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Experiential Networked Intelligence (ENI); System Architecture

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Foreword

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

Modal verbs terminology

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Executive summary

The present document specifies a high-level functional abstraction of the ENI System Architecture in terms of Functional Blocks and External Reference Points. This includes describing how different classes of systems interact with ENI. Processes, models, and detailed information are beyond the scope of the present document.

Introduction

The present document defines a high-level functional abstraction of the ENI System Architecture. The organization of the present document is as follows. Clause 1 defines the scope of the present document. Clauses 2 and 3 provide normative and informative references and definition of terms, respectively. Clause 4 provides an informative overview of the ENI System Architecture, including its motivation, benefits, important concepts, and an overview of its Functional Blocks. Clause 5 lists requirements of the ENI System Architecture. Clause 6 defines important design principles of the ENI System Architecture, and then specifies the different Functional Blocks that make up the ENI System Architecture. Clause 7 specifies the External Reference Points of the ENI System Architecture. Clause 8 describes how ENI interacts with other SDO Systems and clause 9 delineates a list of future study items.

1 Scope

The present document specifies the functional architecture of an ENI System, which is a high-level decomposition of an ENI System into its major components, along with a characterization of the externally visible behaviour (e.g. as defined by a set of reference points) of the components. This includes:

- defining the functionality and behaviour of a system that satisfy the ENI Requirements (ETSI GS ENI 002 [6]);
- defining a functional architecture, in terms of Functional Blocks, that addresses the goals specified by the ENI Use Cases (ETSI GS ENI 001 [5]);
- defining Reference Points used by the above Functional Blocks for all communication with systems and entities that are external to the ENI System;
- proposing a progression plan towards full support of the proposed ENI System and intermediary level of compliance (e.g. support of some architecture components or a subset of the Reference Points).

2 References

2.1 Normative 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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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 necessary for the application of the present document.

[1] OMG formal/2015-06-03: "OMG Systems Modeling Language".

[2] BBF TR-384: "Cloud Central Office Reference Architectural Framework", January 2018, G. Karagiannis, D. Hai.

[3] ETSI GS NFV-MAN 001: "Network Functions Virtualisation (NFV); Management and Orchestration".

[4] IETF RFC 4949: "Internet Security Glossary, Version 2", Shirey, R., August 2007.

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

[6] ETSI GS ENI 002 (V2.1.1): "Experiential Networked Intelligence (ENI); ENI requirements".

[7] MEF 78: "MEF Technical Specification: MEF Core Model", Strassner, J., editor, January 2019.

[8] Strassner, J., Agoulmine, N., Lehtihet, E.: "FOCALE - A Novel Autonomic Networking Architecture", ITSSA Journal 3(1), 64-79, 2007.

[9] Boyd, J. R.: "The Essence of Winning and Losing", June, 1995.

[10] Strassner. J.C.: "Knowledge Representation, Processing, and Governance in the FOCALE Autonomic Architecture", book chapter, 2011, Elsevier.

[11] NIST: "Role-Based Access Control, Second Edition".

NOTE: Available at https://us.artechhouse.com/Role-Based-Access-Control-Second-Edition-P1386.aspx.

[12] NIST: "Attribute Based Access Control".

NOTE: Available at https://csrc.nist.gov/publications/detail/book/2017/attribute-based-access-control.

[13] IETF RFC 8446: "The Transport Layer Security (TLS) Protocol Version 1.3", August 2018.

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] Strassner, J.: "Policy-Based Network Management", Morgan Kaufman, ISBN 978-1558608597, September 2003.

[i.2] Strassner, J., de Souza, J.N., Raymer, D., Samudrala, S., Davy, S., Barrett, K.: "The Design of a Novel Context-Aware Policy Model to Support Machine-Based Learning and Reasoning", Journal of Cluster Computing, Vol 12, Issue 1, pages 17-43, March, 2009.

[i.3] ETSI GR ENI 003 (V1.1.1): "Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis".

[i.4] Strassner, J., Betser, J., Ewart, R., Belz, F.: "A Semantic Architecture for Enhanced Cyber Situational Awareness", Secure and Resilient Cyber Architectures Conference, MITRE, 2010.

[i.5] Gamma, E., Helm, R. Johnson, R., Vlissides, J.: "Design Patterns: Elements of Reusable Object-Oriented Software", Addison-Wesley, Nov, 1994. ISBN 978-0201633610.

