ETSI GR ENI 007 V1.1.1 (2019-11)

Experiential Networked Intelligence (ENI); ENI Definition of Categories for AI Application to Networks

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Reference

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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

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document defines various categories for the level of application of Artificial Intelligence (AI) techniques to the management of the network, going from basic limited aspects, to the full use of AI techniques for performing network management.

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.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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 GS NFV 003 (V1.3.1): "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.2] MEF PDO CfC (V0.8): "Policy-Driven Orchestration", September 2019.

[i.3] ETSI GS ENI 001 (V2.1.1): "Experiential Networked Intelligence (ENI); ENI use cases".

[i.4] MEF 55: "Lifecycle Service Orchestration (LSO): Reference Architecture and Framework", March 2016.

[i.5] MEF MCM 78: "MEF Core Model", September 2019.

[i.6] Gamma E., Helm R., Johnson R. and Vlissides J.: "Design Patterns: Elements of Reusable Object-Oriented Software", Addison-Wesley, November 1994. ISBN 978-0201633610.

[i.7] ISO/IEC 2382-28: "Information technology -- Vocabulary".

[i.8] ISO/IEC/IEEE 42010: "Systems and software engineering -- Architecture description".

[i.9] ETSI GR ENI 004: "Experiential Networked Intelligence (ENI); Terminology for Main Concepts in ENI".

[i.10] ETSI GS ENI 005 (V1.1.1): "Experiential Networked Intelligence (ENI); System Architecture".

[i.11] ETSI GS ENI 002 (V2.1.1): "Experiential Networked Intelligence (ENI); ENI requirements", September 2019.

[i.12] ETSI GR ENI 003 (V1.1.1): "Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis", May 2018.

[i.13] TM Forum whitepaper of Autonomous Networks: "Empowering Digital Transformation For The Telecoms Industry".

NOTE: Available at https://www.tmforum.org/wp-content/uploads/2019/05/22553-Autonomous-Networks-whitepaper.pdf.

[i.14] 5G-PPP White Paper: "5G Automotive Vision", October 20, 2015.
SAE document J3016: 'Taxonomy and Definitions for Terms Related to On-Road Automated Vehicles", January 16, 2014.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GR ENI 004 [i.9] apply.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GR ENI 004 [i.9] apply.

4 Overview

4.1 Background on AI integration and network autonomicity

ETSI ISG ENI defines how Artificial Intelligence (AI) can be usefully applied in telecommunication networks to support the management objectives of operators. These include making management faster, more efficient and providing higher resilience and reliability of the infrastructure and of the services delivered to end-users.

AI can make Operation and Maintenance (O&M) of a traditional network much more efficient with significant cost savings. AI application for early fault discovery and location, for instance, can enhance the performance of the network as perceived by end-users as well as by the operator, and reduce fault detection and recovery costs for the operator; this will in turn reduce loss of income due to service unavailability and from the reduction of maintenance costs thanks to early fault discovery and location.

The transition to virtual networks will further enhance the benefits of AI application. AI can support network entities as orchestrators and provide different ranges of management, from assisting and recommending changes (but not actually performing changes), to performing only those changes that are trusted by the operator, to performing changes without human intervention. AI can enable the dynamic adaptation of resources to changing traffic conditions and business goals, and even enable trusted changes without human intervention; this produces a fully self-managed network in normal conditions. If extraordinary conditions (e.g. when the network exhibits complex faults or is under attack), external (manual) intervention is required (though the AI can provide recommendations for fixing problems).

Figure 1 illustrates the expected step-by-step evolution of networks as AI is integrated into them as well as trusted by operators.

