5 November-2020

ETSI ISG ENI**

Creating an intelligent service optimization solution

	Chairman:	Dr. Raymond Forbes (Huawei Technologies)
	Vice-Chairman:	Mrs. Haining Wang (Intel)
	Vice-Chairman:	Dr. Luca Pesando (Telecom Italia)
Presented by:	Secretary:	Dr. Yue Wang (Samsung)
	Technical Officer:	Mrs. Korycinska Sylwia (ETSI)
	Technical Manager:	Dr. Shucheng Liu “Will” (Huawei Technologies)

***Experiential Networked Intelligence*

Outline

ETSI ISG ENI Progress

- Vision & Background
- Introduce the Status of ETSI ISG ENI (Experiential Networked Intelligence)
- Network Intelligence Activities in 2016 - 2020
- WI Progress

ENI Published Reports, Specifications & Workplan

Published ENI deliverables:

- ETSI GS ENI 001 V2.1.1 (2019-09) Published
  Use Cases
- ETSI GS ENI 002 V2.1.1 (2019-09) Published
  Requirements
- ETSI GR ENI 003 V1.1.1 (2018-05) Published
  Context-Aware Policy Management Gap Analysis
- ETSI GR ENI 004 V2.1.1 (2019-10) Published
  General Terminology
- ETSI GS ENI 005 V1.1.1 (2019-09) Published
  System Architecture
- ETSI GS ENI 006 V2.1.1 (2020-05) Newly Published
  Proof of Concept (PoC) Framework
- ETSI GR ENI 007 V1.1.1 (2019-11) Published
  Definition of Categories for AI Application to Networks

Accessible via Work Item Monitoring - ENI

Ongoing ENI Work Items and Rapporteurs:

- ENI 001 (WI RGS/ENI-0014) - in approval
  Use Cases (Revision 3) – Yue Wang (Samsung)
- ENI 002 (WI RGS/ENI-0015) - in approval
  Requirements (Revision 3) – Haining Wang (Intel)
- ENI 004 (WI RGR/ENI-0018)
  General Terminology (Revision 3) – Yu Zeng (China Telecom)
- ENI 005 (WI DGS/ENI-0016)
  System Architecture (Revision 2) – John Strassner (FutureWei)
- ENI 008 (WI DGR/ENI-0013)
  Intent Aware Network Autonomicity – Yannan Bai (China Telecom)
- ENI 009 (WI DGR/ENI-0017)
  Definition of data processing mechanisms - Weiyuan Li (China Mobile)
- ENI 010 (WI DGR/ENI-0020)
  Evaluation of categories for AI application to Networks - Bingming Huang (China Unicom)
- ENI 011 (WI DGS/ENI-0021)
  Mapping between ENI architecture and operational systems– Yannan Bai (China Telecom)
- ENI 022 (WI DGR/ENI-0022)
  Reactive In-situ flow information Telemetry– Yali Wang (Huawei)

Business Value

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 ENI White Paper, http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp22_ENI_FINAL.pdf

ENI Goals and Leadership Team

Core idea: Network perception analysis, data-driven policy, AI based closed-loop control

ETSI ISG ENI starting in 2017- present

- The ISG ENI focuses on improving the operator experience, adding closed-loop artificial intelligence mechanisms based on context-aware, metadata-driven policies. Enabling quick recognition and incorporation of new and changed knowledge, and hence, make actionable decisions.
- In particular, ENI has specified a set of use cases, and the functional architecture, for a network supervisory assistant system based on the 'observe-orient-decide-act' control loop model.
- This model can assist decision-making systems, such as network control and Interact with the domain orchestration systems, to adjust services and resources offered based on changes in user needs, environmental conditions and business goals. Release 1 defined big data-analysis functionality.
- Definition of AI Categories: levels 0-5

Extended at 19Q1 (2019-2021)

- Version 2: API broker for non-capable signaling systems, specified external reference points, implementation, PoCs, data mechanisms and evaluation of categories.
- Version 2 defines closed loop control in the real-time network.
- Definition of Intent policy and policy management.
- Evaluation of the Categorization.

