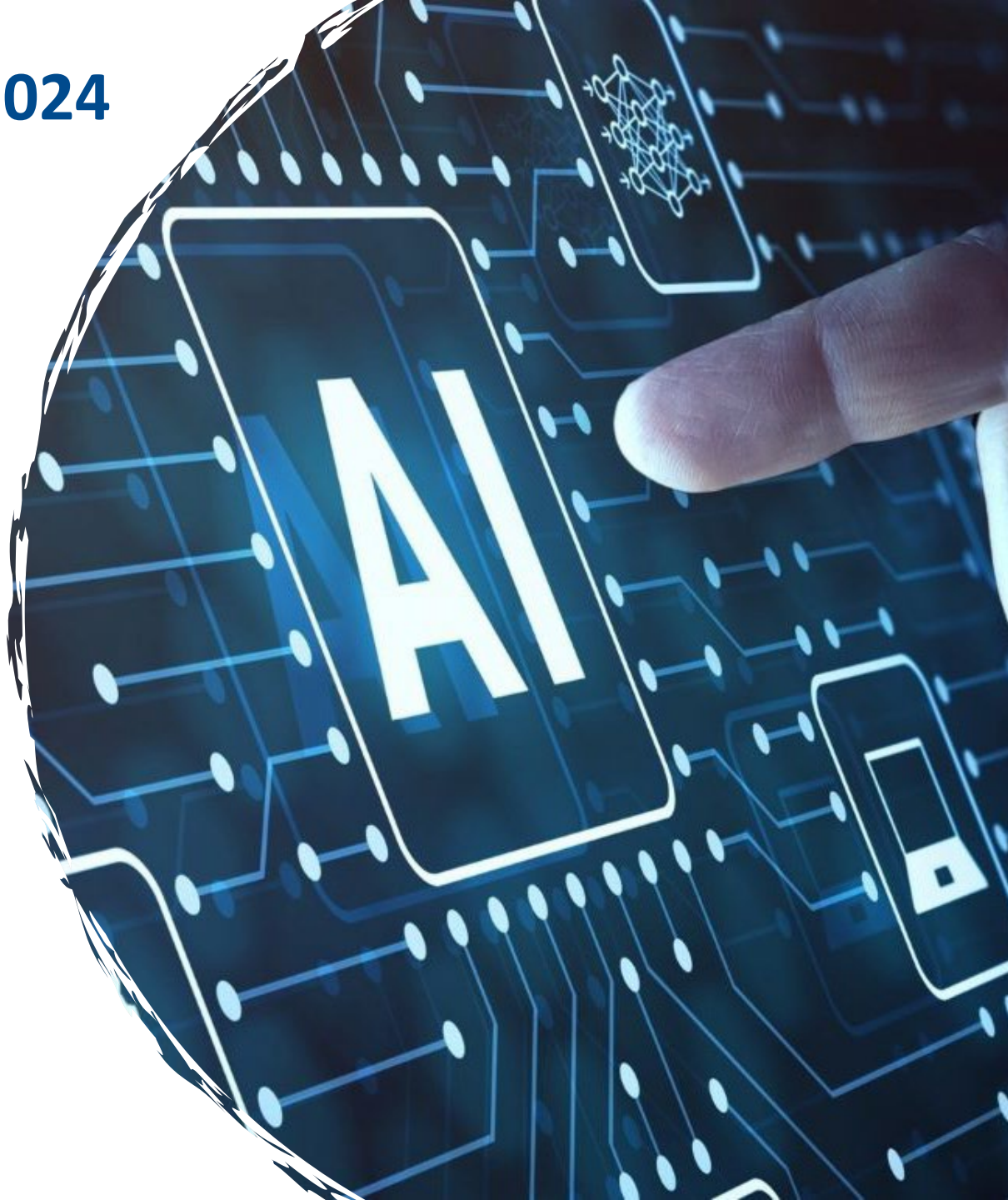
ETSI AI Conference 2024

Overview of AI Specification in Experiential Networked Intelligence (ENI)



Presented by: Dr Raymond Forbes Chair ISG ENI

06/02/2024

ENI Members and Participants

Source: https://portal.etsi.org/TBSiteMap/ENI/ListOfENIMembers.aspx
Members signed the ENI Member agreement and are ETSI members
Participants signed the ENI Participant agreement but are not ETSI members

ENI Vision

Network technology evolution

- Rapidly changing network conditions
- More services, more users

Network intelligence

Network mgmt. and operation evolution

- Human decisions
- Complex manual configuration

Orchestration and operation intelligence

ENI

- Network perception and analysis
- Data driven policy
- AI-based closed-loop control

Enhanced network experience

Better customer experience

Improved QoE of service

Increased service value

Improved business efficiency

Reduced OPEX

Increased profit

5G/IoT automation

Better QoE service delivery

Source: ETSI - White Papers | ICT White Papers *ETSI three ENI White Papers,*
ETSI_WP22_Improved operator experience through Experiential Networked Intelligence (ENI) (etsi.org)
ETSI_WP44_ENI_Vision.pdf
ETSI_WP51_Understanding_the_Operator_Experience_Using_Cognitive_Manage.pdf

Release highlights

Release 1

1. Definition of "operator experience" for a data driven network.
2. Specify a set of use cases, the functional architecture, for a network supervisory assistant system
3. Use of the 'observe-orient-decide-act' control loop model.
4. This model can assist decision-making systems,
5. PoC proof of concept studies.

Release 2

1. Specify detailed use cases, more requirements.
2. the functional architecture in terms of functional blocks and a semantic bus.
3. Recursion and Interactive calling of the functional block using of the 'observe-orient-decide-act' model.
4. Both recommendation systems and Automatic systems.
5. Initial studies of Intent based functions & Telemetry.
6. Automomiticity network categories

Release 3

1. A White paper describing Cognitive management.
2. Definition of Knowledge management and Intent based stems for a data driven network.
3. Specify a set of APIs and information and data models for an automated system.
4. Interoperability of systems in PoCs Proof of Concept projects (19 projects).
5. Studies on transformers.
6. Handling of the Policy Management Model
7. Handling of Intent-based concept

Release 4

1. Specification of Cognitive management.
2. Specify Knowledge management and Intent based stems for a data driven network.
3. Specify more of APIs and information and data models with the use of policy, transformers and LLMs.
4. Publication of a specification on transformers.
6. Specify the Policy Management Model, for OAMs
7. Specification of the Intent language its use in cognitive management and LLM.
8. Use of telemetry and network measurement evaluation based n classification

ENI Published Reports, Specifications

Published ENI deliverables (29 publications):

