

ETSI GS ENI 005 V2.1.1 (2021-12)



Experiential Networked Intelligence (ENI); System Architecture

(<https://standards.iteh.ai>)
Document Preview

[ETSI GS ENI 005 V2.1.1 \(2021-12\)](https://standards.iteh.ai/catalog/standards/etsi/6cbc633d-65d1-4f1f-a30a-afc264c04505/etsi-gs-eni-005-v2-1-1-2021-12)

<https://standards.iteh.ai/catalog/standards/etsi/6cbc633d-65d1-4f1f-a30a-afc264c04505/etsi-gs-eni-005-v2-1-1-2021-12>

Disclaimer

The present document has been produced and approved by the Experiential Networked Intelligence (ENI) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG.
It does not necessarily represent the views of the entire ETSI membership.

Reference

RGS/ENI-0016_Sys_Architecture

Keywords

architecture, API, artificial intelligence, closed control loop, cognition, functional architecture, functional block, intent management, management, model-driven engineering, network, policy management**ETSI**

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2021.
All rights reserved.

Contents

Intellectual Property Rights	10
Foreword.....	10
Modal verbs terminology.....	10
Executive summary	10
Introduction	11
1 Scope	12
2 References	12
2.1 Normative references	12
2.2 Informative references.....	13
3 Definition of terms, symbols and abbreviations.....	15
3.1 Terms.....	15
3.2 Symbols.....	27
3.3 Abbreviations	27
4 Overview of System Architecture (informative).....	29
4.1 Introduction	29
4.2 Motivation for ENI.....	29
4.3 Benefits of ENI.....	30
4.4 High-Level Description of the ENI System Architecture.....	30
4.4.1 Overall Description.....	30
4.4.2 The Assisted System	31
4.4.2.1 Introduction.....	31
4.4.2.2 Communication Options for All Classes of Assisted Systems.....	31
4.4.2.3 Class 1: An Assisted System that has No AI-based Capabilities	32
4.4.2.4 Class 2: An Assisted System with AI that is Not in the Control Loop.....	33
4.4.2.5 Class 3: An Assisted System with AI Capabilities in its Control Loop	33
4.4.2.5.1 Introduction	33
4.4.2.5.2 Class 3 Options.....	34
4.4.2.5.2.1 Introduction.....	34
4.4.2.5.2.2 Option 1 Feedback	34
4.4.2.5.2.3 Option 2 Communication.....	35
4.4.2.5.2.4 Working as an External Discrete System.....	35
4.4.2.6 Summary of Interaction between the Assisted System and ENI.....	35
4.4.3 Communication and Interaction with Other External Systems	36
4.4.4 Mode of Operation.....	36
4.4.4.1 Allowed Modes of Operation	36
4.4.4.2 Setting the Mode of Operation	36
4.4.4.3 Interaction with the Assisted System	36
4.4.4.4 Selecting a Mode of Operation for a Class of Decisions.....	37
4.4.4.5 Communication of Mode of Operation	37
4.4.4.6 Normal Operation of the Selected Mode of Operation.....	37
4.4.4.6.1 Overview	37
4.4.4.6.2 Case 1: ENI Indirectly Instructs the Assisted System to Switch Modes.....	37
4.4.4.6.3 Case 2: ENI Directly Instructs the Assisted System to Switch Modes.....	37
4.4.4.7 Normal Operation of the Selected Mode of Operation.....	38
4.4.4.8 Exception Handling for the Selected Mode of Operation	38
4.4.5 Functional Concepts	38
4.4.5.1 Functional Concepts for Modular System Operation.....	38
4.4.5.2 Overview of Prominent Control Loop Architectures	38
4.4.6 ENI Reference Points.....	39
4.4.6.1 Definition of an ENI Reference Point	39
4.4.6.2 Definition of an ENI External Reference Point.....	39
4.4.6.3 Definition of an ENI Internal Reference Point.....	39
4.4.7 ENI Interfaces.....	39

