com/science/article/pii/S0045782523007089
https://ieeexplore-ieee-org/abstract/document/10234616/
https://www.sciencedirect.com/science/article/pii/S0736584523000832
https://ieeexplore-ieee-org/abstract/document/10234399/
https://www.sciencedirect.com/science/article/pii/S0278612524001298
3.In section 5
Please give a full name for SDN or its rfc URL.

# Section 4: Refine key elements of NDT

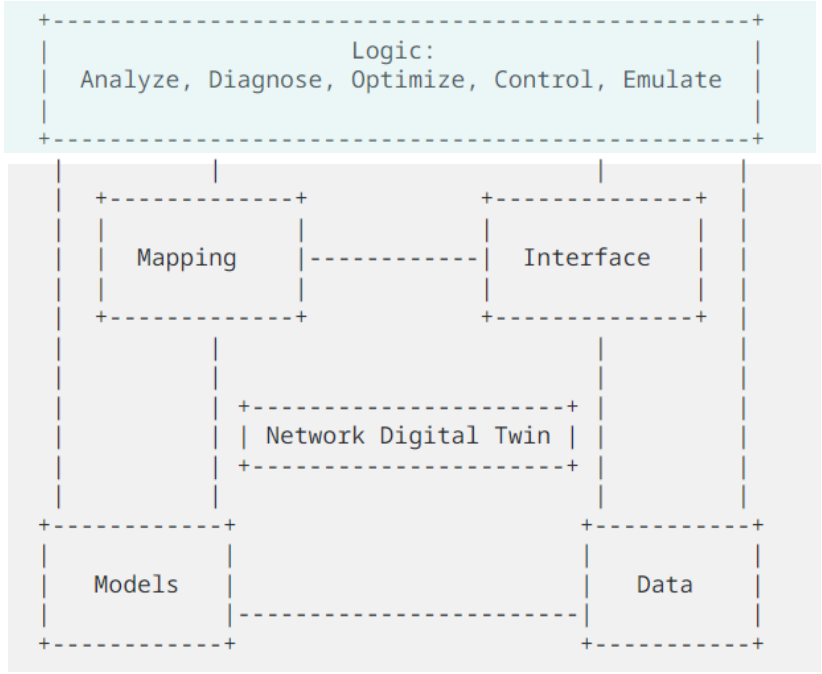



Figure 1: Key Elements of Network Digital Twin

*Comments on Section4 from Ziyang and Yanjie – last call*

The draft provides a comprehensive overview of the concept of Network Digital Twin, its reference architecture, application scenarios, and major challenges.

… …

To further improve the completeness of the draft, I suggest that Section 4 could be further refined. It would be helpful to clarify the interactions between each element, enabling readers to better understand the roles of the elements and how they collaborate.

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3.In section 4
Add arrows to Figure 1, as in Figure 2 - 3.

- **Refined texts:** combined paragraphs to remove redundance; Moved element ‘Logic’ forward, ensuring a unified description of the 5 elements.
- **Figure 1 doesn’t aim at providing working flow, instead, it Focus on key elements which comprise of NDT.**

# Editorial changes

- Corrected all spelling errors from last call
- Conducted a thorough review of the entire article once again
  - Deleted temporary information such as' Discussion Venues’
  - Updated and re-ordered Acronyms and Abbreviations
  - Added the full-name of the abbreviations that only appear once
  - Unified NDT related descriptions throughout the txt as well as the figures.

*Spelling comments from Ziyang Xing – last call*

Dear authors,
I have read this draft and support it.
https://datatracker.ietf.org/doc/draft-irtf-nmrg-network-digital-twin-arch/08/
Suggest the authors to correct the following spelling errors, and just for reference only.
1.In section 2.2
As a proprietary term, it is recommended to always maintain a consistent uppercase format for 'Digital Twin'.
digital twin -> Digital Twin
2.In section 3.2
proposes an digital -> proposes a digital
3.In section 5
Network digital twin can help enabling -> Network digital twin can help enable
Take AI/ ML application as example -> Take AI/ML application as an example
4.In section 9.1
different type of network data -> different types of network data
Whenever building network models for a specific network application -> When building network models for a specific network application
5.In section 11.1
There is a spelling error 'whigh'.
whigh -> which
6.In section 11.2
data and their context -> data and its context
7.In section 6
Blockchain is already a proprietary term.
block chain -> blockchain
8.In section 7
counter-part -> counterpart
All or subset -> All or a subset
a  campus enterprise network, an industrial Internet of Things (IoT) -> a  campus enterprise network, or an industrial Internet of Things (IoT)
9.In Acknowledgments section
no. -> No.

