Integrating Network Digital Twin into Future AI-based 6G Systems (6G-TWIN)

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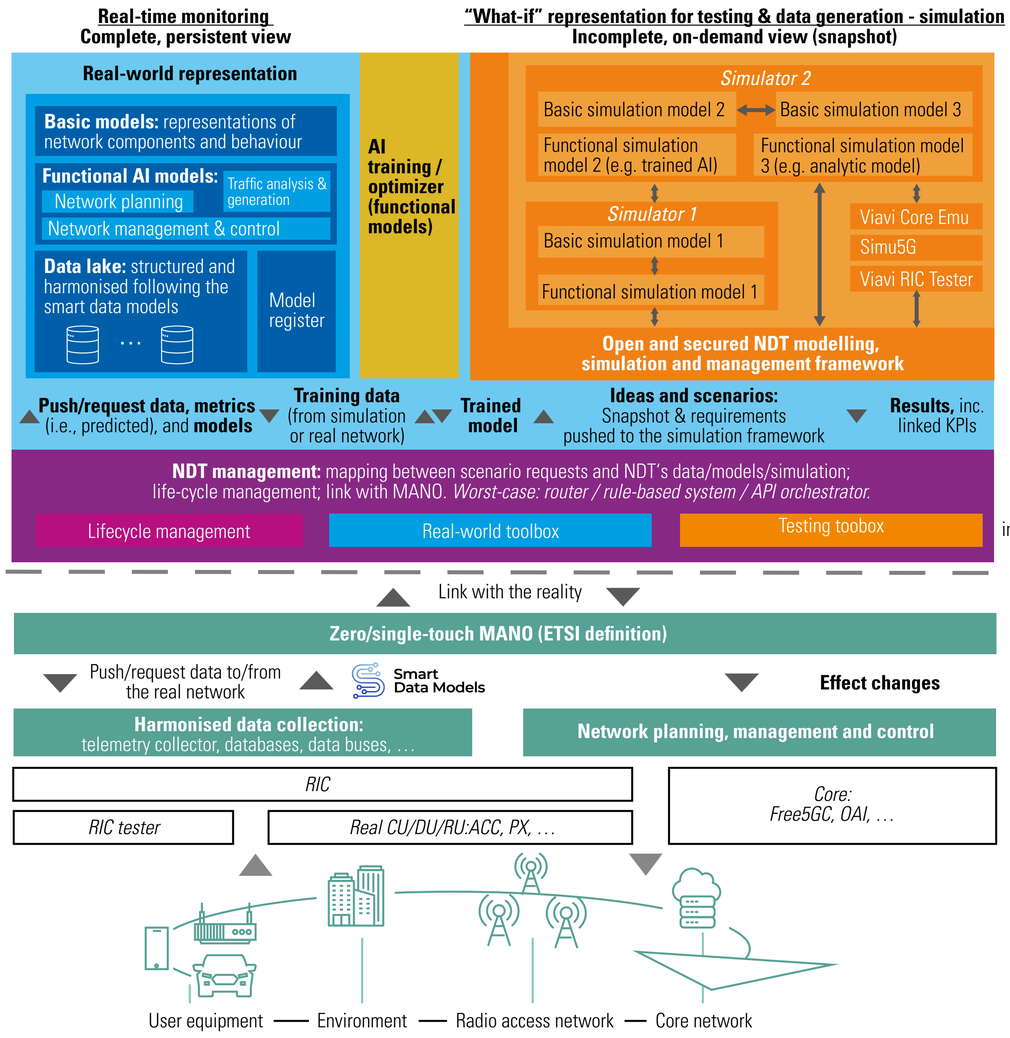
Overview, concept, architecture & technologies

Networks are becoming increasingly complex and distributed, relying on a wide variety of technologies to operate effectively. With 6G expected around 2030, it is crucial to design, experiment with, and standardise network architectures that embed greater intelligence and automation. In this context, **Network Digital Twin (NDT)** is emerging as an essential concept for predicting, testing, and refining network scenarios before deployment, as well as supporting real-time adaptability during operation.

6G-TWIN establishes the foundation for the design, implementation and validation of an AI-native reference architecture for 6G systems that incorporates NDT as a core mechanism for the end-to-end, real-time optimisation, management and control of highly dynamic and complex network scenarios.

