Concepts of
Digital Twin Network (DTN)

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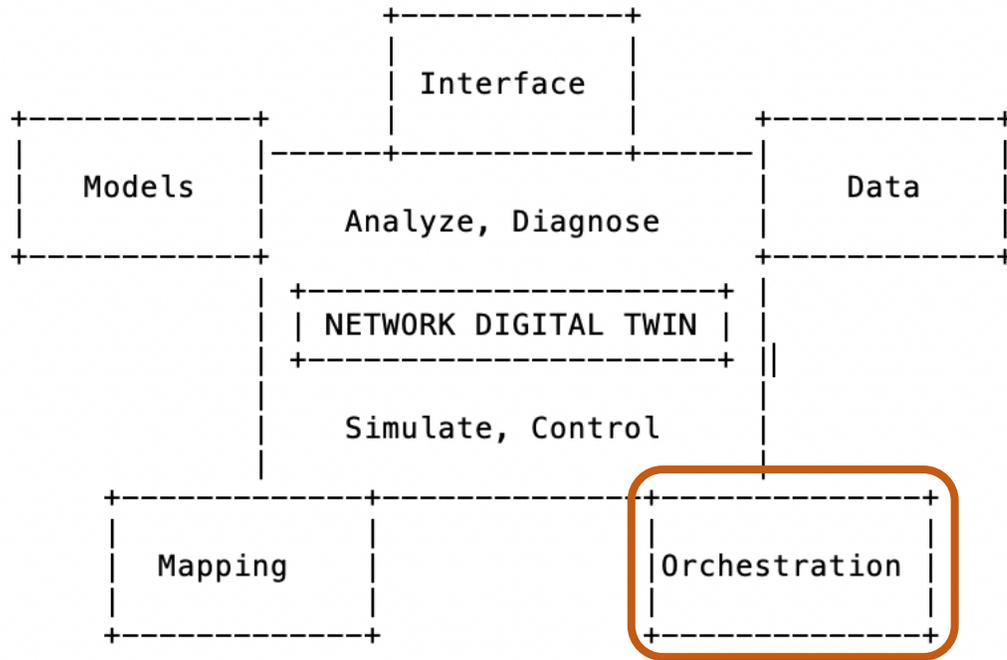# Major Updates from version -00

Table of Contents

A fifth element added: Orchestration

Two new benefits analyzed

New section for reference architecture of DTN

The Fifth Element

```
              +------------+
              |            |
              |  Interface |
+------------+|            |    +------------+
|            ||+--------+--+    |            |
|  Models    |+--------+       |   Data     |
|            | Analyze, Diagnose|            |
+------------+|        |        +------------+
             +-------------------+
             | NETWORK DIGITAL TWIN ||
             +-------------------+ ||
             |                      |
             | Simulate, Control    |
             |                      |
+------------+|        +------------+
|            ||        ||           |
|  Mapping   ||        ||Orchestration|
|            ||        ||           |
+------------+         +------------+
```

- Orchestration
  - Control the data and action flows
  - Applies dynamic lifecycle managament
  - Based on network models
- Supporting
  - Repeatability
    - Replicate network conditions on demand
  - Reproducibility
    - Replay successions of events
    - Controlled variations

Additional Potential Benefits

- Privacy preservation
  - Avoid any use of personal data for management decisions
  - Synthetic and aggregated sources
  - And a better fit to the trend on E2E encryption

- Training
  - Under controlled conditions
  - As close as possible to real operations
  - A/B evaluation
  - Cyber-ranges