4.4.7.1	Definition of an ENI Interface	39
4.4.7.2	Definition of an ENI Hardware Interface	39
4.4.7.3	Definition of an ENI Software Interface	39
4.4.7.4	Definition of an ENI Application Programming Interface	39
4.4.7.5	Comparison of ENI Software Interfaces with ENI APIs.....	40
4.5	Functional Architecture	40
4.5.1	Functional Block Diagram of the ENI System	40
4.5.2	API Broker	42
4.5.2.1	Introduction	42
4.5.2.2	Definition of the ENI API Broker	42
4.5.2.3	Use of an API Broker in ENI	42
4.5.2.4	Alternatives to Using an API Broker	42
4.5.3	ENI System Functional Blocks	43
4.5.3.1	Introduction	43
4.5.3.2	Input Processing	43
4.5.3.2.1	Overview	43
4.5.3.2.2	Data Ingestion Functional Block	43
4.5.3.2.3	Normalization Functional Block	43
4.5.3.3	Analysis.....	44
4.5.3.3.1	Knowledge Management and Processing	44
4.5.3.3.1.1	Overview	44
4.5.3.3.1.2	Cognition Model	44
4.5.3.3.1.3	Knowledge Management Functional Block	44
4.5.3.3.1.4	ContextAware Management Functional Block	44
4.5.3.3.1.5	Cognition Management Functional Block	44
4.5.3.4	Situation-based, Model-driven, Policy Generation	45
4.5.3.4.1	Overview	45
4.5.3.4.2	Situation Awareness Functional Block.....	45
4.5.3.4.3	Model Driven Engineering Functional Block.....	45
4.5.3.4.4	Policy Management Functional Block.....	45
4.5.3.5	Output Generation	46
4.5.3.5.1	Overview	46
4.5.3.5.2	Denormalization Functional Block.....	46
4.5.3.5.3	Output Generation Functional Block.....	46
4.5.4	Decision-Making	46
4.5.4.1	Overview	46
4.5.4.2	Decision-Making using Hindsight	47
4.5.4.3	Decision-Making using Deterministic Processing	47
4.5.4.4	Decision-Making using Predictive Processing	47
4.5.4.5	Decision-Making using Cognitive Processing	47
4.5.5	Introduction to Artificial Intelligence Mechanisms for Modular Systems.....	47
5	ENI Architectural Requirements	48
5.1	Introduction	48
5.2	Functional Architectural Requirements for ENI Operation.....	48
5.3	Architectural Requirements for Mode of Operation.....	49
5.4	Non-Functional Architectural Requirements for ENI Operation.....	50
5.5	Reference Point Requirements	50
5.6	Knowledge Modeling Requirements	52
5.7	Control Loop Processing Requirements	53
5.8	Functional Block Processing Requirements	54
5.8.1	Context Processing Requirements	54
5.8.2	Cognition Requirements	55
5.8.3	Policy Management Requirements	55
5.9	AI Modelling and Training Model Requirements	56
5.10	API Requirements	57
6	ENI Reference Architectural Framework.....	58
6.1	Introduction	58
6.2	Design Principles of the ENI System architecture	58
6.2.1	Overview	58
6.2.2	Nesting of Functional Blocks.....	59
6.2.3	Communication and Interaction.....	60