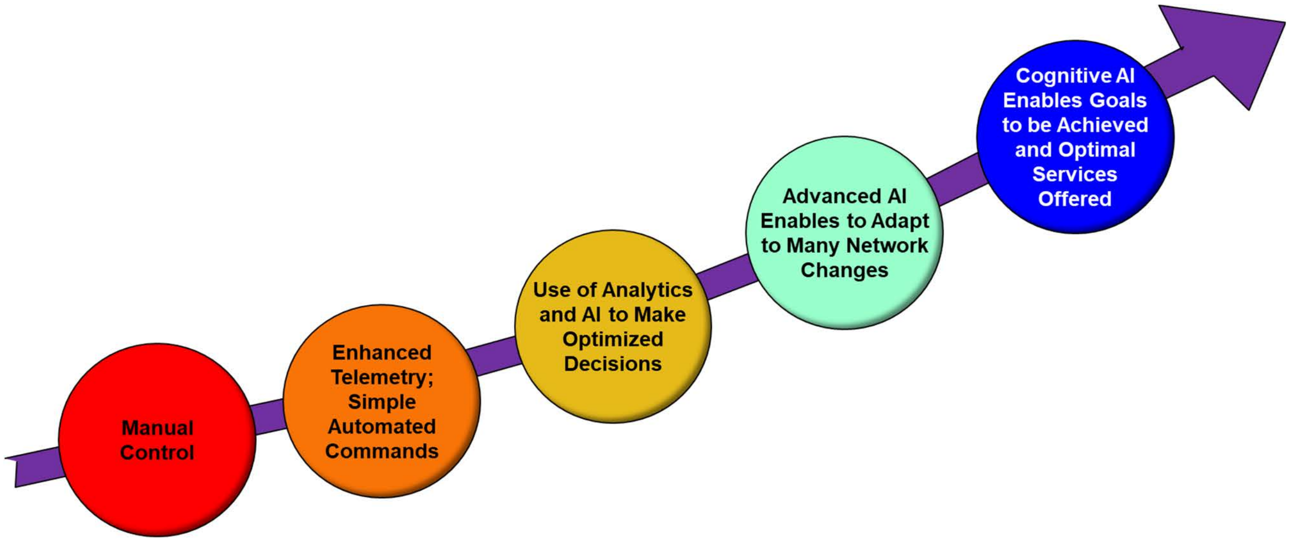

Figure 1: Scenarios of network evolution with the integration of AI

Figure 1 shows how the gradual introduction of increased AI functionality enables more management and control decisions to be enhanced and made with increasingly less human intervention. Most importantly, the use of AI enables many other functionalities to operate with increased accuracy and effectiveness.

- The traditional implementation of network control and management, with no AI and essentially no automation is not shown in the figure.
- Manual control requires complete human intervention. Even if AI is present, it is up to the human to make all decisions and issue all commands. This is sometimes called reactive processing (see clause 4.5.4.2 of ETSI GS ENI 005 [i.10]).
- The first step of using AI has two notable effects. First, it enhances existing telemetry by interacting with the network and ensuring that the most applicable telemetry is provided for a given context. Second, it enables the human to trust its recommendations, and gradually take over some of the management duties. Both of these are based on the ability of the AI to understand cause-and-effect relationships between monitored data and issued commands, and more importantly, for the AI to explain its reasoning so that humans trust its conclusions. This is also called deterministic management (see clause 4.5.4.3 of ETSI GS ENI 005 [i.10]).
- The next step of using AI builds on the previous level, and provides tighter integration with analytics. This enables the system to move from deterministic to predictive management. Predictive management uses different processes to calculate probable future events, states, and/or behaviours. Predictive processing also typically allows probability and/or risk assessment. The prediction is based on analysing current and historical operation, and applying patterns found to identify possible problems as well as opportunities for improving operation (see clause 4.5.4.4 of ETSI GS ENI 005 [i.10]).
- The next step of using AI builds on the previous level, and adds elementary goal-directed behavior. Predictions are now made that are directly related to business goals, which enables the network to provide optimized end-user services. For example, as user needs, business goals, or network conditions change, the system can dynamically change the network configuration to adapt to these changes.
- The final step of using AI builds on the previous level, and creates a cognitive management system. While the previous level is able to make decisions based on stated goals, a cognitive system is able to create new goals in order to optimize system operation. Cognitive processing enables the system to understand what has happened and plan a corrective set of actions to achieve system goals and optimize operations (see clause 4.5.4.5 of ETSI GS ENI 005 [i.10]).

It is recommended that the system uses policy-based management to issue commands, regardless of the level of AI being used. This is because it provides consistent and auditable behavior. This is critical for enabling adaptive and flexible service offerings that respond to changing business goals, user needs, and environmental constraints.

It is therefore possible to speak of different categories, of implementation of AI in telecommunications networks, according to how much the AI system will be able to influence the adaptation of the network and to what extent the diverse parts of the network are controlled using AI assistance.

