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Experiential Networked Intelligence (ENI); Evaluation of categories for AI application to Networks

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Experiential Networked Intelligence (ENI).

Modal verbs terminology

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1 Scope

The purpose of present document is to define quantitative evaluation criteria of network autonomicity categories, which are defined in the published ETSI GR ENI 007 [i.2].

The present document is composed of three components:

1) to further define the categories and quantitative factors determining the network autonomicity categories;

2) to define a framework of quantitative evaluation process and a scoring criteria;

3) to describe several scenario examples of quantitative evaluation criteria.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GR ENI 004 (V2.1.1): "Experiential Networked Intelligence (ENI); Terminology for Main Concepts in ENI".

[i.2] ETSI GR ENI 007 (V1.1.1): "Experiential Networked Intelligence (ENI); ENI Definition of Categories for AI Application to Networks".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

autonomous networks: set of self-governing programmable and explainable systems that seamlessly deliver secure, context-aware, business-driven services that are created and maintained using model-driven engineering and administered by using policies

Autonomous Network Responsibility Index (ANRI): level of responsibility delegated to the AN in all the Operational Procedures bind to the lifecycle management of each Autonomous Domain and E2E Service

digital twin: virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning and reasoning

NOTE: As defined on the IBM® website.

domain technical expert: technical expert that has authority within a domain

evaluation dimension: factors should be considered in the process of intelligent evaluation

NOTE: As defined in ETSI GR ENI 007 [i.2].

evaluation object: AI application or a part of network lifecycle

Network Digital Twin (NDT): virtual digital twin of telecom network, including its own network lifecycle

NOTE: Some of the dimensions can be tailored or merged in line with actual conditions.

network lifecycle: work-flow of activities including network planning, network deployment, network service provisioning, network changes, network maintenance, network optimization in real-time

quantitative evaluation criteria: set of rules that can give a score to specific network intelligent application or system considering multiple dimensions

subsystem: network element, management system, network platform

technical expert: person in charge of defining or supporting Operational Procedures within a CSP Network (e.g. in charge of Capacity Planning, Engineering and Designing, Troubleshooting)

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GR ENI 004 [i.1] and ETSI GR ENI 007 [i.2] apply.

4 Introduction

4.1 Background on categories for AI application to networks

At present, artificial intelligence technology has achieved single breakthrough and application in local scene and local field of network. But there is no unified description language and evolution route of network autonomicity. The realization of autonomous network needs to evolve step by step in exploration, which cannot be accomplished at a single stroke. Therefore, a unified standard categories of network autonomicity should be established to measure the intellectualization level of network and guide the development of network. At present, a variety of network intelligent grading evaluation systems have been formed in different standards organizations.

Since 2018, ETSI ISG ENI has initiated the network intelligence classification project, officially released in November 2019. On the basis of TMF classification standard, it further describes the characteristics of each level from the perspectives of market and technology.

The present document will mainly refer to the intelligence grading standard proposed by ETSI ENI and its application for relevant research and exploration. The definition of categories for AI application to networks is shown in Table 4-1. Table 4-2 support evaluation of the level of Autonomicity, identifying the responsibility shift from human operator to the System.

For details, refer to the document ETSI GR ENI 007 [i.2].

Table 4-1: Categories of network intelligence from a technical point of view (Source: ETSI GR ENI 007 [i.2])

Category	Name	Definition	Man-Machine Interface	Decision Making Participation	Decision Making and Analysis	Degree of Intelligence	Environment Adaptability	Supported Scenario
Level 0	Traditional manual network	O&M personnel manually control the network and obtain network alarms and logs	How (command)	All-manual	Single and shallow awareness (SNMP events and alarms)	Lack of understanding (manual understanding	Fixed	Single scenario
Level 1	Partially automated network automated diagnostics	Automated scripts are used in service provisioning, network deployment, and maintenance. Shallow perception of network status and decision making suggestions of machine	How (command)	Provide suggestions for machines or humans and help decision making	Local awareness (SNMP events, alarms, KPIs, and logs)	A small amount of analysis	Little change	Few scenarios
Level 2	Automated network	Automation of most service provisioning, network deployment, and maintenance Comprehensive perception of network status and local machine decision making	HOW (declarative)	The machine provides multiple opinions, and the machine makes a small decision	Comprehensive awareness (Telemetry basic data)	Powerful analysis	Little change	Few scenarios
Level 3	Self-optimization network	Deep awareness of network status and automatic network control, meeting users' network intentions	HOW (declarative)	Most of the machines make decisions	Comprehensive and adaptive sensing (such as data compression and optimization technologies)	Comprehensive knowledge Forecast	Changeable	Multiple scenarios and combinations