6.2.3.1	Introduction	60
6.2.3.2	Discovery	61
6.2.3.3	Direct Communication	61
6.2.3.4	Indirect Communication	61
6.2.3.5	Negotiation	61
6.2.3.5.1	Introduction	61
6.2.3.5.2	Distributive Negotiation	61
6.2.3.5.3	Integrative Negotiation	62
6.2.3.5.4	Functional Model: an Informative Example	62
6.2.3.5.5	Usage	62
6.2.4	Administrative and Management Domains	63
6.2.4.1	Introduction	63
6.2.4.2	Domain Operations	63
6.2.4.3	Interaction between Hierarchical Domains	64
6.2.4.4	Interaction between Distributed Administrative Domains	65
6.2.4.5	Interaction between Federated Administrative Domains	65
6.2.5	Modelled Knowledge	66
6.2.6	Bias	66
6.2.6.1	Introduction	66
6.2.6.2	Protection Against Bias	66
6.2.6.3	Adherence to Applicable Standards to Mitigate Bias	66
6.2.7	Ethics	67
6.2.7.1	Introduction	67
6.2.7.2	Methods to Ensure Ethical Decision-Making	67
6.2.7.3	Adherence to Applicable Standards and Initiatives	67
6.2.8	The Assisted System	69
6.2.8.1	Overview	69
6.2.8.2	Class 1 and 2 Assisted Systems	69
6.2.8.3	Class 3 Assisted Systems	69
6.2.8.3.1	Single Class 3 Assisted Systems	69
6.2.8.3.2	Multiple Class 3 Assisted Systems	70
6.3	Architectural Functional Blocks of the ENI System	72
6.3.1	ENI Functional Architecture with Reference Points	72
6.3.1.1	Introduction	72
6.3.1.2	ENI Functional Architecture with External Reference Points	72
6.3.1.3	ENI Functional Architecture with Internal Reference Points	73
6.3.1.4	ENI Functional Architecture with Administrative and Management Domains	73
6.3.1.5	ENI Functional Architecture with Control Loops	75
6.3.1.6	ENI Functional Architecture with Domains and Control Loops	77
6.3.2	Data Ingestion Functional Block	77
6.3.2.1	Introduction	77
6.3.2.2	Motivation	78
6.3.2.3	Function of the Data Ingestion Functional Block	78
6.3.2.3.1	Introduction	78
6.3.2.3.2	Data Filtering	79
6.3.2.3.3	Data Correlation	79
6.3.2.3.4	Data Cleansing	79
6.3.2.3.5	Data Anonymization and Pseudonymization	79
6.3.2.3.6	Data Augmentation	79
6.3.2.3.7	Data Labelling and Annotation	80
6.3.2.3.7.1	Introduction	80
6.3.2.3.7.2	Types of Data Annotations	80
6.3.2.3.7.3	Labelling Accuracy and Labelling Quality	80
6.3.2.3.7.4	Semantic Annotation	81
6.3.2.4	Operation of the Data Ingestion Functional Block	81
6.3.2.4.1	Introduction	81
6.3.2.4.2	Telemetry Processing	82
6.3.2.4.2.1	Cognitive and Situation-Aware Directed Telemetry Gathering	82
6.3.2.4.2.2	Detecting Anomalies	82
6.3.2.4.2.3	Storing Telemetry Information	83
6.3.2.4.2.4	Changing Telemetry Gathering using Policies	83
6.3.2.4.3	Use of Metadata	83