[i.6] Bäumer, D. Riehle, W. Siberski, M. Wulf: "The Role Object Pattern", Proceedings of the 1997 Conference on Object-Oriented Programming Systems, Languages and Applications (OOPSLA '97), ACM Press, 1997, Page 218-228.

[i.7] Rowley, J.: "The wisdom hierarchy: representations of the DIKW hierarchy", Journal of Information and Communication Science, 33(2): 163-180.

[i.8] Chin, K.O., Ganb, K.S., Alfred, R., Anthony, P, and Lukose, D.: "Agent Architecture: An Overview", Transactions on Science and Technology, vol 1, No 1, pp 18-35, 2014.

[i.9] Shehory, O and Sturm, A., editors: "Agent-Oriented Software Engineering", Springer, 2014.

[i.10] Martin, R. C.: "Agile Software Development, Principles, Patterns, and Practices", Prentice Hall, 2003 ISBN 978-0135974445.

[i.11] Ritter, F.E., Tehranchi, F., Oury, J.D.: "ACT-R: A Cognitive Architecture for Modeling Cognition", Wiley Interdisciplinary Reviews, Cognitive Science 10(4): e1488.

NOTE: Available at http://act-r.psy.cmu.edu.

[i.12] IETF RFC 8328: "Policy-Based Management Framework for the Simplified Use of Policy Abstractions (SUPA)", Liu, W., Xie, C., Strassner, J., Karagiannis, G., Klyus, M., Bi, J., Cheng, Y., and D. Zhang .

NOTE: Available at https://www.rfc-editor.org/info/rfc8328.

[i.13] Rothenberg, J.: "The Nature of Modelling", Artificial Intelligence, Simulation, and Modeling, John Wiley and Sons, Inc., 1989, pp. 75-92.

NOTE: Available at https://www.rand.org/content/dam/rand/pubs/notes/2007/N3027.pdf.

[i.14] Recommendation ITU-T 9594-1: "Information Technology - Open Systems Interconnection - The Directory: Overview of Concepts, Models, and Services".

[i.15] Recommendation ITU-T 9594-7: "Information Technology - Open Systems Interconnection - The Directory: Selected Object Classes".

[i.16] ETSI GR ENI 003 (V1.1.1): "Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis".

[i.17] MEF Technical Specification: "Policy-Driven Orchestration", Call for Comments v0.7, August 2017, Strassner, J., editor.

NOTE: Available at https://wiki.mef.net/download/attachments/59846378/MEF%20PDO%20CfCB1.zip?api=v2.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

agent: computational process that implements the autonomous, communicating functionality of an application

- **software agent:** software that acts on behalf of a user or another program
- **software autonomous agent:** software agent that acts on behalf of the entity that owns it without any communication from the owning entity
- **software intelligent agent:** software agent that reasons about its environment and take the best set of actions to satisfy a set of goals

NOTE: This has the connotation of containing AI mechanisms to provide the reasoning and decision-making capabilities.

- **software multi-agent:** set of software agents that are physically separate that work together to satisfy a set of goals

API: set of communication protocols, code, and tools that enable one set of software components to interact with either a human or a different set of software components

NOTE: This is also known as an Application Programming Interface.

API Broker: software entity that mediates between two systems with different APIs, enabling the two different systems to communicate transparently with each other

architecture: set of rules and methods that describe the functionality, organization, and implementation of a system

- **cognitive architecture:** system that learns, reasons, and makes decisions in a manner resembling that of a human mind

NOTE: Specifically, the learning, reasoning, and decision-making is performed using software that makes hypotheses and proves or disproves them using non-imperative mechanisms that typically involve constructing new knowledge dynamically during the decision-making process.

- **deliberative architecture:** symbolic world model that enables problem-solving components to be built using a sense-plan-act paradigm
- **hybrid architecture:** system made up of reactive and deliberative components that are combined into a hierarchy of interacting layers, where each layer reasons at a different level of abstraction
- **reactive architecture:** system that is aware of changes that affect its computations and adjusts accordingly

NOTE: The adjustment is made by reacting to an event in real-time without centralized control. The availability of new information drives program logic execution.

- **software architecture:** high-level structure and organization of a software-based system. this includes the objects, their properties and methods, and relationships between objects

assisted system: system that the ENI system is providing recommendations and/or management commands to is referred to as the "assisted system"

cognition: process of understanding data and information and producing new data, information, and knowledge

context: collection of measured and inferred knowledge that describe the environment in which an entity exists or has existed

decision making: set of processes that result in the selection of a set of actions to take from among several alternative possible actions

designated entity: operator, nms, ems, controller, or orchestrator acting on behalf of the assisted system

NOTE: The Designated Entity is a trusted entity [4].

design pattern: general, reusable solution in a given context to a commonly occurring software problem

NOTE: This type of design pattern is not an architecture and not even a finished design; rather, it describes how to build the elements of a solution that commonly occurs. It may be thought of as a reusable template.

