**3GPP TSG-SA5 Meeting #156 *S5-243697***

Maastricht, Netherlands, 19 - 23 August 2024

**Source: Huawei**

**Title: Update emulation and simulation**

**Document for: Approval**

**Agenda Item: 6.19.5**

# 1 Decision/action requested

***The group is asked to discuss and approval.***

# 2 References

[1] 3GPP draft TR 28.915: “Management and orchestration; Study on management aspects of Network Digital Twin v0.3.0”.

[2] SP-231727 "New Study on management aspects of Network Digital Twin"

# 3 Rationale

This contribution proposes to update the description of Relation between emulation and simulation in clause 4.2.3 to make it more general (e.g., network traffic function 🡪 network function, because network traffic function is not well defined.), and provide the suggestion that in this study NDT should support both emulation and simulation.

Background information about emulation and simulation:

1, From <https://academy.simumatik.com/blog/introduction-to-emulation-and-digital-twins>

* A simulation is a system that behaves similar to something else, but is implemented in an entirely different way. It provides the basic behavior of a system to give you an idea about how something works.
* An emulation is a system that behaves exactly like something else, and abides by all of the rules of the system being emulated. It is compatible with the emulated system’s inputs and outputs, but operating in a different environment to the environment of the original emulated system.

2, From <https://webstrategiesblog.com/digital-twins-simulation-vs-emulation/>

* **Simulation: Acting as If**

**Simulation** involves creating a virtual representation of an object or system while simplifying or abstracting some aspects. The key here is that it acts "as if" it were the real thing, replicating behaviors and interactions without the need for an exact match in hardware or software.

**Use Cases for Simulation:**

1. **Complex Systems Modeling:** Simulation-centric digital twins are ideal for modeling complex systems like cities, where replicating every detail precisely isn't necessary. These simulations help urban planners optimize infrastructure and transportation.
2. **Scenario Testing:** If you need to test different scenarios without replicating specific hardware, simulation is your go-to choice. For instance, emergency response simulations allow professionals to prepare for various disaster scenarios.
3. **Predictive Analysis:** Simulations are handy for predicting outcomes and analyzing trends. Supply chain simulations, for example, help professionals forecast inventory levels and delivery times.
* **Emulation: Acting the Same**

On the other side of the coin is **emulation**, which aims to create a digital twin that acts precisely the same as the original. It replicates both the external behavior and internal workings of the object or system, providing an exact duplicate for testing and development purposes.

**Use Cases for Emulation:**

1. **Hardware Testing:** When precise replication of hardware components is critical, emulation shines. Mobile network emulation, for instance, involves replicating base stations and communication protocols for thorough network testing.
2. **Firmware and Software Development:** Emulation-centric digital twins are perfect for software and firmware development when testing on specific hardware configurations is necessary. Think of it as emulating mobile devices to test apps and firmware.
3. **Security Assessment:** For security testing, where pinpoint accuracy is essential, emulation is the preferred choice. It replicates both hardware and software components to identify vulnerabilities and threats accurately.

3, From ZSM (ZSM-015)：

* emulation typically refers to the complete imitation of a machine running binary code. The objective of this is to duplicate as exactly as possible the detailed processes by which the emulated object operates, which is a satisfactory general description of emulation methods. An emulation mimics in detail the detailed workings of an object and thus may capture a broad range of its detailed behaviours;
* Simulation, on the other hand, makes use of mathematical models, algorithms, transfer functions, etc. in order to generate targeted behavioural predictions. A simulation operates at a more abstracted level and focuses more narrowly on particular aspects of behaviour.

# 4 Detailed proposal

It proposes to make the following changes to TR 28.915[1].

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| **1st Change** |

### 4.2.3 Relation between emulation and simulation

#### 4.2.3.1 Emulation

Emulation uses a system’s actual algorithms or functions to mimic how a system will behave. For NDT, duplicates of the network functions and/or network management functions are executed in an NDT environment.

To emulate the behaviour of a mobile network, it is necessary to create an NDT environment which contains virtualized network equipment, network functions, network management functions, and all the configuration and status data for this equipment/functions. To measure the reaction to network traffic, the NDT environment also contains traffic generators.

#### 4.2.3.2 Simulation

Simulation uses a mathematical model to mimic how a system will behave. For NDT, models of the behaviour of network functions and/or network management functions to mimic the behaviour of the overall mobile network (or part thereof).

To simulate the behaviour of a mobile network, it is necessary to create an NDT environment which combines the models of network equipment, network functions and/or network management functions, with the relevant configuration and status data for this equipment/functions. To measure the reaction to network traffic, the network traffic is also modelled.

#### 4.2.3.3 Comparison of emulation and simulation

Emulation has the advantage of more accurate behaviour, especially in complex systems that are experiencing abnormal cases. Emulation also has the advantage that there is no need to create a mathematical model of the behaviour of each individual component. The vendor-provided software for each emulated component can be executed in the emulation environment and should produce the expected behaviour.

Emulation has the disadvantage that it is resource-expensive, because the emulation environment will require a similar amount of compute/storage/network resources as a real network. Therefore, the primary advantage of simulation is to reduce cost.

A major disadvantage of simulation is the need to create models of how each component will behave. The typical or expected behaviour of equipment or a function may be possible to model easily. But in extreme cases (such as overload or error), only the vendor knows exactly how the equipment or function will behave.

It may be possible to combine emulation and simulation to create an integrated solution. Because emulation and simulation are not mutually exclusive and each has value in different scenarios, NDT need to support both emulation and simulation.

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| **End of Changes** |