6.3.2.4.4	Use of Structure, Pattern, and Feature Matching.....	83
6.3.2.4.5	Use of AI-based Mechanisms.....	84
6.3.2.4.6	Use of Formal Logic and Ontologies.....	84
6.3.3	Data Normalization Functional Block.....	85
6.3.3.1	Introduction.....	85
6.3.3.2	Motivation.....	85
6.3.3.3	Function of the Data Normalization Functional Block.....	85
6.3.3.4	Operation of the Data Normalization Functional Block.....	85
6.3.3.4.1	Introduction.....	85
6.3.3.4.2	Database Design Analogy (informative).....	86
6.3.3.4.3	Normalization for Machine Learning.....	86
6.3.3.4.4	Applying Normalization to ENI.....	87
6.3.3.4.5	Storing Normalized Telemetry Information.....	88
6.3.3.4.6	Changing Telemetry Gathering using Policies.....	88
6.3.3.4.7	Cognitive and Situation-Aware Directed Normalized Telemetry Gathering.....	88
6.3.3.4.8	Use of Metadata.....	88
6.3.3.4.9	Use of Structure, Pattern, and Feature Matching.....	88
6.3.3.4.10	Use of AI-based Mechanisms.....	88
6.3.3.4.11	Use of Formal Logic and Ontologies.....	89
6.3.4	Knowledge Management Functional Block.....	89
6.3.4.1	Introduction.....	89
6.3.4.2	Inferencing.....	89
6.3.4.3	Motivation.....	90
6.3.4.4	Knowledge Processing.....	90
6.3.4.4.1	Knowledge Representation and Enhancement.....	90
6.3.4.4.2	Knowledge Normalisation.....	91
6.3.4.4.3	Transforming Data, Information, and Knowledge into Wisdom.....	92
6.3.4.4.4	Semantic Bus.....	93
6.3.4.5	Repositories.....	93
6.3.4.5.1	Overview.....	93
6.3.4.5.2	Data Repository.....	94
6.3.4.5.3	Model Repositories.....	94
6.3.4.5.4	Knowledge Repositories.....	94
6.3.4.5.5	Blackboard Repositories.....	95
6.3.4.5.6	Repository Operation.....	96
6.3.4.5.7	Semantically Augmented Query and Learning.....	96
6.3.4.6	Function of the Knowledge Management Functional Block.....	96
6.3.4.6.1	Introduction.....	96
6.3.4.6.2	Grounding Knowledge Using Semantics.....	97
6.3.4.6.3	Resolving Knowledge Conflicts.....	97
6.3.4.6.4	Knowledge Distribution.....	97
6.3.4.7	Operation of the Knowledge Management Functional Block.....	97
6.3.4.7.1	Introduction.....	97
6.3.4.7.2	Observe Functionality.....	98
6.3.4.7.3	Orient Functionality.....	99
6.3.4.7.4	Decide Functionality.....	99
6.3.4.7.5	Model-Driven-Enhanced Decide Functionality.....	100
6.3.4.7.6	Act Functionality.....	100
6.3.4.7.7	Model-Driven-Enhanced Act Functionality.....	100
6.3.4.7.8	Learning-Enhanced OODA.....	100
6.3.4.7.9	Reasoning-Enhanced OODA.....	101
6.3.5	Context-Aware Management Functional Block.....	101
6.3.5.1	Introduction.....	101
6.3.5.2	Motivation.....	101
6.3.5.3	Function of the Context-Aware Management Functional Block.....	101
6.3.5.3.1	Introduction.....	101
6.3.5.3.2	Modelling and Representation of Context Awareness.....	102
6.3.5.3.3	Processing Contextual Updates.....	104
6.3.5.4	Operation of the Context-Aware Management Functional Block.....	105
6.3.6	Cognition Management Functional Block.....	107
6.3.6.1	Introduction.....	107
6.3.6.2	Motivation.....	107