- **design pattern, architecture:** general, reusable solution in a given context to a commonly occurring problem in the design of the software architecture of a system

- **design pattern, software:** general, reusable solution in a given context to a commonly occurring problem in the design of a software system

formal: study of (typically linguistic) meaning of an object by constructing formal mathematical models of that object and its attributes and relationships

knowledge: analysis of data and information, resulting in an understanding of what the data and information mean

NOTE: Knowledge represents a set of patterns that are used to explain, as well as predict, what has happened, is happening, or is possible to happen in the future; it is based on acquisition of data, information, and skills through experience and education.

- **inferred knowledge:** knowledge that was created based on reasoning, using evidence provided

- **measured knowledge:** knowledge that has resulted from the analysis of data and information that was measured or reported

- **propositional knowledge:** knowledge of a proposition, along with a set of conditions that are individually necessary and jointly sufficient to prove (or disprove) the proposition

location: physical geographic location (e.g. a geocode or a bounding polygon) of an entity (e.g. a server)

NOTE: Contrast this with Placement.

Model-Driven Behaviour (MDB): approach in which the behaviour of components, modules of systems are managed using MDE. For ENI, this applies to Functional Blocks, not components within a Functional Block

Model-Driven Engineering (MDE): approach in which models are central to all phases of the development and implementation processes

negotiation: set of communications that is intended to reach a beneficial outcome for a set of conflicting issues

- **distributive negotiation:** zero-sum game, in which each participant assumes that there is a fixed amount of value to be divided between the (winning) bidders

- **integrative negotiation:** win-win (or non-zero-sum) game, in which all collaborating participants receive optimal value

placement: logical placement of an entity (e.g. a virtual machine) on or in another entity (e.g. a server).

NOTE: Contrast this with Location.

repository: centralized location of a set of storage devices that enable different functional blocks to store and retrieve information

- **active repository:** repository that pre- and/or post-processes information that is stored or retrieved

NOTE: It may contain dedicated (typically internal) Reference Points that provide the loading, activation, deactivation, and unloading of specialized functions that change the pre- and/or post-processing functionality according to the needs of the application.

- **passive repository:** repository that stores or retrieves information without pre- or post-processing

SDO system: part of an Assisted System that is defined by another SDO

NOTE: Examples include NFV MANO and MEF LSO.

semantics: study of the meaning of something (e.g. a sentence or a relationship in a model)

telemetry: process of recording and transmitting data to receiving equipment for monitoring purposes

NOTE: The process is typically automated, and the data transfer may include wireless, cellular, optical, and other mechanisms.

3.2 Symbols

Void.

3.3 Abbreviations

Void.

4 Overview of System Architecture (informative)

4.1 Introduction

This clause provides an informative introduction to the ENI System Architecture. Clauses 4.2 and 4.3 describe the motivation and benefits of ENI. Clause 4.4 provides a high-level description of the ENI System Architecture, including how it interacts with the Assisted System (and/or its Designated Entity), different types of Assisted Systems, the mode of operation that the Assisted System (or its Designated Entity) can choose, direct and indirect communication between the ENI System and the Assisted System (or its Designated Entity), and important concepts used in this System Architecture. Clause 4.5 describes the functional architecture of the ENI System in terms of Functional Blocks. It ends with a discussion of how decision-making is done in the ENI System.

NOTE: See clause 9 for further applicable future work.

4.2 Motivation for ENI

Current network management provisioning and monitoring functions are time-consuming and error-prone. This is due to the proliferation of different technologies, as well as different implementations from different vendors. In addition, users are demanding more complex services (e.g. context-aware, personalized services). Hence, operators are concerned about the increasing complexity of integration of different platforms in their network and operational environment. These human-machine interaction challenges increase the time to market of innovative and advanced services. Moreover, there is no efficient and extensible standards-based mechanism to provide contextually-aware services (e.g. services that adapt to changes in user needs, business goals, or environmental conditions).

These and other factors contribute to a very high OPerational EXpenditure (OPEX) for network operation and management. Operators need to optimize the use of networked resources (e.g. through the automation of their network configuration and monitoring processes to reduce this OPEX). More importantly, operators need to improve the use and maintenance of their networks.