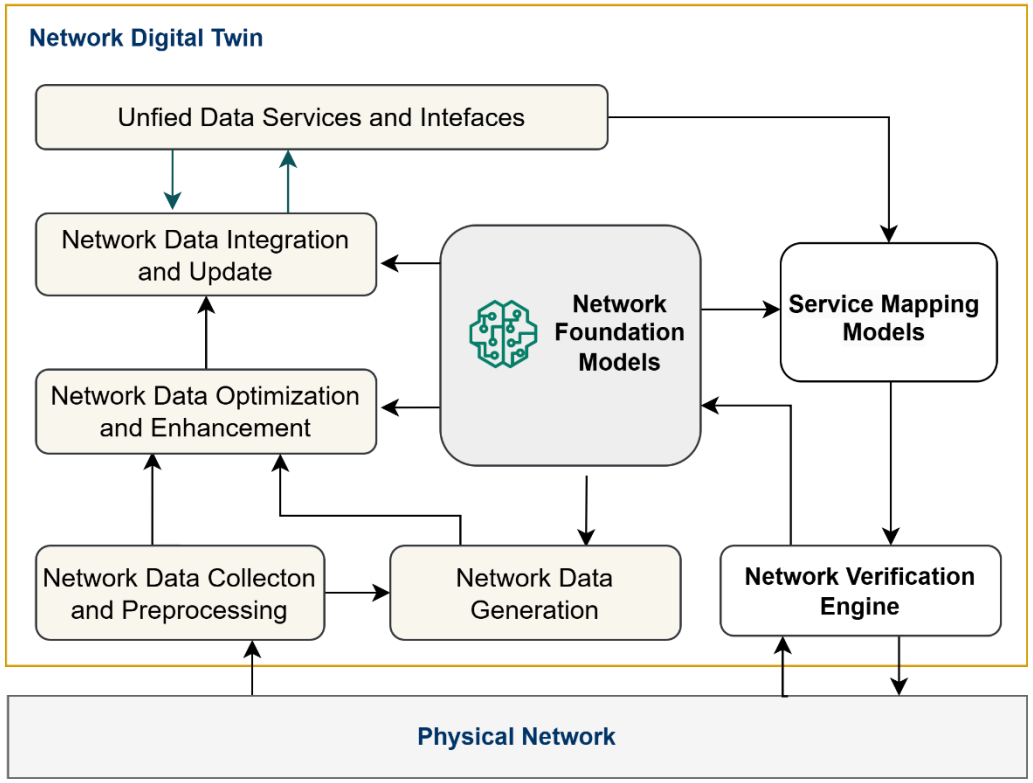
# Next Steps

- The draft has now addressed all comments raised in last call
- Ready for IRSG review, and request document publication