- ETSI GS ENI 001 V3.2.1 (2020-12) Published Use Cases (4 revisions, in revision)
- ETSI GS ENI 002 V3.2.1 (2020-12) Published Requirements (4 revisions, in revision)
- ETSI GR ENI 003 V1.1.1 (2018-05) Published Context-Aware Policy Man.
- ETSI GR ENI 004 V3.1.1 (2021-12) Published General Terminology (4 Revisions, in revision)
- ETSI GS ENI 005 V3.1.1 (2021-12) Published System Architecture (2 Revisions, in revision)
- ETSI GS ENI 006 V2.1.1 (2020-05) Published PoC Framework (2 Revisions)
- ETSI GR ENI 007 V1.1.1 (2019-11) Published Definition of Categories
- ETSI GR ENI 008 V2.1.1 (2021-03) Published Intent Aware Net. Autonomicity
- ETSI GR ENI 009 V1.2.1 (2021-06) Published Data Mechanisms (2 revisions, in revision)
- ETSI GR ENI 010 V1.1.1 (2021-03) Published Evaluation of categories (in revision)
- ETSI GR ENI 012 v1.1.1 (2022-03) Published Reactive In-situ flow information Telemetry
- ETSI GR ENI 013 v1.1.1 (2024-01) Published ENI Intent Policy Model
- ETSI GR ENI 016 V2.1.1 (2021-07) Published Functional Concepts
- ETSI GR ENI 017 V2.1.1 (2021-08) Published Control Loop Archit. (in revision)
- ETSI GR ENI 018 V2.1.1 (2021-08) Published AI Mechanisms
- ETSI GS ENI 019 V3.1.1 (2024-06) Published Representing, Inferring and Proving Knowledge in ENI (in revision)
- ETSI GR ENI 035 V4.1.1 (2024-12) Published Definition of IP networks autonomicity level recently published

Accessible via Work Item Monitoring - ENI

Ongoing ENI Work Items and Rapporteurs: Reports, Specifications & Work plan

- ENI 001 (WI RGS/ENI-001v411) – Revision to start June 2023
  Use Cases (Release 3) – Chao Wu (NTT)
- ENI 002 (WI RGS/ENI-002v411) – Revision to start June 2023
  Requirements (Release 3) – Haining Wang (Intel)
- ENI 004 (WI RGR/ENI-004v3411) – Revision to start June 2023
  General Terminology (Release 3) – Yu Zeng (China Telecom)
- ENI 005 (WI RGS/ENI-005v411) – Revision to start June 2023
  System Architecture (Release 3) – John Strassner (FutureWei)
- ENI 009 (WI RGS/ENI-0009v411) – Revision to start Sept 2023
  Data mechanisms – Hongdan Ren(China telecommunications)
- ENI 010 (WI RGR/ENI-0010v121) –draft in progress
  Measurement of Evaluation Categories for AI application to Networks – Yu Zeng (China Telecom)
- ENI 015 (WI DGR/ENI-0025) – nearly stable draft in progress
  Processing and Management of Intent Policy – Ziting Zhang (China Telecom)
- ENI 017 (WI RGR/ENI-0017v221) – Stable draft in progress Dec 2024
  Overview of Prominent Control Loop Architectures – Sen Bian (AsiaInfo)
- ENI 019 (WI RGS/ENI-0019v411) – Revision to start June 2023
  Representing, Inferring and Proving Knowledge in ENI – John Strassner (Futurewei)
- ENI 030 (WI DGS/ENI-0030v411) – Release 4 in approval before publication
  Transformer Architecture – John Strassner (Futurewei)
- ENI 031 (WI DGR/ENI-0031v311) – Release 4 in approval before publication
  Fault maintenance network knowledge graphs – Bingming Huang (China Unicom)
- ENI 032 (WI DGR/ENI-0032v411) – draft in progress
  iFit Deployment Scenarios – Giuseppe Fioccola (Huawei)
- ENI 033 (WI DGS/ENI-0033v411) – draft in progress
  Definition, Requirements and Procedure of Intent Policy Multi-Stage Translating – Jingyu Wang (BUPT)
- ENI 034 (WI DGS/ENI-0034v411) – draft in progress
  Conflict detection – Jingyu Wang (BUPT)
- ENI 036 (WI DGR/ENI-0036v411) – draft in progress
  Space-Ground Cooperative Network Slicing – Yu Zeng (China telecommunications)
- ENI 037 (WI DGS/ENI-0037v411) – draft in progress
  Coordination orchestration of multiple elements – Shoufeng Wang (Asia Info Inc.)
- ENI 038 (DGS/ENI-038v411) – draft in progress
  Detailed Procedure of AI Models Centralized Management and Sharing; Hanting Duan (China telecommunications).
- ENI 039 (WI DGR/ENI-0039v411) – 1st draft in progress
  Dataset for Large Language Model applied in the network field – Hongdan Ren (China telecommunications)
- ENI 040 (WI DGS/ENI-0040v411) – draft in progress
  Orchestration functional requirements specification for network OAM large models – Yu Zeng (China telecommunications)
- ENI 041 (WI DGS/ENI-0041v411) – draft in progress
  Network knowledge management enhanced large models for network OAM – Tiantian Lv (China telecommunications)
- ENI 042 (DGS/ENI-0042 v411) – not yet started
  Collaborative Blockchain-Based Multi-Operator Co-Construction and Sharing; Rapporteur Zhongping Dong (China Telecommunications)
- ENI 043 (DGS/ENI-0043 v411) – draft in progress
  Intelligent customer service based on large language model; Rapporteur Yupei Wang (China Telecommunications).
- ENI 044 (DGS/ENI-0044 v411) – not yet started
  Interaction between network large language model and add-on components; Rapporteur Qiaoqiao Liu (China Telecommunications).
- ENI 044 (DGS/ENI-0044 v411) – not yet started
  Interaction between network large language model and add-on components; Rapporteur Qiaoqiao Liu (China Telecommunications).

Accessible via Work Item Monitoring - ENI

Main concepts: Use Cases

Infrastructure Management
Policy-driven IDC traffic steering
Handling of peak planned occurrences
Energy optimization using AI
Intelligent Optimization for Transmission Network
Energy saving in radio network

Network Operations
Policy-driven IP managed networks
Radio coverage and capacity optimization
Intelligent software rollouts
Intelligent fronthaul management and orchestration
Elastic Resource Management and Orchestration
Application Characteristic based Network Operation
AI enabled network traffic classification
Automatic service and resource design framework for cloud service
Intelligent time synchronization of network
Intelligent Content-Aware Real-Time Gaming Network