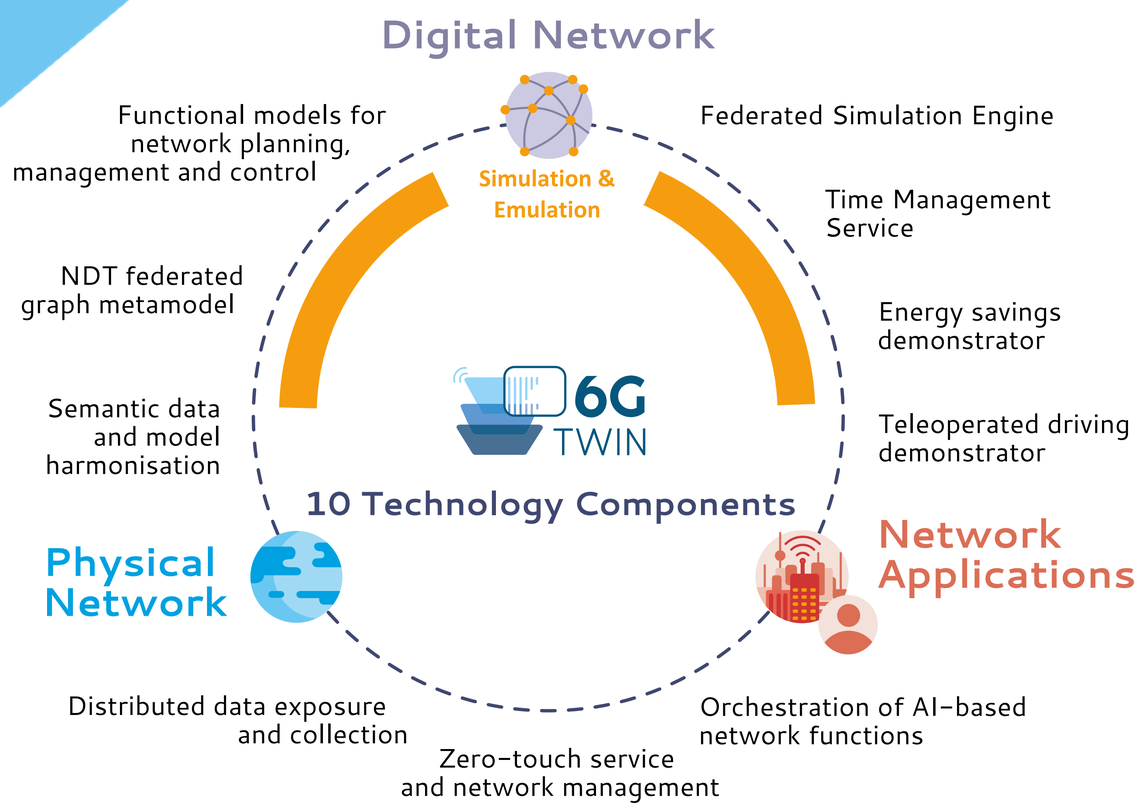
6G-TWIN develops methods, modelling, and simulation solutions for designing, creating, and managing multi-layered virtual representations of future 6G systems. These representations incorporate heterogeneous domains (e.g., edge, fog, and cloud) and diverse communication technologies (e.g., cellular, optical, and non-terrestrial networks). The project's functional architecture (see Figure) combines key components, including real-time data collection from the physical network, NDT data and model management, AI training, and an on-demand simulation framework. These elements are orchestrated through a unified management layer that ensures seamless integration, lifecycle management, and feedback loops between real-world operations and simulation-driven insights.



6G-TWIN architecture

The 6G-TWIN NDT framework introduces a multi-layered architecture bridging real-world network operations with predictive and simulation-driven decision-making. In this context, a key innovation is the formalisation of the NDT concept: while digital twin is increasingly applied across various sectors, this project establishes a structured, AI-native framework specifically for 6G networks, ensuring clarity, scalability, and scientific rigour in its implementation. This NDT provides a dynamic and controlled environment to test and optimise network scenarios. This approach accelerates the development of intelligent, scalable, and cost-effective systems, setting a new standard for NDT use in 6G.

Use cases, results & standardisation



6G-TWIN will achieve its objectives through the integration of 10 technology components over 4 dimensions. Key expected results include the **Federated and AI-native network reference architecture that integrates multiple NDTs** for real-time data analytics & decision-making.

The project's solutions are validated through two use cases (UCs) tackling mobility and energy-efficiency challenges: 1 Teleoperated driving: predictive NDT solutions will anticipate network behaviour before a vehicle's departure, ensuring extreme quality of service and resource availability throughout its journey. 2 Energy savings: reactive NDT solutions will optimise end-to-end network energy efficiency in real time. Both UCs will leverage low-TRL, lab-scale demonstrators and open approaches (e.g., O-RAN) to maximise the project's impact.

6G-TWIN adopts **ETSI NGSI-LD** and **Smart Data Models** to harmonise data exchange and support federated AI workflows. The architecture aligns with **ITU-T Y.309x series** and follows **ETSI ZSM** developments to ensure compatibility with emerging zero-touch automation and management frameworks.

Partners

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Authors: Régis Decorme & Mojtaba Maktabifard, R2M Solution | Sébastien Faye & Jean-Sébastien Sottet, Luxembourg Institute of Science and Technology (LIST) | **Contact**: regis.decorme@r2msolution.com | +33 6 81 47 55 40