6.3.6.3	Function of the Cognition Management Functional Block	107
6.3.6.3.1	Introduction (informative)	107
6.3.6.3.2	The Symbolic Approach (informative).....	108
6.3.6.3.3	The Connectionist Approach (informative).....	110
6.3.6.4	Operation of the Cognition Management Functional Block	110
6.3.7	Situational Awareness Functional Block	110
6.3.7.1	Introduction	110
6.3.7.2	Motivation	111
6.3.7.3	Function of Situational Awareness	111
6.3.7.4	Operation of the Situational Awareness Functional Block	111
6.3.7.4.1	Introduction	111
6.3.7.4.2	Use of Memory and the Cognition Model	111
6.3.7.4.3	Definition and Management of Goals to be Achieved.....	112
6.3.7.4.4	Architecture of a Cognitive Functional Block	112
6.3.7.4.5	Leveraging Historical Situation Information	114
6.3.7.5	Difference between Context Awareness and Situational Awareness	114
6.3.8	Model Driven Engineering Functional Block	114
6.3.8.1	Introduction	114
6.3.8.2	Motivation	114
6.3.8.3	Function of the Model Driven Engineering Functional Block	115
6.3.8.4	Operation of the Model Driven Engineering Functional Block	115
6.3.8.4.1	Introduction	115
6.3.8.4.2	Knowledge Data Fusion, Transformation, and Processing.....	117
6.3.8.4.3	Knowledge Transformation into Policy Information.....	117
6.3.9	Policy Management Functional Block.....	117
6.3.9.1	Introduction.....	117
6.3.9.2	Motivation.....	117
6.3.9.3	Modelling and Representing Types of Policies.....	118
6.3.9.3.1	Introduction	118
6.3.9.3.2	Reuse of the MEF Policy Model	118
6.3.9.3.3	Reuse of the MEF Core Model.....	118
6.3.9.3.4	Types of Policies Used in ENI	119
6.3.9.3.5	Overview of a Unified Policy Information Model.....	120
6.3.9.3.5.1	Introduction.....	120
6.3.9.3.5.2	Representing Different Types of Policies with a Single Information Model	120
6.3.9.3.6	Definition of Key Classes and Relationships	120
6.3.9.3.6.1	MCPolicyObject	120
6.3.9.3.6.2	MPMPolicyStructure	121
6.3.9.3.6.3	MPMPolicyHasMPMPolicyStatement Aggregation.....	122
6.3.9.3.6.4	MPMPolicyHasMPMPolicySource Aggregation	122
6.3.9.3.6.5	MPMPolicyHasMPMPolicyTarget Aggregation	122
6.3.9.3.6.6	MPMPolicyComponentStructure.....	122
6.3.9.3.6.7	MPMPolicyStatement	122
6.3.9.3.6.8	MPMPolicySource	123
6.3.9.3.6.9	MPMPolicyTarget	124
6.3.9.3.7	Definition of Key Supporting Classes	124
6.3.9.3.7.1	Subclasses of MPMPolicyStructure.....	124
6.3.9.3.7.2	Subclasses of MPMPolicyComponentStructure	124
6.3.9.3.8	Policy Interaction.....	125
6.3.9.4	Processing Policies.....	125
6.3.9.4.1	Introduction	125
6.3.9.4.2	Constructing Policies: Parsers vs. Compilers vs. Interpreters	125
6.3.9.4.3	Policy Languages.....	126
6.3.9.4.3.1	Introduction.....	126
6.3.9.4.3.2	Controlled Languages	126
6.3.9.4.3.3	DSLs	126
6.3.9.4.3.4	GPLs	126
6.3.9.4.3.5	Recommendation	126
6.3.9.4.4	Policy Scope	127
6.3.9.4.4.1	Introduction.....	127
6.3.9.4.4.2	Policy Communication Requirements	127
6.3.9.4.4.3	Policies that Affect the Behaviour of an External Entity	127