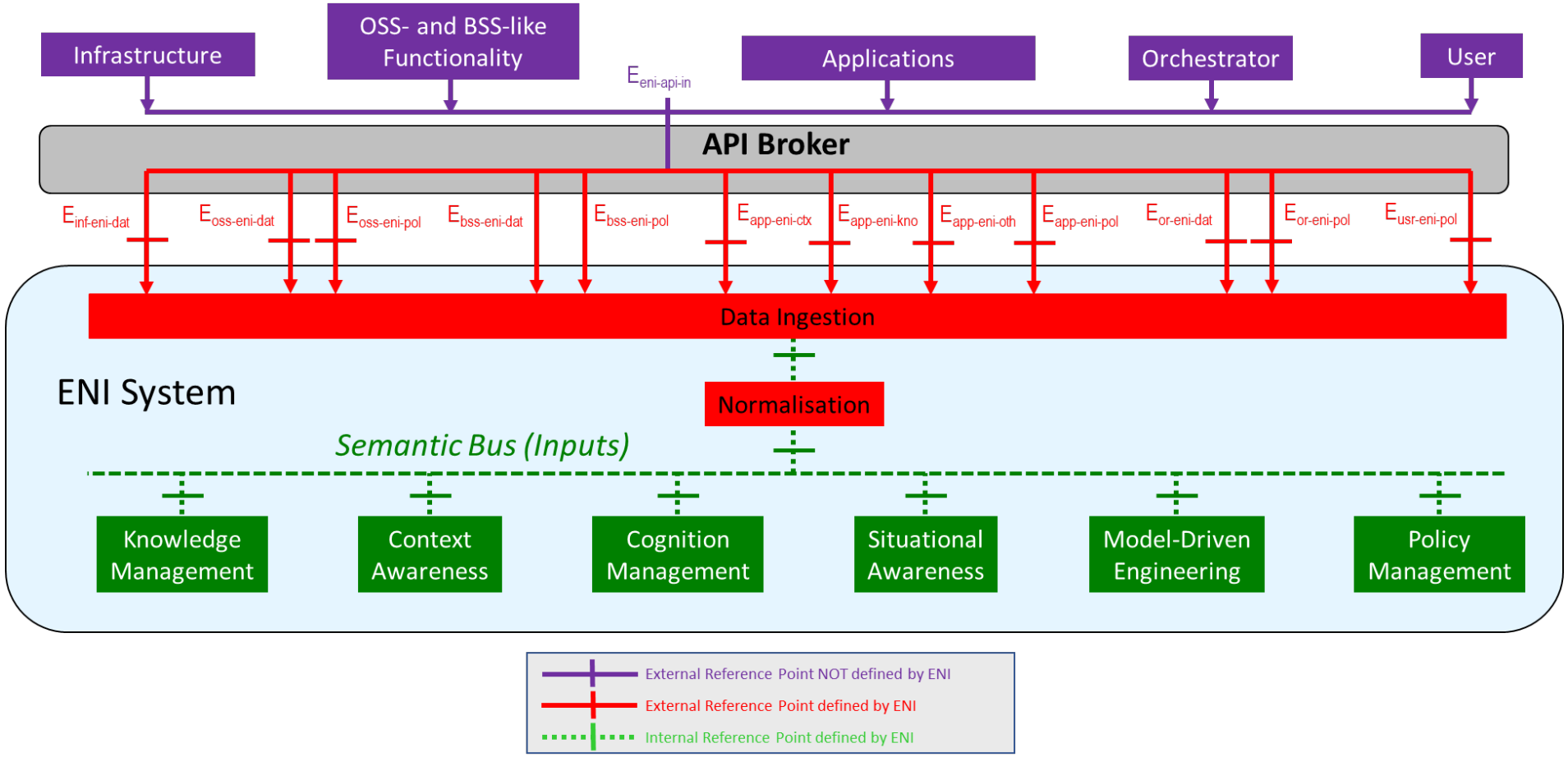
Service Orchestration and Management
Context aware VoLTE service experience optimization
Intelligent network slicing management
Intelligent carrier-managed SD-WAN
Intelligent caching based on prediction of content popularity
Service experience optimization of E2E slicing involving both OSS and BSS
Intent-based Cloud Management for VDI service
Intelligent vehicle diversified service fulfillment based on polymorphic network
AI based family broadband network user experience optimization

Network Assurance
Network fault identification and prediction
Assurance of Service Requirements
Network Fault Root-cause Analysis and Intelligent Recovery

Network Security
Policy-based network slicing for IoT security
Limiting profit in cyber-attacks

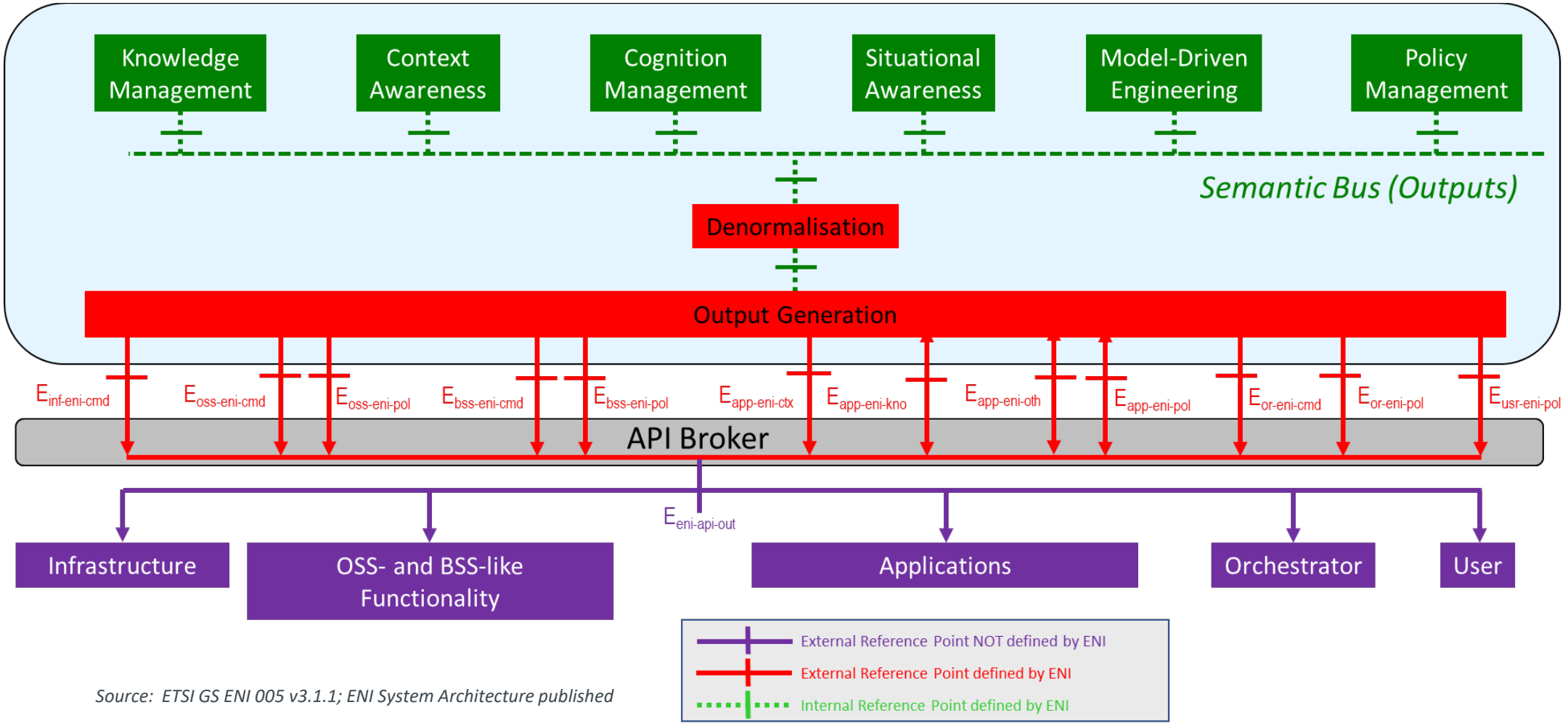
Source: ETSI GS ENI 001 v3.2.1; ENI Use Cases Published