4.2 Examples of application in specific areas

4.2.1 Automation applied to vehicle driving

The concept of automation categories is already used in specific fields, such as the automotive industry [i.14], for which the aspects considered to define the categories involve the level of intervention required by the human driver of a vehicle, versus the level of control delegated to networked, onboard, and environmental AI assisted agents. The categories of vehicle driving automation have been defined by the Society of Automotive Engineers (SAE), USA and by the German Association of the Automotive Industry (Verband der Automobilindustrie (VDA)). The levels of automation defined by the SAE/VDA for automotive applications are illustrated in Figure 2, where the description of the level of control the driver has over the car for each category is also given.

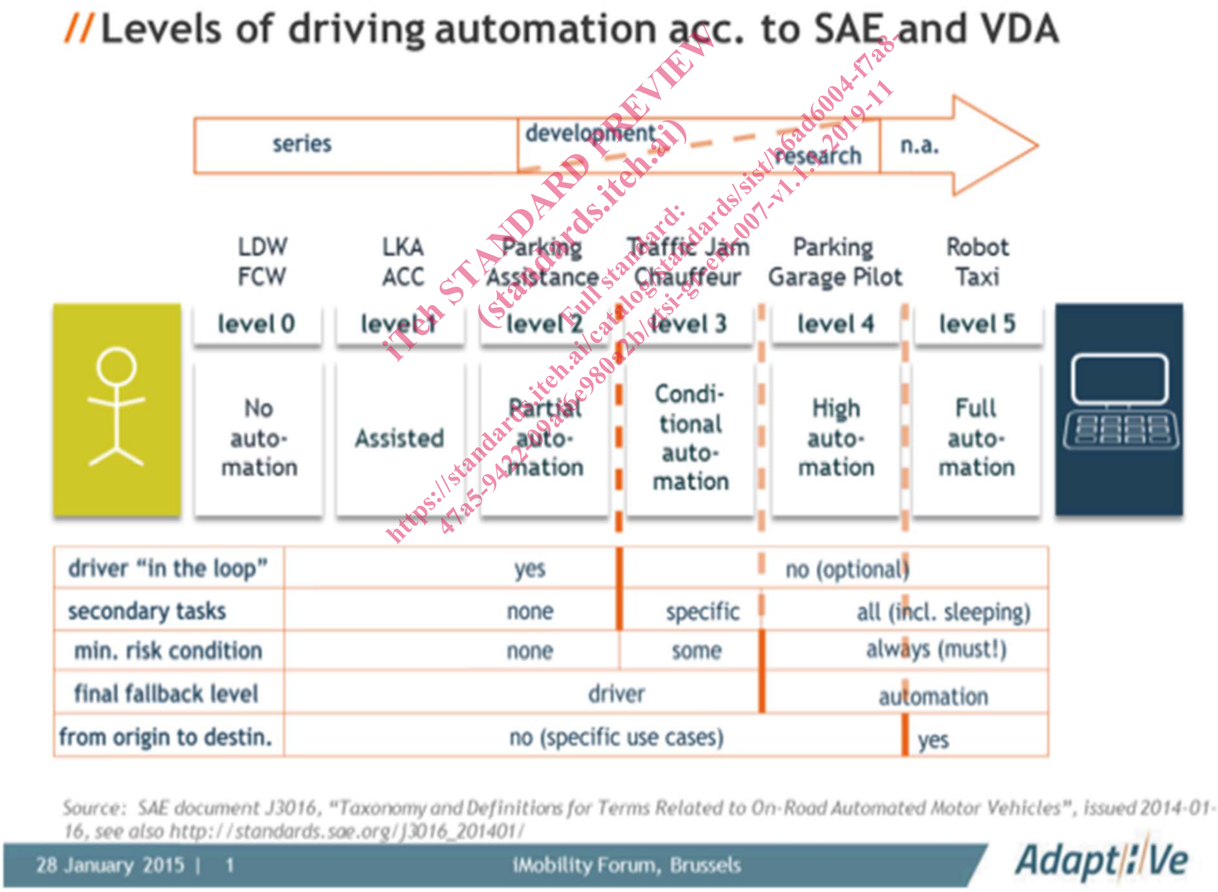

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Figure 2: Levels of automation defined by the SAE/VDA for automotive applications [i.14]

NOTE 1: The content of the figure refers to the terminology used by SAE/VDA in the context of automotive applications, e.g. the term automation may often be found. Therefore, Figure 2 is provided just as a conceptual example and the used terminology is not relevant to the present document.