6.3.9.4.4.4	Policies that Affect the Behaviour of an ENI System	128
6.3.9.5	Function of the Policy Management Functional Block	129
6.3.9.6	Operation of the Policy Management Functional Block	129
6.3.9.6.1	Introduction	129
6.3.9.6.2	The Policy Continuum	130
6.3.9.6.3	Policy Management Architecture	131
6.3.9.6.3.1	Policy Input	131
6.3.9.6.3.2	Policy Acknowledgements and Output	132
6.3.9.6.3.3	Policy Management Options	133
6.3.9.6.3.4	Option 1: a Single Unified Policy Management Architecture	133
6.3.9.6.3.5	Option 2: Differentiating between Intent and Other Types of Policies	135
6.3.9.6.4	Policy Management Federation	137
6.3.9.6.5	Constructing, Deploying, and Activating Policies	137
6.3.9.6.6	Managing Policies	139
6.3.9.6.7	Deactivating and Removing Policies	139
6.3.10	Denormalization Functional Block	140
6.3.10.1	Introduction	140
6.3.10.2	Motivation	140
6.3.10.3	Function of the Denormalization Functional Block	140
6.3.10.4	Operation of the Denormalization Functional Block	141
6.3.11	Output Generation Functional Block	142
6.3.11.1	Introduction	142
6.3.11.2	Motivation	142
6.3.11.3	Function of the Output Generation Functional Block	142
6.3.11.4	Operation of the Output Generation Functional Block	142
6.3.11.4.1	Introduction	142
6.3.11.4.2	Treating Output Generation as the Inverse of Normalization	143
6.4	API Broker	144
6.4.1	Introduction	144
6.4.2	Motivation	144
6.4.3	Function of the API Broker	144
6.4.4	Operation of the API Broker	145
6.5	Communication Between Functional Blocks	145
6.5.1	Introduction	145
6.5.2	Common Communication Requirements	146
6.5.3	Recommended Communication Patterns to be Used Within ENI	146
6.5.3.1	Introduction	146
6.5.3.2	Remote Procedure Calls and Remote Method Invocations	147
6.5.3.3	Batch File Exchange	147
6.5.3.4	Shared Database	147
6.5.3.5	Messaging	147
6.5.3.5.1	Introduction	147
6.5.3.5.2	Common Requirements of Messaging Systems	147
6.5.3.5.3	Messaging Functionality	148
6.5.4	Recommended Communication Patterns to be Used Between ENI and External Systems	149
6.6	Security Considerations	149
7	Reference Points	149
7.1	Introduction	149
7.2	External Reference Point Overview	149
7.3	External Reference Point Definitions	152
7.3.1	Reference Point $E_{oss-eni-dat}$	152
7.3.2	Reference Point $E_{oss-eni-cmd}$	152
7.3.3	Reference Point $E_{oss-eni-pol}$	153
7.3.4	Reference Point $E_{app-eni-ctx}$	153
7.3.5	Reference Point $E_{app-eni-oth}$	154
7.3.6	Reference Point $E_{app-eni-kno}$	154
7.3.7	Reference Point $E_{app-eni-pol}$	154
7.3.8	Reference Point $E_{bss-eni-dat}$	155
7.3.9	Reference Point $E_{bss-eni-cmd}$	155
7.3.10	Reference Point $E_{bss-eni-pol}$	155
7.3.11	Reference Point $E_{usr-eni-pol}$	156

7.3.12	Reference Point $E_{or-eni-dat}$	156
7.3.13	Reference Point $E_{or-eni-cmd}$	157
7.3.14	Reference Point $E_{or-eni-pol}$	157
7.3.15	Reference Point $E_{inf-eni-dat}$	157
7.3.16	Reference Point $E_{inf-eni-cmd}$	158
7.3.17	Reference Point $E_{eni-api-in}$	158
7.3.18	Reference Point $E_{eni-api-out}$	158
7.4	External Reference Points Protocol Specification	158
7.4.1	Introduction.....	158
7.4.2	Generic Protocols for use with External Reference Points	158
7.4.3	Specific Protocols for use with External Reference Points	158
7.5	API	159
7.6	Internal Reference Point Overview	159
7.7	Internal Reference Point Definitions	160
7.7.1	Reference Point $I_{ing-norm}$	160
7.7.2	Reference Point $I_{norm-sem}$	160
7.7.3	Reference Point I_{sem-km}	161
7.7.4	Reference Point I_{sem-ca}	161
7.7.5	Reference Point $I_{sem-cog}$	161
7.7.6	Reference Point I_{sem-sa}	161
7.7.7	Reference Point $I_{sem-mde}$	161
7.7.8	Reference Point I_{sem-pm}	161
7.7.9	Reference Point $I_{sem-denorm}$	162
7.7.10	Reference Point $I_{denorm-out}$	162
7.8	Internal Reference Point Protocol Specification.....	162
7.8.1	Introduction.....	162
7.8.2	Generic Protocols for use with Internal Reference Points	162
7.8.3	Specific Protocols for use with Internal Reference Points	162
8	Interacting with Other Standardized Architectures	162
8.1	Introduction	162
8.2	Generic Architecture	163
8.3	Generic SDO Interaction Architecture	164
8.3.1	Introduction.....	164
8.4	Interaction with NFV MANO	165
8.4.1	High Level description of the NFV MANO - ENI Interaction	165
8.4.2	Initial proposals for interaction scenarios	166
8.4.2.1	Introduction.....	166
8.4.2.2	Scenario 1: Passive Notification to NFV MANO	166
8.4.2.3	Scenario 2: Active Data Analysis for NFV MANO.....	166
8.4.2.4	Scenario 3: Active Assistance to the NFV MANO System	166
8.4.2.5	Scenario 4: Active Assistance to the Assisted System	167
8.4.3	Interaction Scenarios for Assisted Policy Management in NFV MANO	167
8.5	Interaction with the MEF LSO RA	167
9	Areas for Future Study	168
9.1	Open Issues for the Present Document.....	168
9.2	Issues for Future Study	168
Annex A (informative): SDO and Open Source Interactions		170
A.1	Integration with Other SDOs and Open Source Communities.....	170
A.1.1	Introduction	170
A.1.2	Interaction with BBF CloudCO.....	170
A.2	Interaction with Open Source Communities	172
Annex B (informative): ENI Architectural Evolution.....		173
B.1	ENI Architecture Evolution Motivation.....	173
B.2	ENI Architecture Evolution Proposal.....	173
B.3	Proposed Definition of the ENI Phases	173
History		174