The ISG ENI Leadership team

Role	Name (Organization)
Chairman	**Dr. Raymond Forbes** (Huawei)
Vice Chairman	**Mrs. Haining Wang** (Intel)
Second Vice Chairman	**Dr. Luca Pesando** (Telecom Italia)
Secretary	**Dr. Yue Wang** (Samsung)
Technical Officer	**Mrs. Christine Mera** (ETSI)
Technical Manager	**Dr. Shucheng Liu "Will"** (Huawei)
ENI ISG PoC Review Team	**Raymond Forbes** (Huawei) **Christine Mera** (ETSI Technical Officer) **Michele Carignani** (ETSI CTI) **Bill Wright** (Redhat) **Haining Wang** (Intel) **Luca Pesando** (Telecom Italia) **Mostafa Essa** (Vodafone) **Yu Zeng** (China Telecom) **Antonio Gamelas** (Portugal Telecom)

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

Use Cases

Infrastructure Management
Policy-driven IDC traffic steering
Handling of peak planned occurrences
Energy optimization using AI

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

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

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

Source: ETSI GS ENI 001 ; ENI Use Cases

Requirements

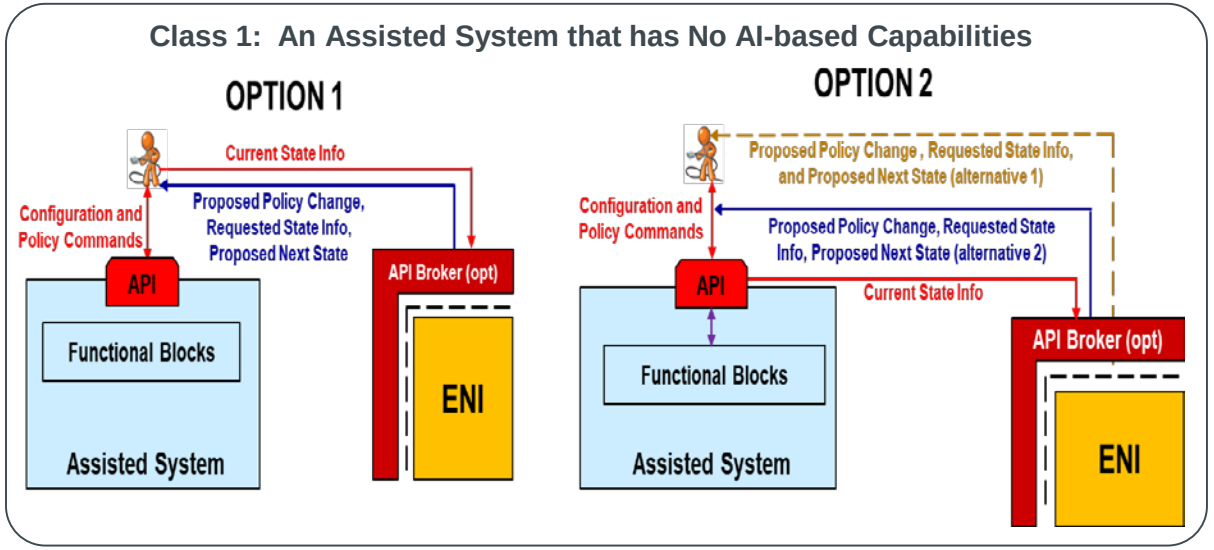
Level 1	Level 2
Service and network requirements	General requirements
	Service orchestration and management
	Network planning and deployment
	Network optimization
	Resilience and reliability
	Security and privacy

