

## TECHNICAL OVERVIEW

# Network Digital Twin Ecosystem

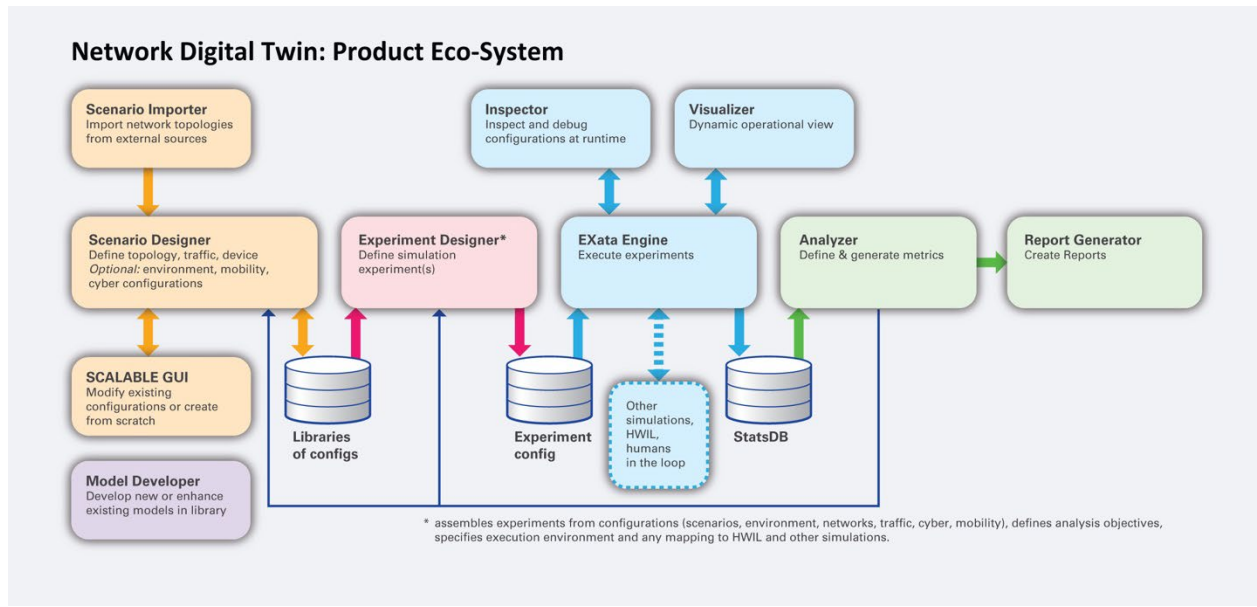
## Digital Twins to Model and Visualize Communication Networks and Cyber Threats

A network digital twin refers to a computer simulation model of the communication network along with its operating environment and the application traffic that it carries. The digital twin can be used to study the behavior of its physical counterpart under a diverse set of operating conditions, including cyber attacks, in a low-cost and zero-risk environment. However, to do so effectively, the digital twin must have sufficient fidelity to accurately reflect the network dynamics that can cause networks to behave unpredictably. The network dynamics are typically created by the interplay among the communication protocol, device configurations, network topology, application traffic, the physical environment, and any cyber threats.

In addition, live hardware and software applications can be seamlessly interfaced with, or integrated into, a network digital twin that executes in real time. These real-time network digital twins can then be used to improve management, performance, and cyber resilience of networks in all domains, from commercial enterprise IoT to military networked systems operating from seabed to space.

### Network Digital Twin: Product Ecosystem

The use of the network digital twin reduces recurring costs and lead times and provides an easier way to perform analysis, testing, and optimization. The framework enables testing of a large number of networks in a low-cost, lab-based setting with a small hardware footprint while reducing risk in fielding frequently changing network devices and programs. The network digital twin's ability to respond exactly like a live network can play a key role in testing cybersecurity and helping defend the networked systems against evolving cyber threats.



## Creating a Network Digital Twin

Given the complexity of most networks, creating a digital twin that accurately represents the topology, configuration, and traffic of an existing physical network can be challenging. Keysight Technologies has developed an ecosystem of tools to assist the user in automatically creating network digital twins as well as modifying, executing, visualizing, and analyzing their performance.