Reference Architecture of DTN

```
+-----------------------------------------------------------------+
|   +--------+   +--------+              +--------+    Network|
|   | App 1  |   | App 2  |    ...       | App n  |  Application|
|   +--------+   +--------+              +--------+            |
+------------^----------------------------------+-------------------+
             | ability supply    |intent input
             |                   |
+----------------------------------------v--------------------------+
|                                      Network Digital Twin|
|   +--------+   +----------------------------+   +--------+   |
|   |        |   |  Service Mapping Models |   |        |   |
|   |        |   |   +------------------+  |   |        |   |
|   | Data   +--->   |Functional Models |  +---> Digital|   |
|   | Sharing|   |   +-----+-----^------+  |   | Twin   |   |
|   | Repo-  |   |         |     |         |   | Entity |   |
|   | sitory |   |   +-----v-----+------+  |   | Mngmt  |   |
|   |        <--+  |  Basic Models    |  <---+   |        |   |
|   |        |   |   +------------------+  |   |        |   |
|   +--------+   +----------------------------+   +--------+   |
+--------^----------------------------------------------------------+
         |                   |
         | data collection   | control
+----------------------------------------v--------------------------+
|                                      Physical Network|
|            Network infrastructures                             |
+-----------------------------------------------------------------+
```
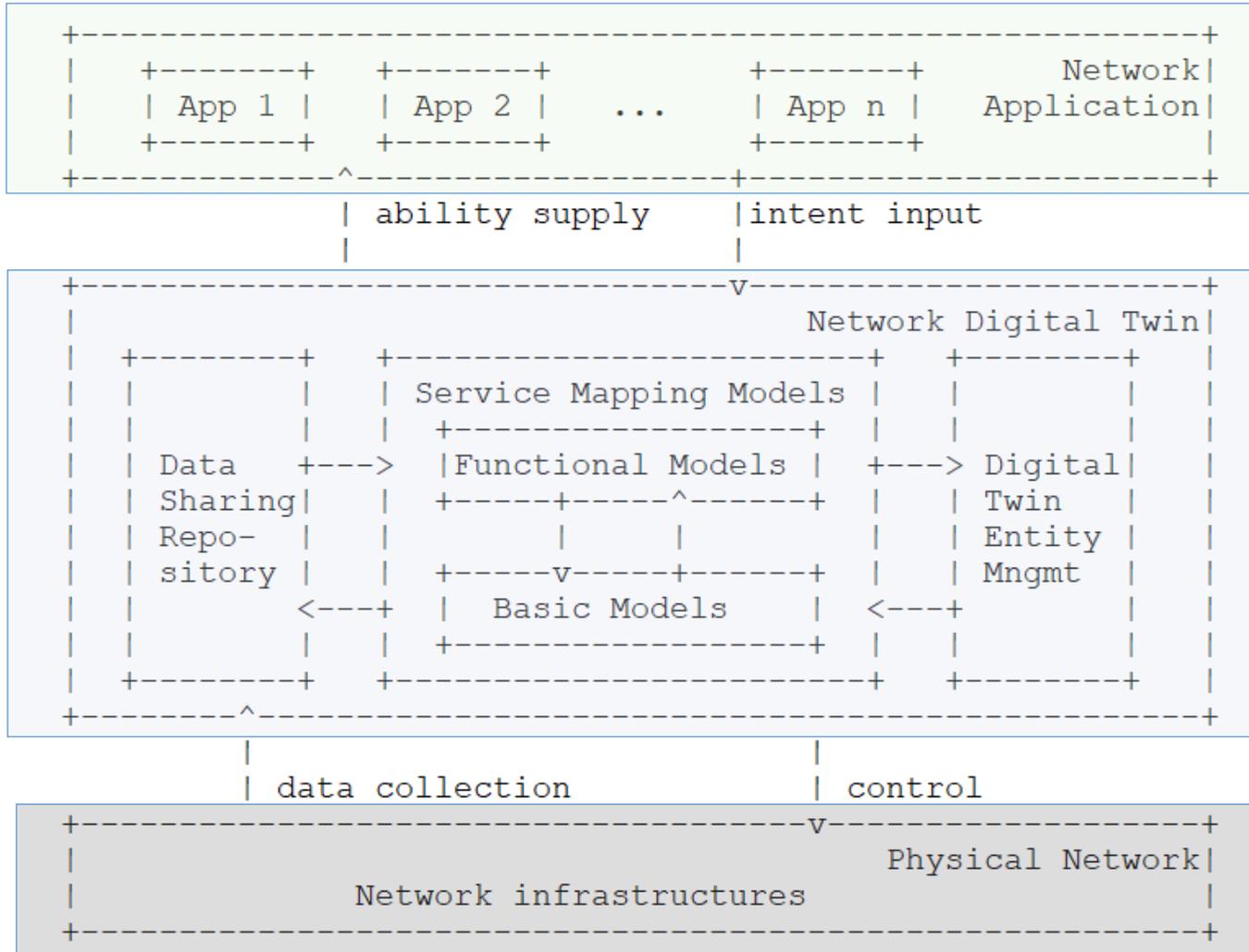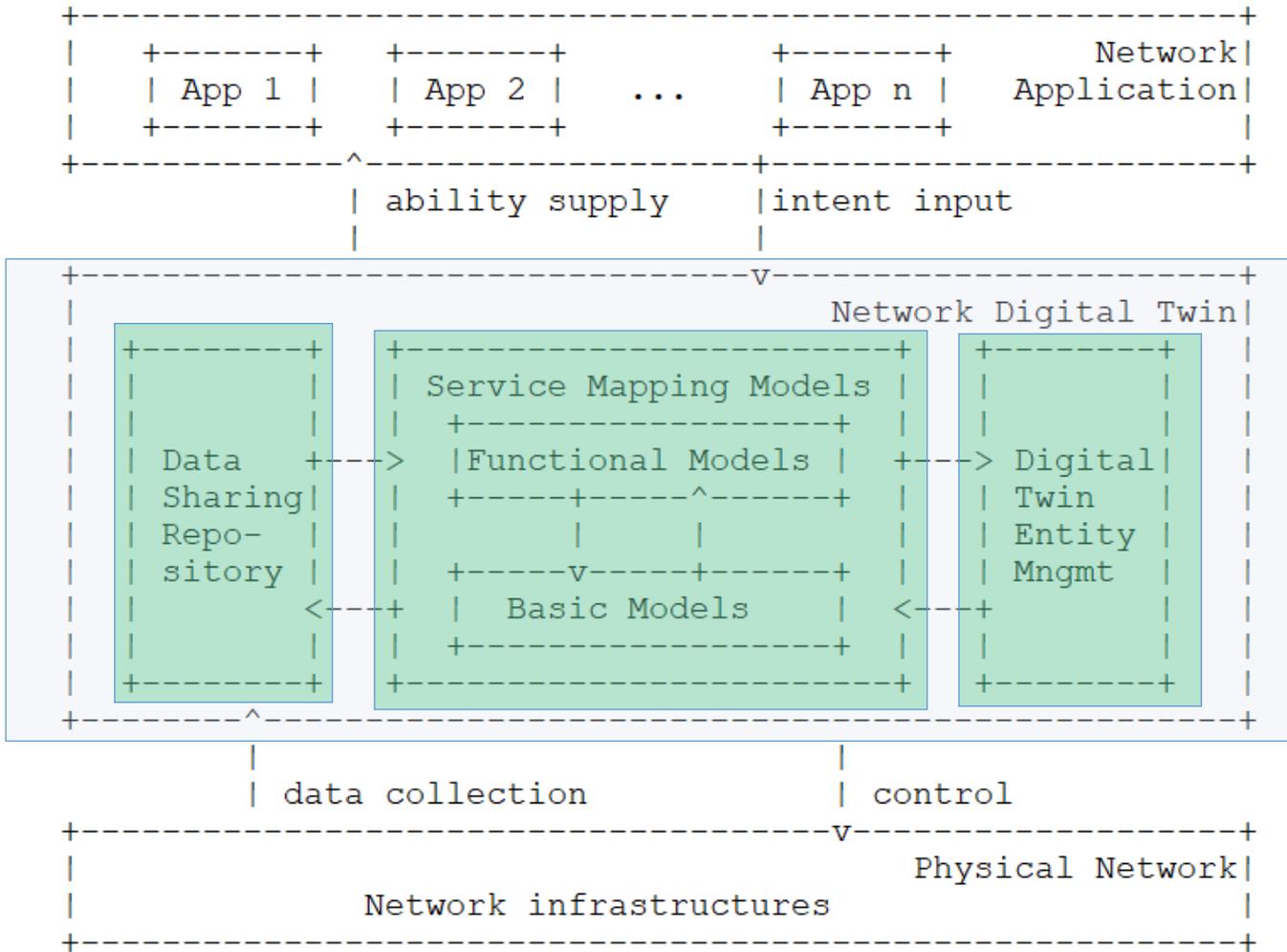
Three-layer DTN system