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

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

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

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.

i Teh Sa nda ds
(<https://standards.iteh.ai>)
Document Preview

ETSI GS ENI 005 V2.1.1 (2021-12)

<http://standards.iteh.ai/catalog/standards/etsi/6bc6c3635d4df4b3-0afca26044c8tsi-gs-eni-00v251-1-2-012>

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 [i.40]);
- defining a functional architecture, in terms of Functional Blocks, that addresses the goals specified by the ENI Use Cases (ETSI GS ENI 001 [3]);
- 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] ETSI GS NFV-MAN 001: "Network Functions Virtualisation (NFV); Management and Orchestration".
- [2] IETF RFC 4949: "Internet Security Glossary, Version 2", Shirey, R., August 2007.
- [3] ETSI GS ENI 001 (V3.1.1): "Experiential Networked Intelligence (ENI); ENI use cases".
- [4] Strassner, J., Agoulmine N., Lehtihet, E.: "FOCALE - A Novel Autonomic Networking Architecture", ITSSA Journal 3(1), 64-79, 2007.
- [5] Boyd, J. R.: "The Essence of Winning and Losing", June, 1995.
- [6] Strassner, J.: "Knowledge Representation, Processing, and Governance in the FOCALE Autonomic Architecture", chapter 11 of Autonomic Network Management Principles, 2011, Elsevier.
- [7] MEF 78.1: "MEF Technical Specification: MEF Core Model", Strassner, J., editor, July 2020.

NOTE: Available at: <https://www.mef.net/resources/mef-78-1-mef-core-model-mcm/>.

- [8] MEF 95: "MEF Policy Driven Orchestration", Strassner, J, editor, July 2021.

NOTE: Available at: <https://www.mef.net/resources/mef-95-mef-policy-driven-orchestration>.

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] Strassner, J., van der Meer, S., O'Sullivan, D., and Dobson, S.: "The Use of Context-Aware Policies and Ontologies to Facilitate Business-Aware Network Management", Journal of Network and Systems Management 17(3), pages 255-284, 2009.
 - [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] 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.8] Shehory, O and Sturm, A., editors: "Agent-Oriented Software Engineering", Springer, 2014.
 - [i.9] Martin, R. C.: "Agile Software Development, Principles, Patterns, and Practices", Prentice Hall, 2003 ISBN 978-0135974445.
 - [i.10] Ritter, F.E., Tehranchi, F., Oury, J.D.: "ACT-R: A Cognitive Architecture for Modeling Cognition", Wiley Interdisciplinary Reviews, Cognitive Science 10(4): e1488.
 - [i.11] 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.
 - [i.12] Rothenberg, J.: "The Nature of Modelling", Artificial Intelligence, Simulation, and Modeling, John Wiley and Sons, Inc., 1989, pp. 75-92.
 - [i.13] Recommendation ITU-T 9594-1: "Information Technology - Open Systems Interconnection - The Directory: Overview of Concepts, Models, and Services".
 - [i.14] Recommendation ITU-T 9594-7: "Information Technology - Open Systems Interconnection - The Directory: Selected Object Classes".
 - [i.15] ETSI GR ENI 003 (V1.1.1): "Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis".
 - [i.16] REGULATION (EU) 2016/679, 'General Data Protection Regulation', 2016.
- NOTE: Available at: <https://gdpr.eu/tag/gdpr/>
- [i.17] Mitchell, Tom M.: "Machine Learning", McGraw-Hill, 978-0070428072.