ENI Input External Reference Points



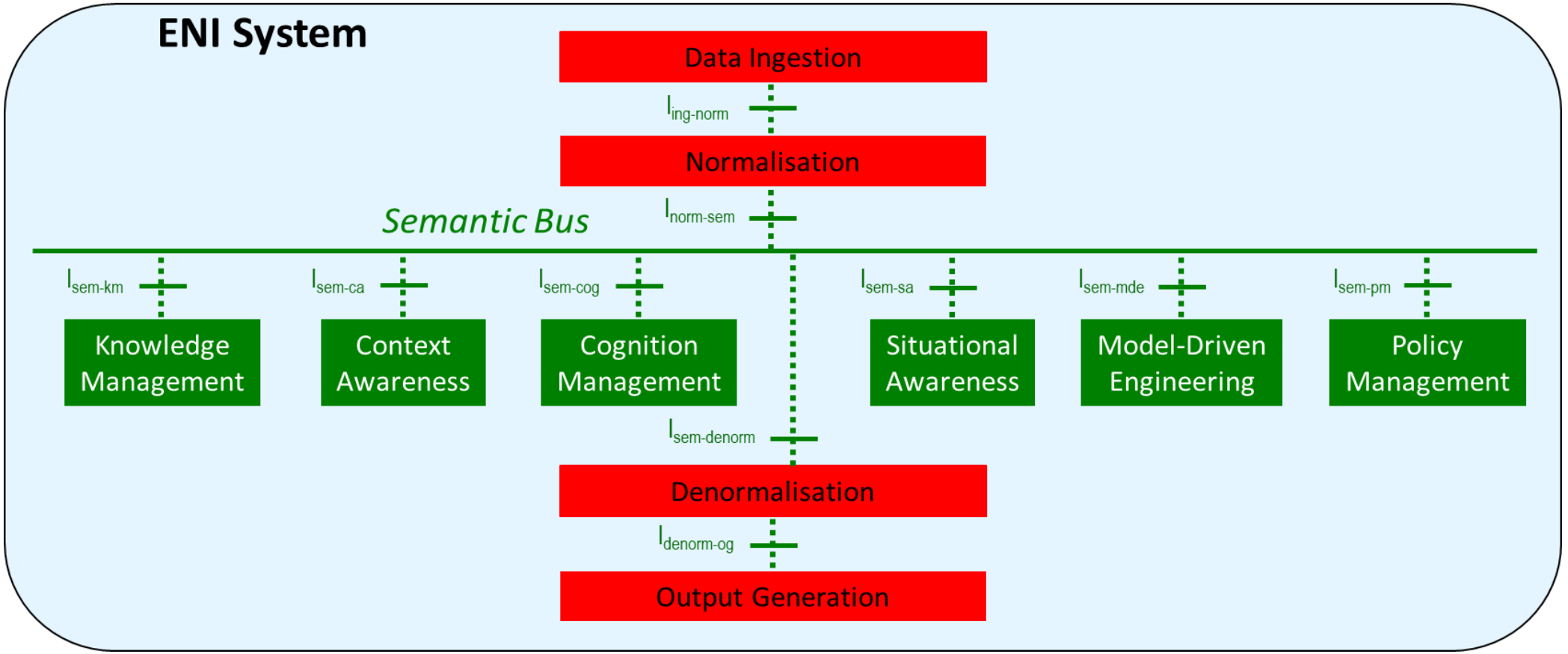
Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