Analysing the categories defined in the figure, and the associated documents [i.1] and [i.2], one can easily understand how categories can also be defined for an autonomic network, if the role of the car driver is replaced by that of the human operator of a network. With reference to Figure 2, instead of 'driver in the loop', one could speak of 'operator in the loop'. Moreover, increasing categories will have an increasing role of autonomic management based on AI application, with the subsequent reduction of required intervention of the operator. ETSI ISG ENI already provides the fundamentals for defining different categories of AI based network autonomicity in the "Use Cases" [i.3], "Requirements" [i.11] and in the "Context-aware policy management Gap Analysis" [i.12] documents. It is therefore straightforward to define AI-based network-autonomicity categories, in analogy to what has been just described in the different area of automotive application for AI. However, as it has been pointed out in note 1, the car automation example is not strictly and directly mapped to any network autonomicity use cases.

NOTE 2: An autonomic system is a ***self-governing system*** that can manage itself in accordance with high-level objectives.

NOTE 3: Self-governance is performed using cognition. The term "manage itself" means that the autonomic system can *sense* changes in itself and its environment, *analyse* changes to ensure that business goals are being met, and *execute* changes to protect ***business goals.***

4.2.2 Autonomicity applied to home broadband services

The example in this clause is the application of the concepts discussed above to a specific and limited set of network resources; this is the home network scenario, which is similar to an operator's network on a much smaller scale and with a much simpler architecture.

Figure 3 illustrates the definition of categories for autonomicity of broadband home services.

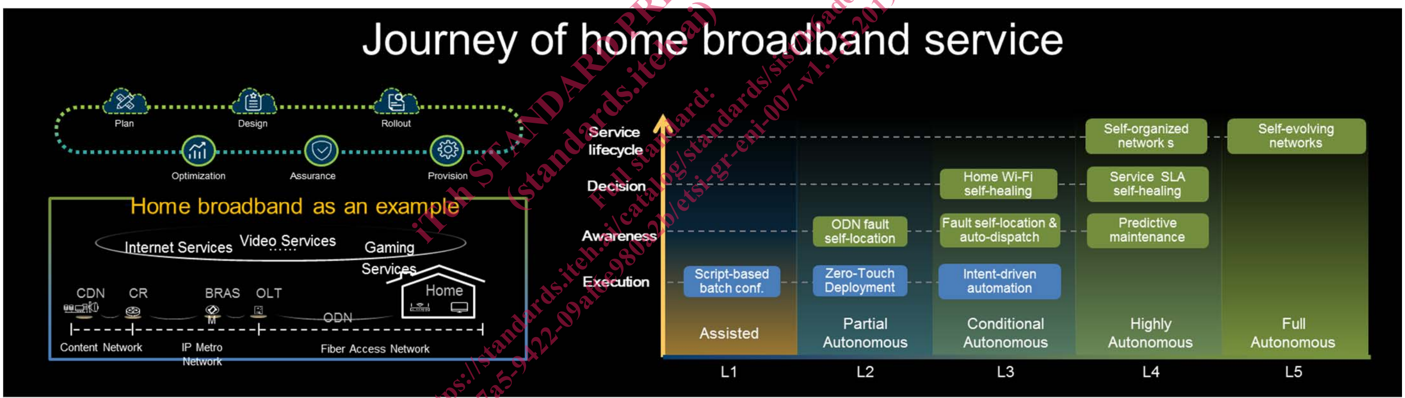

Figure 3: Example of definition of categories for autonomicity of home broadband services

NOTE 1: Figure 3 was originally made for different purposes, and is provided in the present document as an example; the terms used in it do not match necessarily the terminology used in ENI.

- The L0 category, fully manual, does not appear in figure 3.
- In the L1 category, where the Network Management System (NMS) is used to deliver device configuration scripts in batches, the efficiency is improved.
- In the L2 category, the Optical Network Terminal (ONT) box supports plug and play (PnP) for home terminals and implements partial autonomicity of the home network and services management. An example of this category is the implementation of intelligent fault location for the access network, at the level of the Optical Distribution Network (ODN).