- [i.18] Gruber, Thomas R.: "Toward Principles for the Design of Ontologies Used for Knowledge Sharing", International Journal of Human Computer Studies, Vol 43, pp 907-928, 1993.
- [i.19] Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., and Stal, M.: "Pattern-Oriented Software Architecture - A System of Patterns", John Wiley and Sons, 1996.
- [i.20] IEEE P7003: "Algorithmic Bias Considerations".
- NOTE: Available at <http://sites.ieee.org/sagroups-7003/>.
- [i.21] The Moral Machine.
- NOTE: Available at <https://www.media.mit.edu/projects/moral-machine/overview/>.
- [i.22] The Moral Machine project demonstration.
- NOTE: Available at <http://moralmachine.mit.edu/>.
- [i.23] Anderson, M. and Anderson, S.L.: "GenEth: A general ethical dilemma analyzer", AAAI, pgs 253-261, 2014.
- [i.24] Cointe, N., Bonnel, G., and Boissier, O.: "Ethical judgment of agents' behaviors in multi-agent systems", AAMAS, pgs 1106-1114, 2016.
- [i.25] The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems.
- NOTE: Available at <https://standards.ieee.org/industry-connections/ec/autonomous-systems.html>.
- [i.26] Gartner: "Magic Quadrant for Full Life Cycle API Management", October, 2019.
- [i.27] Koene, A., Smith, A.L., Egawa, T., Mandalh, S., and Hatada, Y.: "IEEE P70xx, Establishing Standards for Ethical Technology", KDD, 2018.
- [i.28] Rao, A.S. and Georgeff, M.P.: "BDI Agents: From Theory to Practice", AAAI, 1995.
- [i.29] IEEE: Ethically Aligned Design: "A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems".
- NOTE: Available at https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/other/ead_v2.pdf.
- [i.30] Famaey, J., Latré, S., Strassner, J., and De Turck, F.: "An Ontology-Driven Semantic Bus for Autonomic Communication Elements", IEEE International Workshop on Modeling Autonomic Communication Environments, pgs 37-50, 2010.
- [i.31] OMG: "Semantics of Business Vocabulary and Rules", version 1.5, December, 2019.
- [i.32] Attempto Controlled English.
- NOTE: Available at <http://attempto.ifi.uzh.ch/site/resources/>.
- [i.33] ETSI GR ENI-008 (V0.0.20): "Experiential Networked Intelligence (ENI); Intent Aware Network Autonicity", September 2020.
- [i.34] Hohpe, G. and Woolf, B.: "Enterprise Integration Patterns", Addison-Wesley, 2003, ISBN 9780321200686.
- [i.35] ETSI GR ENI 016 (V1.1.1): "Experiential Networked Intelligence (ENI); Functional Concepts for Modular System Operation".
- [i.36] ETSI GR ENI 017 (V1.1.1): "Experiential Networked Intelligence (ENI); Overview of Prominent Control Loop Architectures".
- [i.37] ETSI GR ENI 018 (V1.1.1): "Experiential Networked Interlligence (ENI); Introduction to Artificial Intelligence Mechanisms for Modular Systems".