ENI Output External Reference Points



Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

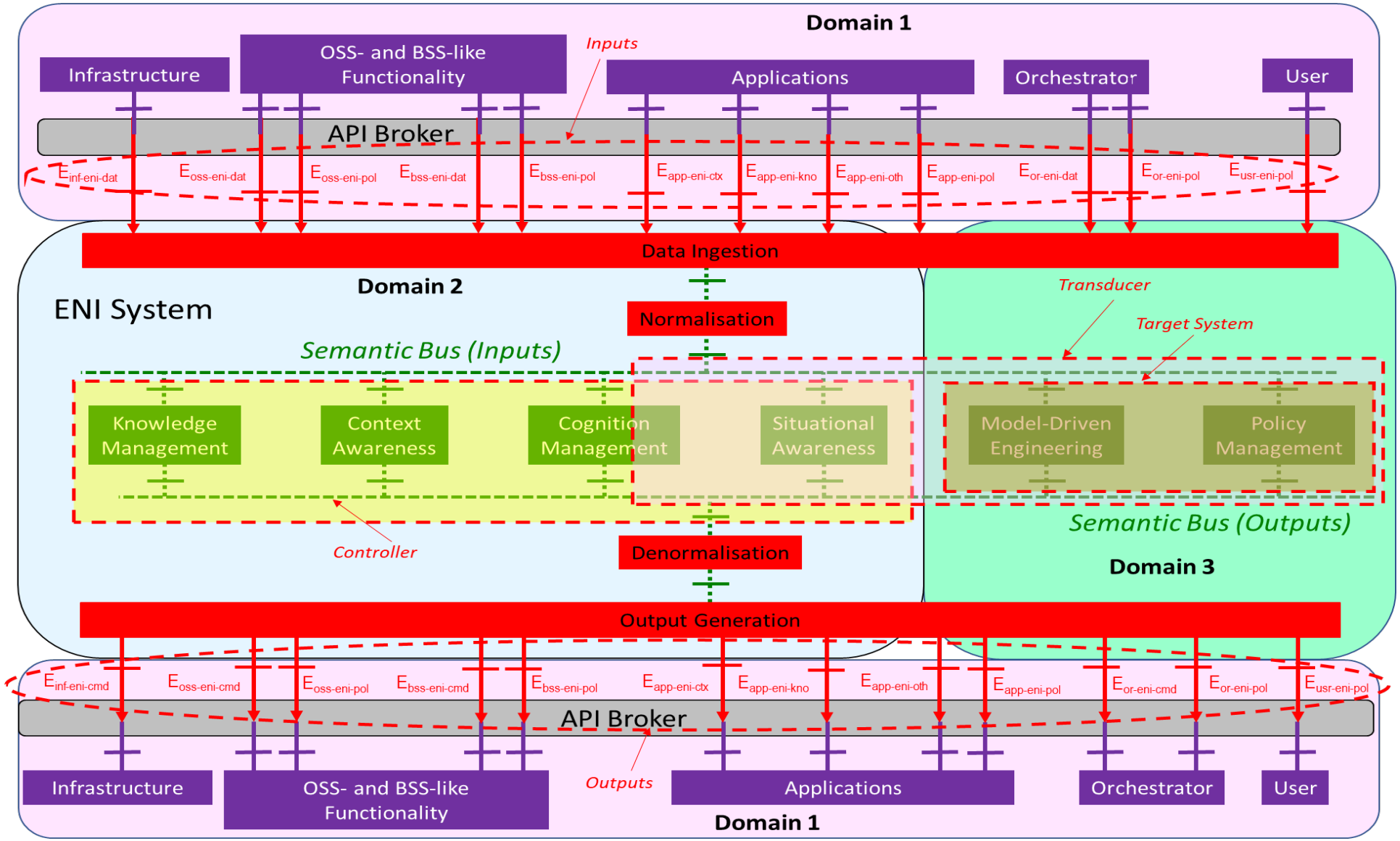
ENI Internal Reference Points



Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

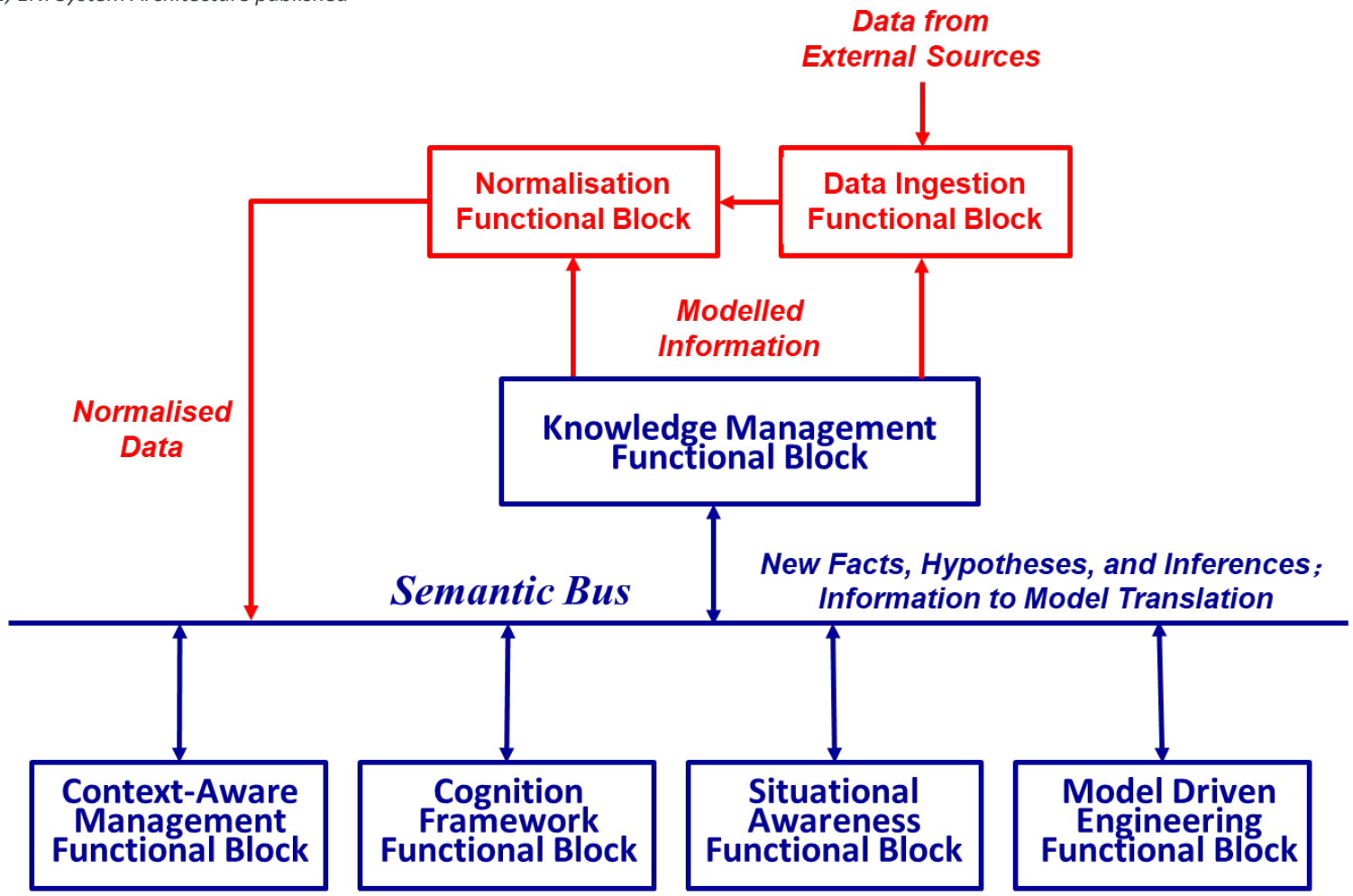
ENI Domains and Control Loops

Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

