**3GPP TSG-SA5 Meeting #155 *S5-243175***

Jeju, South Korea, 27 - 31 May 2024

**Source: Huawei**

**Title: Add background information on emulation and simulation**

**Document for: Approval**

**Agenda Item: 6.19.5**

# 1 Decision/action requested

***For approval***

# 2 References

[1] 3GPP TR 28.915: “Study on management aspects of Network Digital Twin”.

# 3 Rationale

This contribution proposes to add the following to [1]:

- Background information on emulation and simulation

# 4 Detailed proposal

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

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| **1st change** |

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[x] “Emulation versus simulation: a case study of TCP-targeted denial of service attacks”  
https://www.cs.purdue.edu/homes/fahmy/papers/tridentcom.pdf

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| **2nd change** |

### 4.2.x Relation between emulation and simulation

#### 4.2.x.1 Emulation

Emulation uses a system’s actual algorithms or functions to mimic how a system will behave. For NDT, duplicates of the network traffic functions and 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 traffic 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.

To test how the mobile network would respond in a certain scenario, the operator configures the NDT environment, for example synchronizing configuration data from the mobile network to the emulated network. The operator may also configure traffic generators to mimic appropriate traffic. The algorithms in the network equipment, network traffic functions and network management functions are allowed to execute, and the results are observed. For example, the network operator may observe performance data and alarms issued by the network management functions.

#### 4.2.x.2 Simulation

Simulation uses a mathematical model to mimic how a system will behave. For NDT, models of the behaviour of network traffic functions and network management functions are combined 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 traffic functions, 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.

To test how the mobile network would respond in a certain scenario, the operator configures the NDT environment, for example synchronizing configuration data from the mobile network to the emulated network. The operator may also configure traffic models to mimic appropriate traffic. The mathematical models of the network equipment, network traffic functions and network management functions are used to estimate the individual behaviours and their interactions, and the results are observed. For example, the network operator may observe performance data and alarms issued by the network management functions.

#### 4.2.x.3 Comparison of emulation and simulation

Emulation has the advantage of more accurate behaviour, especially in complex systems that are experiencing abnormal cases. Complex systems may suffer from emergent behaviours (such as oscillations or race conditions) that result from combining the individual behaviours of multiple components. Because emulation accurately mimics the individual behaviours, it is more likely also to mimic any unexpected system-level emergent behaviours. For example, see clause IV of [x] “The primary advantage of using a network emulator – as opposed to a simulator – for […] experiments is that an emulation environment affords higher fidelity, and real […] appliances can be tested on it. This can expose unforeseen implementation vulnerabilities, protocol interactions, and resource constraints. This is because an emulation testbed uses real computers with limited resources, and real applications and operating systems running on them, to faithfully represent every host in an experiment. Flaws and vulnerabilities are not abstracted by a simplified simulation model.”

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. For example, network equipment and network traffic functions may be simulated, while network management functions may be emulated. This could reduce the cost of the overall test environment, while focusing on accurate behaviour of the network management functions.

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| **End of changes** |