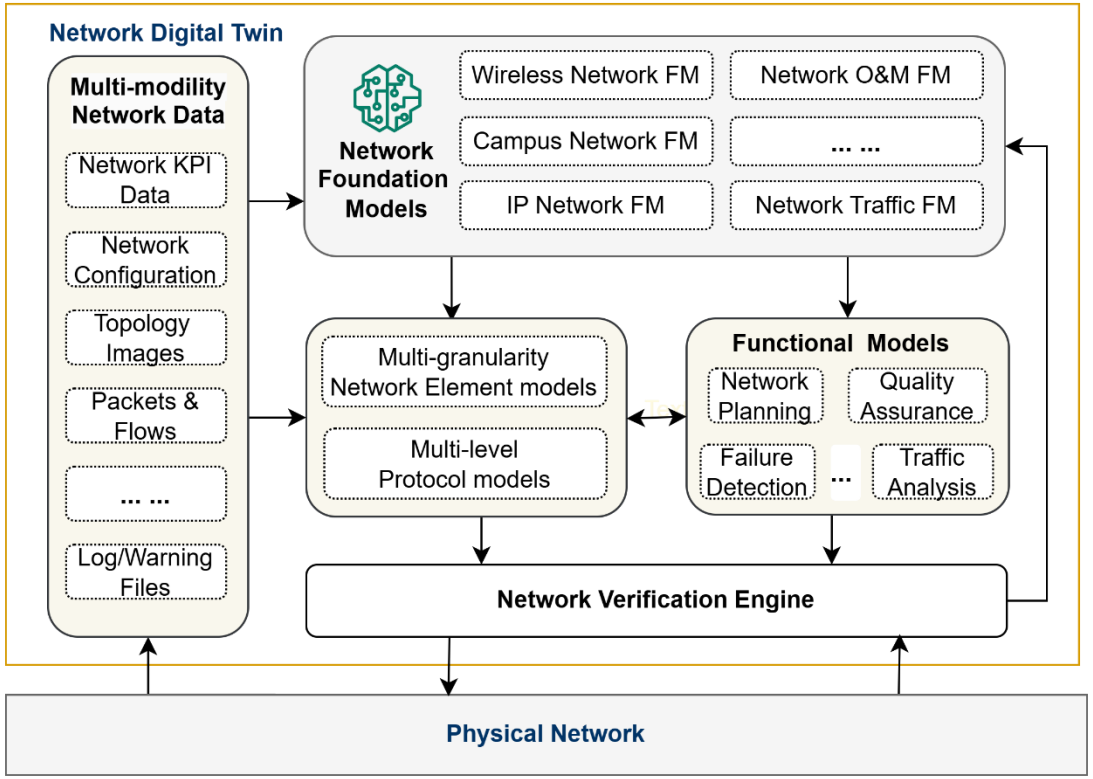
# Backups

- Research directions on NDT leveraging AI foundation models (GenAI)…

# Network Foundation Models (GenAI) for NDT



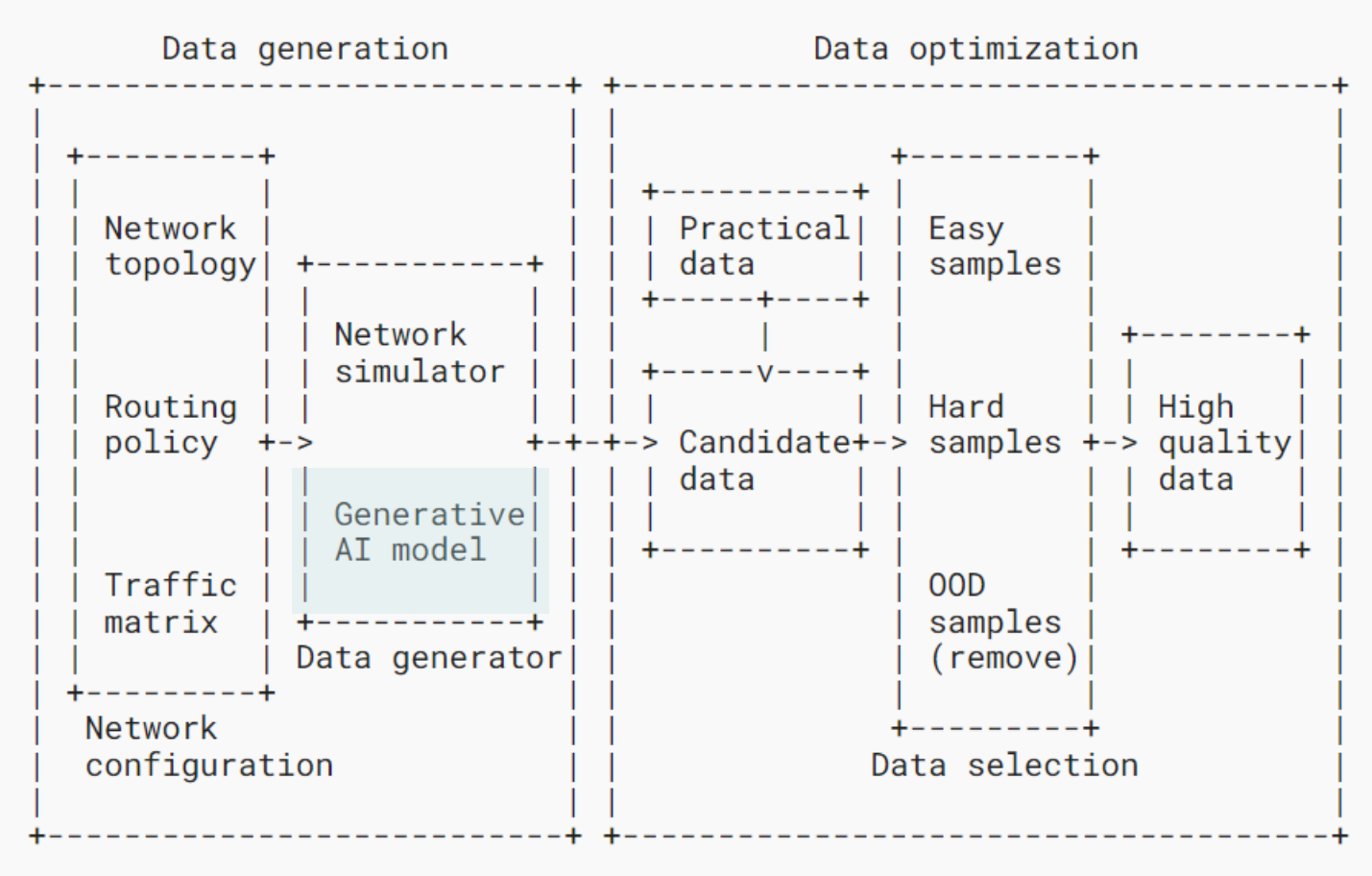

- NFM/GenAI for NDT Data
  - Data generation
  - Data optimization & enhancement




- NFM/GenAI for NDT Modeling
  - Quickly building basic models
  - Efficiently inferencing and decision making

# Example: Data generation and optimization for NDT modeling

- Motivation
  - Practical data shortage
  - Data privacy protection
- Goals
  - Generate simulated data
  - Select high-quality data from multi-source data
- Individual draft:
  - *https://datatracker.ietf.org/doc/draft-li-nmrg-dtn-data-generation-optimization*
- Call for inputs
  - Data generation methods
  - Data optimization methods
  - Deployment




*Framework of Data Generation and Optimization for NDT Performance Modeling*