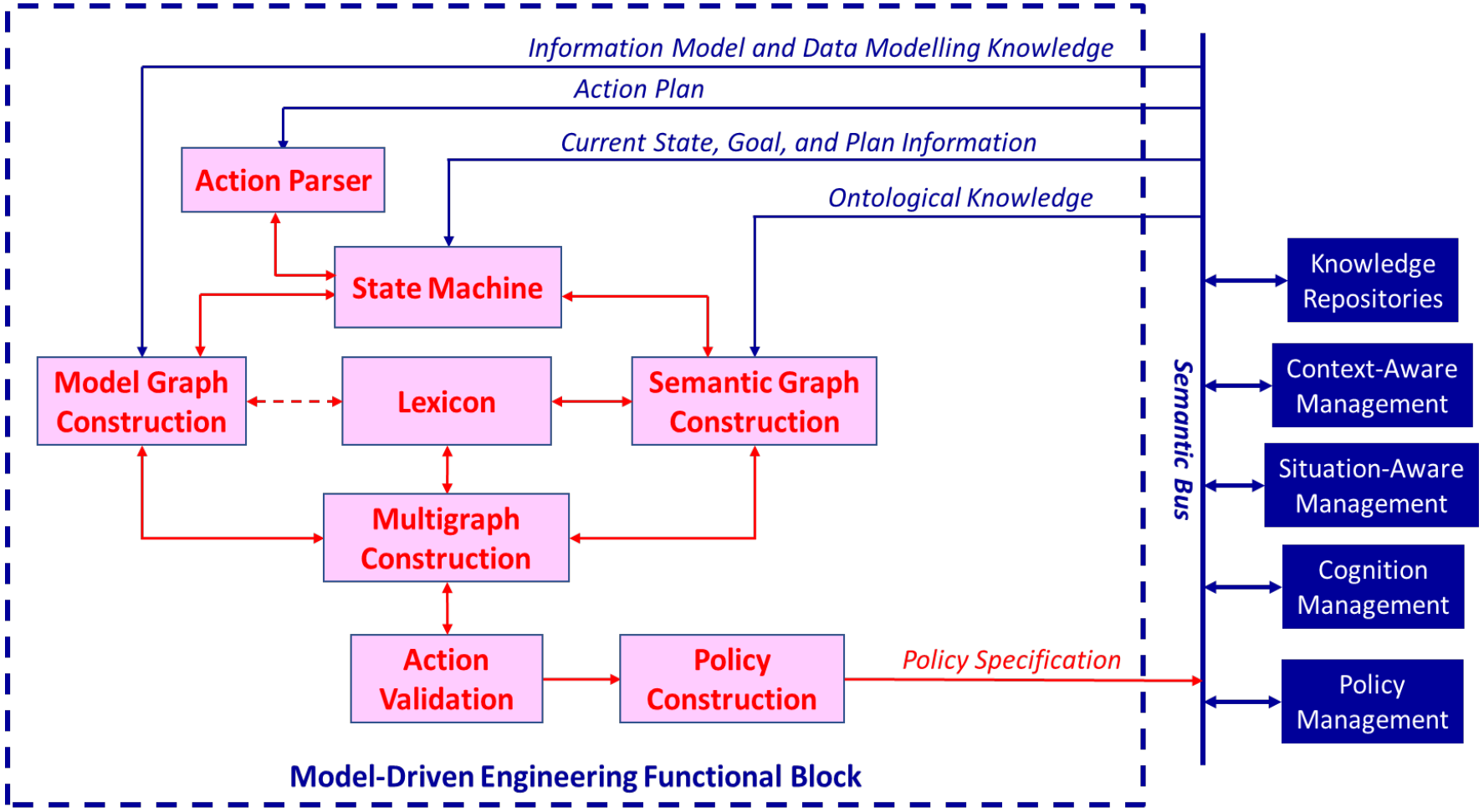


Normalizing Input Data in ENI

Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

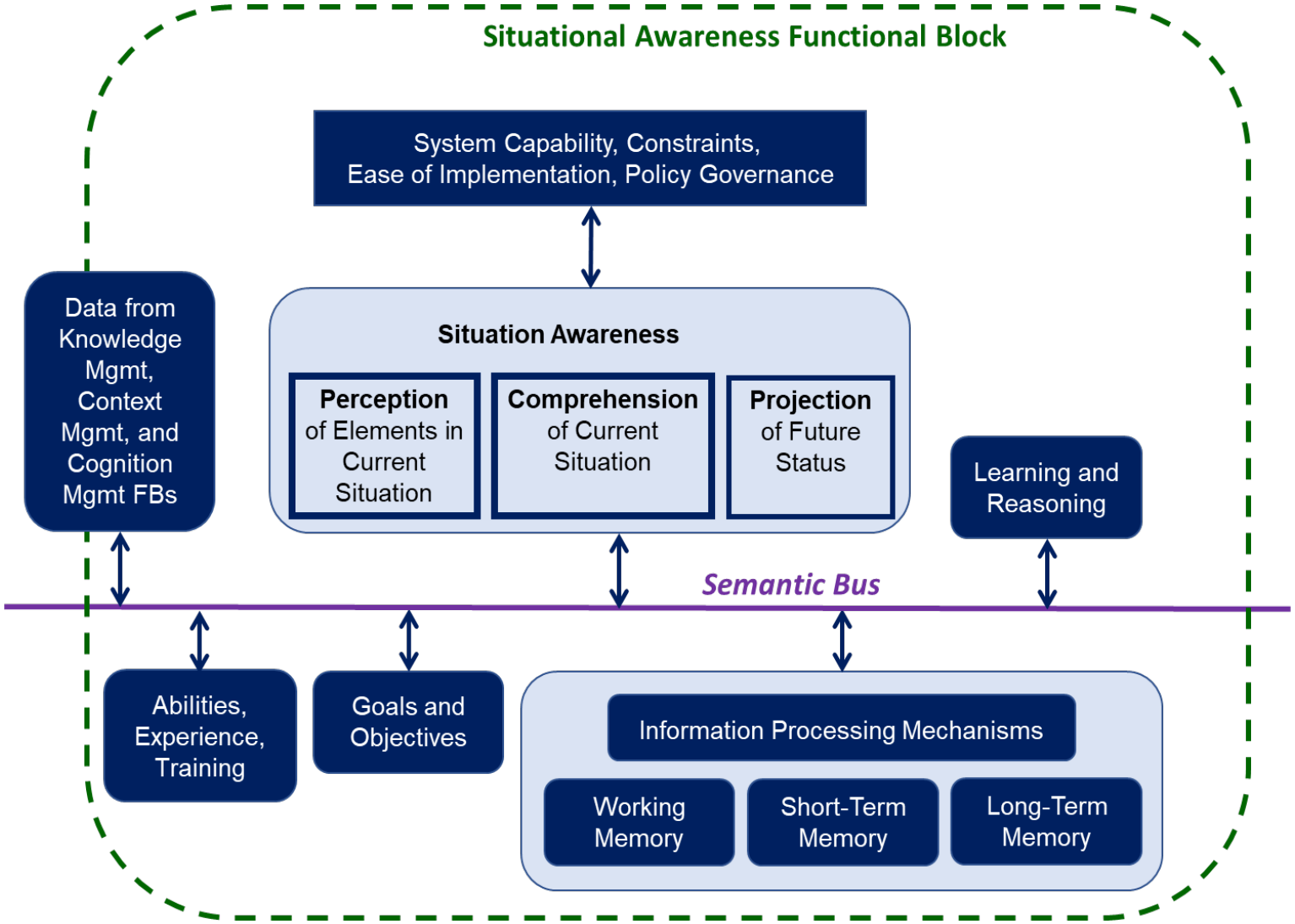


Overview of Model Driven Engineering



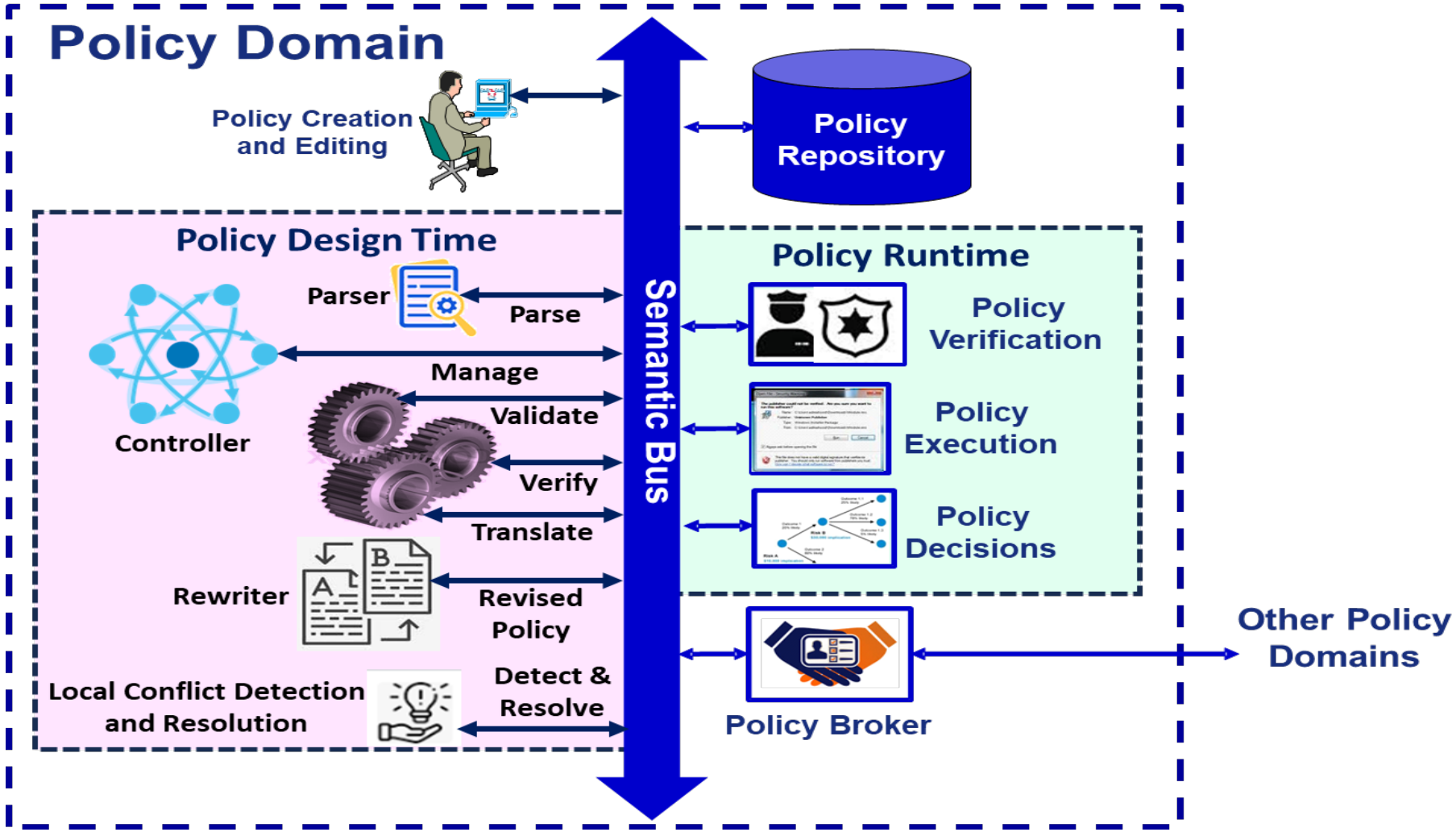
Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