Category	Name	Definition	Man-Machine Interface	Decision Making Participation	Decision Making and Analysis	Degree of Intelligence	Environment Adaptability	Supported Scenario
Level 4	Partial autonomous network	In a limited environment, people do not need to participate in decision-making and adjust themselves	WHAT (intent)	Optional decision-making response (decision comments of the challenger)	Adaptive posture awareness (edge collection + judgment)	Comprehensive knowledge Forward forecast	Changeable	Multiple scenarios and combinations
Level 5	Autonomous network	In different network environments and network conditions, the network can automatically adapt to and adjust to meet people's intentions	WHAT (intent)	Machine self-decision	Adaptive deterioration optimization (edge closed-loop, including collection, judgment, and optimization)	Self-evolution and knowledge reasoning	Any change	Any scenario & combination

Table 4-2 below referenced from ETSI GR ENI 007 [i.2] reports the level of network autonomicity from a Market point of view, showing the users perception relating to the business functions of BSS. It is in good alignment with concept defined within TM forum. The scheduling, perception, analysis, customer experience, system capabilities & network generation may be mapped to technical capabilities. Some like perception and analysis are a one to one mapping. Others, like MMI degree of intelligence and environment adaptability may each have both a customers and systems aspects.

As reported in clause 5.2 in ETSI GR ENI 007 [i.2] about market relevance: *"The factors that impact the market relevance of network autonomicity involve the possibility to adapt the system and create service offers in different scenarios and involving, according to the 5G network concept, different stakeholders covering a part of or the whole service chain. The market relevance is determined by aspects as the level of simplicity of the AI assisted Network management, the resulting flexibility of the supported services, the required effort and staffing to operate and manage the network, the usage of resources and energy, the level of customer experience".*

Table 4-2: Level of network autonomicity from a market point of view (Source: ETSI GR ENI 007 [i.2])

Level	Name	Definition	Scheduling execution	Perception monitoring	Analysis and decision-making	Customer experience	System capability	Example of network generation
Level 0	Manual O&M	O&M operators manually control the network and obtain network alarms and logs	Operator	Operator	Operator	Operator	n/a	Command line
Level 1	Assisted O&M	Automated scripts are used in service provisioning, network deployment, and maintenance. Shallow perception of network status and machine suggestions for decision making	Operator and system	Operator	Operator	Operator	Selected service scenarios	NMS
Level 2	Partial automation	Automation of most service provisioning, network deployment, and maintenance Comprehensive perception of network status and local machine decision making	Operator and System	Operator	Operator	Operator	Selected service scenarios	NMS + controller
Level 3	Conditional automation	In specific environmental and network conditions there is automatic network control and adaptation	Mostly System	Operator and system	Operator	Operator	Multiple service scenarios	Single-domain: Automation + perception analysis + limited context-awareness trigger conditions drive closed-loop management

Level	Name	Definition	Scheduling execution	Perception monitoring	Analysis and decision-making	Customer experience	System capability	Example of network generation
Level 4	Partial autonomicity	Deep awareness of network status; in most cases the network performs autonomic; decision-making and operation adjustment	Mostly System	Operator and System	Operator and System	Operator and System	Multiple service scenarios	Cross-domain (for some service scenarios): Automation + perception analysis + experience; context-awareness and simple cognitive processing closed-loop management
Level 5	Full autonomicity	In all environmental and network conditions, the network can automatically adapt	System	System	System	System	Any service scenario	Cross-domain and any service: Automation + perception analysis + experience; situation awareness and cognitive processing closed-loop management

4.2 The motivation for evaluating categories of AI application to network

Evaluation for categories of AI application to network is proposed to give a score to a specific network intelligent application considering multiple dimensions (e.g. data collection, analysis, decision, etc.).

Based on the definition of categories and of application cases, according to the use of AI in the implementation process:

1) the technical requirements of each link and step are detailed;

2) the test verification scheme and specification are formulated;

3) the evaluation criteria and index are quantified.

In the evaluation, it is necessary to avoid the requirements for the specific implementation methods of intelligence, and focus on the evaluation of the implementation effect, such as the degree of automation, whether closed-loop, unit efficiency, etc.

Figure 4-1: The categorization and evaluation for AI application to network

The definition and evaluation of categories for AI application to network complement each other, jointly promote network evolution.