- **Bottom Layer: Physical Network**
  - ➢ Various network domains
  - ➢ Exchange data and control with Network Digital Twin
- **Middle Layer: Network Digital Twin**
  - ➢ Core layer of DTN system
  - ➢ 3 key subsystems;
- **Top Layer: Network Application**
  - ➢ Both conventional and innovative applications.
  - ➢ Provide requirement to Network Digital Twin entity;

Reference Architecture of DTN (cont.)

```
+--------------------------------------------------------------+
|  +-------+    +-------+              +-------+      Network|
|  | App 1 |    | App 2 |    ...       | App n | Application|
|  +-------+    +-------+              +-------+            |
+----------^---------------------------------------------------+
           | ability supply    | intent input
           |                   |
+----------------------------------v---------------------------+
|                                   Network Digital Twin|
|  +-------+    +-----------------------+    +-------+        |
|  |       |    | Service Mapping Models |    |       |        |
|  |       |    |  +-----------------+   |    |       |        |
|  | Data  +--->  |Functional Models |   |  +---> Digital|    |
|  | Sharing|    |  +-----+-----^-----+   |    | Twin   |     |
|  | Repo- |    |        |     |         |    | Entity |     |
|  | sitory|    |  +-----v-----+-----+   |    | Mngmt  |     |
|  |       <---+  |  Basic Models    |   |  <--+       |     |
|  |       |    |  +-----------------+   |    |       |        |
|  +-------+    +-----------------------+    +-------+        |
+----------^---------------------------------------------------+
           |                   |
           | data collection   | control
+----------------------------------v---------------------------+
|                                   Physical Network|
|        Network infrastructures                              |
+--------------------------------------------------------------+
```

Three Sub-systems in Network DT layer

- **Data Sharing Repository**
  - ➤ Various network domains
  - ➤ Exchange data and control with Network Digital Twin
- **Service Mapping Models**
  - ➤ <u>Basic Models:</u> network elements and network topology;
  - ➤ <u>Functional Models:</u> various data models such as network analysis, simulation, diagnosis, prediction, assurance, etc.
- **Digital Twin Entity Management**
  - ➤ Life-cycle management entity;
  - ➤ Visualizes and controls various elements, including topology, model, security, etc.

Next Steps

- To consider dynamic data collection through day-N orchestration

  - SPIDER project: https://spider-h2020.eu

- To analyze requirements on flow provenance

  - INSPIRE-5Gplus project: https://www.inspire-5gplus.eu

- To investigate more use cases and requirements of DTN.

- To define basic southbound and northbound interfaces of DTN system.

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