Cognitive Processing in ENI



Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published

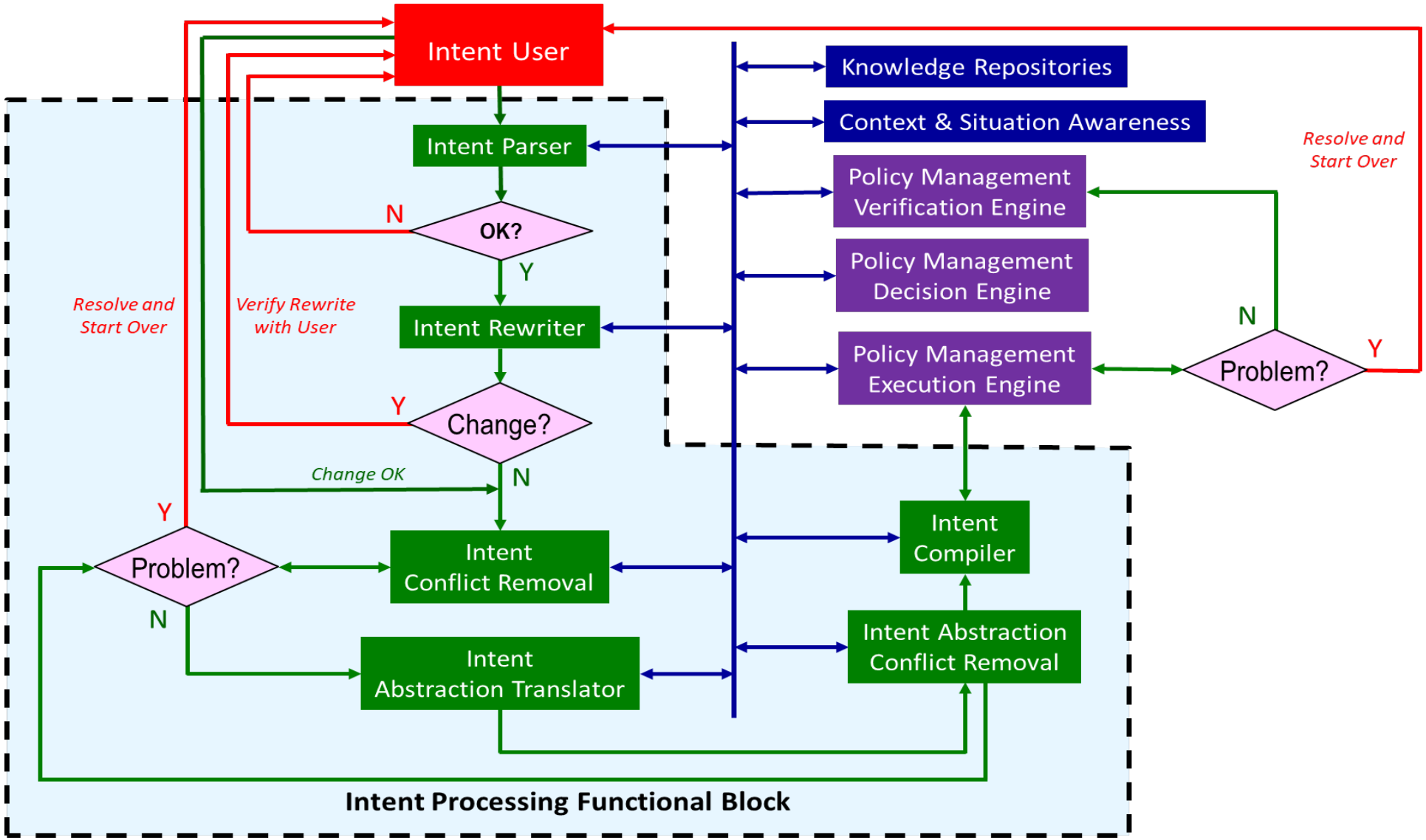
High Level Policy Architecture



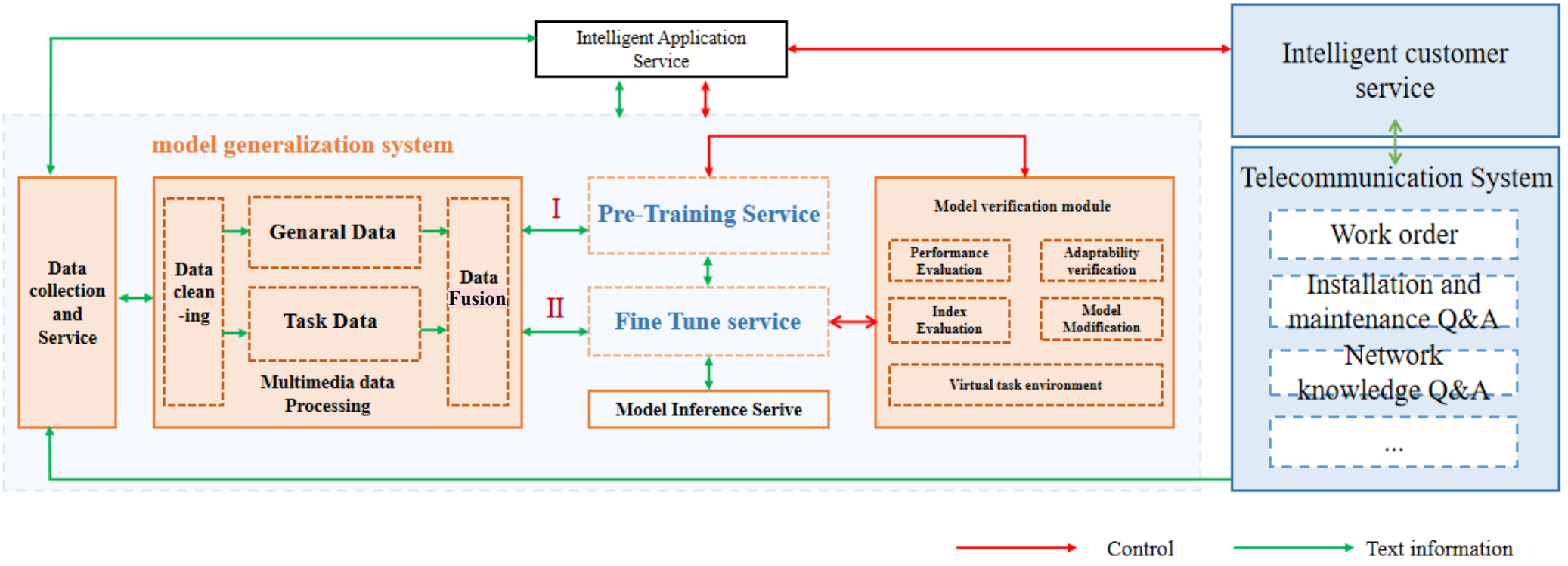
Source: ETSI GS ENI 005 v4.1.1; ENI System Architecture revision in drafting