The goals and motivation of definition of network autonomicity categories:

- Unified evaluation: Provide basis for categories of network intelligence and promote the whole industry to form a unified understanding of intelligent network and other related concepts.
- Planning Guideline: Provide reference for operators to formulate relevant strategies, and clarify the stage division and stage objectives of development planning.
- Decision-making assistance: Provide decision-making assistance for operators, equipment manufacturers and other industry participants in technology cooperation, product planning, etc.

The goals and motivation of quantitative evaluation criteria:

- Network Evaluation: quantitatively evaluating capability of autonomous network.
- Implementation: defining a process of evaluating network autonomicity categories.
- Technology Innovation: cognizing the disadvantages of the current network and applications, developing new technologies to improve the level of network autonomicity.

4.3 Responsibility Index in Autonomous Network

Autonomous Network introduces a new aspect to be considered in parallel to the technical capabilities of the Network and related management systems in themselves. Responsibility and Liability related to autonomous decision represent a relevant point to be taken into account.

The defining characteristic of an Autonomous Network is its ability to assume Responsibilities that the Humans accept to delegate it.

According to this statement, the level of Autonomicity assumed by network can potentially be regarded less as a technical one and more related to the decision responsibilities delegated to network by the Operator. Please refer to Table 4-2 for more information on Operator vs Network responsibilities and roles.

ENI Engine is an enabler for network decision making process across the overall lifecycle of the assisted system.

The Operator, according to AI training and a proper growth in trust for the network capacity to take final decision, can delegate the responsibility of the decision to AN stepwise.

Any reference in the follow up to the network Responsibility, refers to the level of Responsibility the Operator delegated to the network to autonomously take the final decision before it get executed.

In some specific case, Human intervention could be needed to execute actions according to decisions taken automatically by network (e.g. expansion of a datacentre according to a capacity plan generated automatically).

In this case, the Responsibility remains with the network (final decision maker), regardless of the Executor.

In general, responsibility is with the entity taking the ultimate decision, independently of how and who implement the related actions.

The Operator, in delegating the network for final decision, express trust in network to be properly trained by its experts and to correctly behave in obtaining expected results. The liability for errors, SLA breach or wrong investment or any unexpected side effects remain within the Operator remit and is out of scope for the determination of the Autonomicity Level of the network itself.

Autonomous Network have to control the lifecycle of two main entities: Autonomous Domains and E2E Services.

The Responsibility Level is than strictly related to the level of Autonomicity of the Network in managing the lifecycle of all its Autonomous Domains and E2E Services.

A quantification of the overall Responsibility Level assumed by the network could be estimated by analysing the lifecycle and relative Operational phases (network planning, network deployment, network service provisioning, network changes, network maintenance, network optimization) of each individual Autonomous Domain within the network, as well as of any E2E Service type.

To properly quantify the Responsibility Level within a Network, **Responsibility Matrixes** have to be created, having the phases of the Operator Lifecycle in each column and in each row the Technology Domains (e.g. Transport, Radio, Fixed Access) or E2E Services (e.g. VoLTE, Enterprise Hybrid Cloud connection, Enterprise VPN).

For each cell of the matrix, a Responsibility Index (e.g. 0 - 5) could be estimated according to:

1) operator responsible of the decision;

2) network has tool to guide and support Operator decision and immediate side effects;

3) network recommend decision presenting a complete view of the element supporting the decision and the possible side effects;

4) as per level 3, but network has the possibility to take fully autonomous decision in off-peak hours;

5) network fully autonomous in taking decisions, with escalation to Technical Experts in case of severe unforeseeable events.

The following Tables 4.3 and 4.4 is indicative and modification to lifecycle phases or additions of other Autonomous Domains or E2E services is possible network planning, network deployment, network service provisioning, network changes, network maintenance, and network optimization.

Table 4-3: Operator Lifecycle Responsibility within Network Domains

Lifecycle/ Autonomous Domain	Auto DomainWeight	Total	Network planning		Network deployment		Network service provisioning		Network changes		Network maintenance		Network optimization	
			Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Phase Weight (0..1)	X	x	1		1		1		1		1		1	
RAN	1													
Transport	1													
Core Network	1													
Fixed Access	1													
Total														

Table 4-4: Operator Lifecycle responsibility within E2E Services

Lifecycle/E2E Services	E2E Service Weight	Total	Network planning		Network deployment		Network service provisioning		Network changes		Network maintenance		Network optimization	
			Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Phase Weight (0..1)	X	x	1		1		1		1		1		1	
VoLTE	1													
Enterprise VPN	1													
FWA	1													
Enterprise Hybrid Cloud Connectivity	1													
Total														