**Scenario Designer** is used to configure the network digital twin, including:

- Network topology, device characteristics, and traffic
- For wireless (sub)-networks, includes terrain, environmental conditions (e.g., weather) and platform mobility
- For cyber resilience assessment, may include cyber device configurations, vulnerabilities, firewall rules, and cyber attacks

The Scenario Designer includes two major components: Scenario Importer and the Keysight Technologies GUI. The Scenario Importer automatically creates the network digital twin from external sources. The Keysight Technologies GUI can create a network digital twin from scratch or modify any part of an automatically created network digital twin for what-if analysis.

**Scenario Importer** can import device, traffic, and cyber characteristics from an existing (as-is) network. It may:

- Use the Topology Converter to convert a network topology specified in other formats that include live network scans, MBSE tools, Visio diagrams, and network simulators
- Use the Extractor to retrieve (a subset of) the relevant topology and device information from an external simulation (e.g., OneSAF, AFSIM, STK, VR-Forces, STAGE, ASCOT, and other mission simulations)

The Scenario Designer stores multiple configurations in libraries to facilitate mixing and matching in Experiment Designer.

**Experiment Designer can:**

- Choose configurations from the libraries created by Scenario Designer (e.g., network, traffic, cyber, environment, and mobility) to create experiments (e.g., running a live traffic recording on various wireless topologies)
- Define analysis objectives, including key performance parameters (KPPs) of interest (e.g., latency, packet drop, throughput, and jitter)
- Specify the execution environment for the network digital twin (e.g., local machine, server, or cloud) and connections to live equipment or external simulations

**EXata Engine creates** the network digital twin and executes the experiments, connecting to specified live equipment, live applications, and external simulations.

**Inspector interacts** with the network digital twin at run time to provide the ability to inspect and debug experiment configurations.

**Visualizer can:**

- Superimpose networks on 3D environments to create a dynamic operational picture for visualizing entities, movement, terrain (e.g., undersea), active network connections, packet routing, delivery, data rates, and cyber state
- Enable human-in-the-loop (HITL) interactions and launching of electronic warfare and cyberattacks

**Analyzer can:**

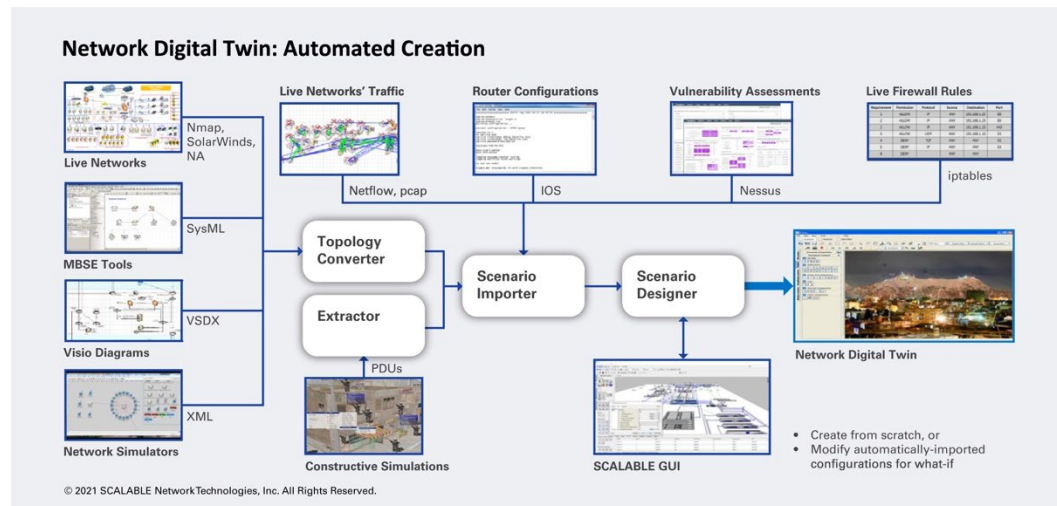
- Display a variety of statistical measures (e.g., the KPPs specified in the Experiment Designer)
- Display heat maps and statistics over time
- Compare results across experiments

**Report Generator can:**

- Facilitate the generation of useful reports from experiment statistics
- Report in tabular and graphical form can be generated using external tools such as Excel or Tableau

## Network Digital Twin: Automated Creation

While many of the steps and tools for creating network digital twins are common to all types of network digital twins, some depend on the type of network that the twin represents (either a physical or constructive network) and its intended use (e.g., network performance or cyber resilience assessment).



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