ENI Intent Policy Control

Source: ETSI GS ENI 005 v3.1.1; ENI System Architecture published



Initial ideas on the Large Language model for telecom



Source: ETSI Drat GS ENI 043 v4.0.1; ENI Intelligent customer service based on large language model: Early draft

Definition of Categories for AI Application to Networks

Autonomicity capability
Continuous improvement

Category	Name	Definition	Man-Machine Interface	Decision Making Participation	Data Collection and Analysis	Degree of Intelligence	Environment Adaptability	Supported Scenario
Category 0	Manual O&M	O&M operators manually control the network and obtain network alarms and logs	How (command)	All-manual	Single and shallow awareness (SNMP events and alarms)	Lack of AI based understanding (manual management and control)	Fixed	Single scenario
Category 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	How (command)	Provide suggestions for machines or humans and help decision making	Local awareness (SNMP events, alarms, KPIs, and logs)	Limited analysis capability	Limited adaptability to changes	Selected scenarios
Category 2	Partial automation	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 limited decisions	Comprehensive awareness (basic telemetry data)	Deep analysis capability	Limited adaptability to changes	Selected scenarios
Category 3	Conditional automation	In specific environmental and network conditions there is automatic network control and adaptation	How (declarative)	Most of the machines make decisions	Comprehensive and adaptive sensing (such as data compression and optimization technologies)	Comprehensive analysis and knowledge; Short-term forecast capability	Adaptability to significant changes	Multiple scenarios
Category 4	Partial autonomicity	Deep awareness of network status; in most cases the network performs autonomic decision-making and operation adjustment	What (intent)	Optional decision-making response	Adaptive posture awareness	Comprehensive analysis and knowledge Long-term forecast capability	Adaptability to significant changes	Multiple scenarios
Category 5	Full autonomicity	In all environmental and network conditions, the network can automatically adapt	What (intent)	Machine autonomous decision	Adaptive optimization as a consequence of quality of service deterioration	Autonomic evolution and knowledge reasoning	Adaptability to any change	Any scenario

Categories of network autonomicity from a technical point of view

Source: ETSI GR ENI 007 , ENI Definition of Categories for AI Application to Networks

ENI PoC List (Release 3 & 4)

Title	PoC Team Members	Main Contact	Start Time	Current Status (June 2024)
PoC#15: PINet—Polymorphic Intelligent Network	**China Telecommunications** China Telecommunications, China Mobile Research Institute, AsiaInfo Technologies Inc., Maipu Communication Technology Co., Ltd.	Ziting Zhang	Nov.-2021	Completed
PoC#16: AI based family broadband network user experience optimization	**China Mobile** China Mobile Research Institute, AsiaInfo Inc., Intel	Bian Sen	October - 2022	Final report in review
PoC#17: Intelligent Satellite-Terrestrial Integration Network Architecture	**China Telecommunications** China Telecommunications, Tsinghua University, AsiaInfo Technologies Inc., Huawei (UK) Technologies Ltd., CNIT, CNR IST.	Yu Zeng	July 2024	Ongoing
PoC#18: Intent-driven Operating for User-Centric Cloud-Network Convergence Services	**China Telecommunications** China Telecommunications, AsiaInfo Technologies Inc., Huawei (UK) Technologies Ltd., BUPT, Xidan University.	Li Zhen	July 2024	Ongoing
PoC#19: Space-Ground Cooperative Network Slicing	**China Telecommunications** China Telecommunications, National Digital Switching System Engineering and Technology Research Center, CAICT, AsiaInfo Technologies Inc., Huawei (UK) Technologies Ltd..	Yu Zeng	July 2024	Ongoing

More info can be found https://eniwiki.etsi.org/index.php?title=Ongoing_PoCs

Network Intelligence Events & Milestones between 2016 and 2024

- **Forum on Network Intelligence, Dec'16, Shenzhen, China**
- **ENI & SDNIA Joint Forum, Sep'17, Beijing, China**
- **ENI & H2020-SliceNet Workshop, Dec'17, London, UK**
- **ENI & 5GPPP MoNArch Workshop, Jun'18, Turin Italy**
- **ENI presentation to ITU workshop, Aug'18, San Jose, CA, USA**
- **ENI & CCSA TC610 AIAN Joint Forum, Sep'18, Beijing, China**
- **ENI & 5Tonic Joint Workshop, Dec'18, Madrid, Spain**
- **ENI & Samsung joint Workshop, Apr'19, Warsaw, Poland**
- **ENI & Altice Lab / Portugal Telecom joint Workshop, Jul'19, Aveiro, Portugal**
- **ENI & China Telecom Research labs, workshop with CCSA TC 610 SNIA, September 2019**
- **ENI in the pandemic 4 plenaries online remote, Release 2 progressed to near completion**
- **In 2020 – 6 deliverables approved**
- **Early 2021 ENI Release 3 start: 4 Work-items started initially**
- **Summer 2021 complete ENI Release 2; more Release 3 Work-items started**
- **End of 2021 Release 2 finalized**
- **2022 Release 3 definition approved, 4th term extension request approved by ETSI**
- **2024 Release 3 completed release 4 started**

Forum on Network Intelligence, Dec'16

ENI & SDNIA Joint Forum on Network Intelligence, Sep'17

ENI & SliceNet workshop, Dec'17

ENI & Samsung Workshop, Apr'19

ENI & Altice Lab / Portugal Telecom Workshop, Jul'19

ENI & China telecom Labs, Sept'19

Contact Details:
Chair: Dr. Raymond Forbes Raymond.Forbes@huawei.com

+44 771 851 1361

Please Contribute

ENI Activity Report	ENI membership list	White Paper 22	ENI Blog
ENI Terms of Reference	ENI Published Deliverables	White Paper 44	ENI Webpage
ENI Participant Agreement	ENI Wiki and PoC info	White paper 51	ENI Release 4
ENI Presentation		ENI Open Area	ENI Release 3

Thank you!