NOTE 2: In addition, zero touch deployment, where devices are provisioned and configured automatically, also avoids the use of manual operation.

- In L3 category, conditional autonomicity, the system is autonomic in some phases of the service life cycle. For example, the service provisioning, driven by the intent 'broadband service', could configure 100 Mbit/s of fixed bandwidth based on the type of the house (villa, apartment), or could even define the bandwidth to be allocated based on user preferences (such as degree of game enthusiasm and video enthusiasm). This implementation completely replaces manual service deployment and greatly improves the O&M efficiency in service deployment.

NOTE 3: Home Wi-Fi self-healing and fault self-location and dispatch may also be utilized.

- The L4 category is highly autonomic, where service awareness and decision-making based on service provisioning are implemented. For example, with this increase on the degree of autonomicity, proactive maintenance, SLA-based self-healing, and service driven self-organizing networks can be implemented. This could represent a solution in support of those scenarios for which continuously accelerating service innovation creates revenue, while planning and design are not required.

- In the L5 category, full autonomic management is implemented in all scenarios, which can be seen as a long term goal.

The concepts provided in the examples will have to be extended in order to define general categories for the AI based networks autonomicity. This will be done in the following clauses.

5 Categories of Network Autonomicity

5.1 Introduction

Establishing suitable network autonomicity categories is helpful to guide users in choosing a specific implementation of AI assisted network, and understanding the self-adaptation capabilities to, i.e. changed service conditions, faults, deployment of new services and the autonomicity of operation and overall management.

It is important to note that the categories are focusing on the level of autonomicity the network is characterized by as a consequence of AI tools deployment. In other words, the different categories are providing a classification in terms of the advantages automation and autonomicity bring into the network management and operation processes thanks to the capabilities of adaptation and optimization acquired. Different categories will therefore correspond to different approaches and perspectives in network management and operation. The lowest category corresponds to the absence of automation and autonomicity, and their presence and influence increase in higher categories up to the full AI based autonomicity of network management and operation, thanks to cognition capabilities and closed loop implementation.

In the present clause, the characteristics that an AI assisted network needs are discussed with respect to:

1) match the requirements imposed by the services that the provider wants to implement; and

2) offer the needed level of autonomicity (which includes the many aspects mentioned above in clause 4).

Categories of network autonomicity are detailed below with a clear indication of what services and applications and what management approach the network is suited to support.

5.2 Factors determining the network autonomicity level

5.2.1 Technical factors

A number of technical factors need to be taken into account to determine the degree of AI based autonomicity in a network, and thus, the category that the system can be associated with. The increasing autonomicity of the network with the support of the ENI system open different market perspectives for its use in terms of supported services. Therefore, both technical and market factors will be taken into account for the different categories of network autonomicity, offering separate views. In this clause the technical factors will be considered, while market factors are considered in clause 5.2.2. The technical factors that influence the AI assisted network autonomicity are:

- Man-machine interface and level of required manual interaction/configuration with:
  - Imperative based mode, requiring to specify how a change in the network configuration is implemented (e.g. all manual, CLI by-device configuration, NETCONF multi-device collaboration management)
  - Declarative/intent based mode, requiring to specify what should be configured, without specifying how this configuration is realized
- Data collection and awareness parameters that define the attainable level of awareness:
  - Single device and shallow awareness (e.g. based on SNMP events and alarms)
  - Local awareness (e.g. based on SNMP events, alarms, KPIs, and logs)
  - Comprehensive awareness (based on basic telemetry data)
  - Comprehensive and adaptive sensing (such as compatible with data compression and optimization technologies)
  - Adaptive posture awareness (edge collection plus judgment)
  - Adaptive optimization upon deterioration (edge closed-loop, including collection, judgment, and optimization)
- Decision making participation (human operator in the loop or not): relevance of human decision versus machine decision
- Degree of intelligence and level of knowledge, analysis and understanding:
  - Lack of understanding (manual analysis)
  - Limited autonomous analysis
  - Deep autonomous analysis
  - Comprehensive knowledge based short-term forecast
  - Comprehensive knowledge based long-term forecast
  - Self-adaptation and knowledge-based reasoning
- Adaptation of the configuration to changes in the environment:
  - Static if no autonomic adaptation is supported
  - Limited adaptability to changes
  - Adaptability to significant changes
  - Any change when any autonomic adaptation is supported