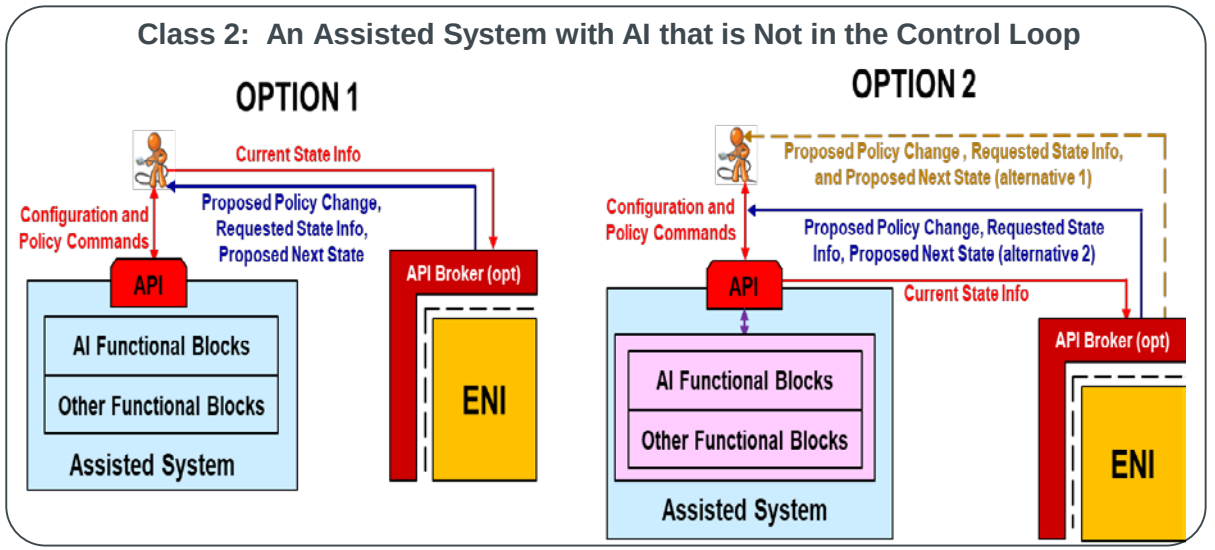
Level 1	Level 2
Functional requirements	Data collection and analysis
	Policy management
	Data learning
	Interworking with other systems
	Mode of operations
	Model training and iterative optimization
	API requirements

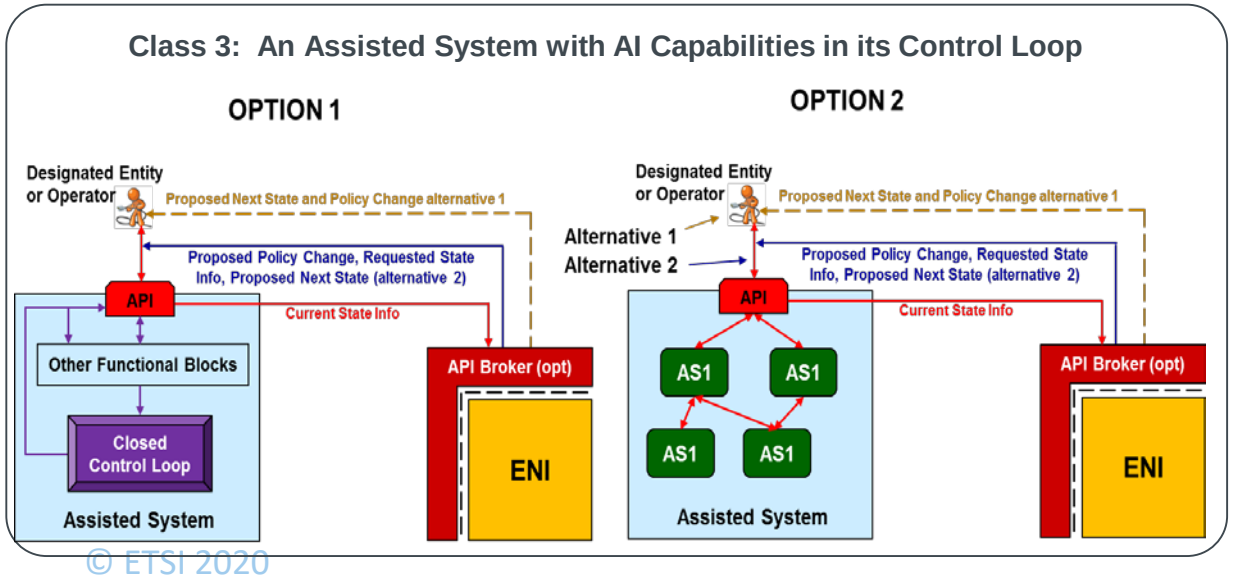
Level 1	Level 2
Non-functional requirements	Performance requirements
	Operational requirements
	Regulatory requirements

Source: ETSI GS ENI 002 , ENI Requirement

ENI System Architecture - Mode of Operation and Class

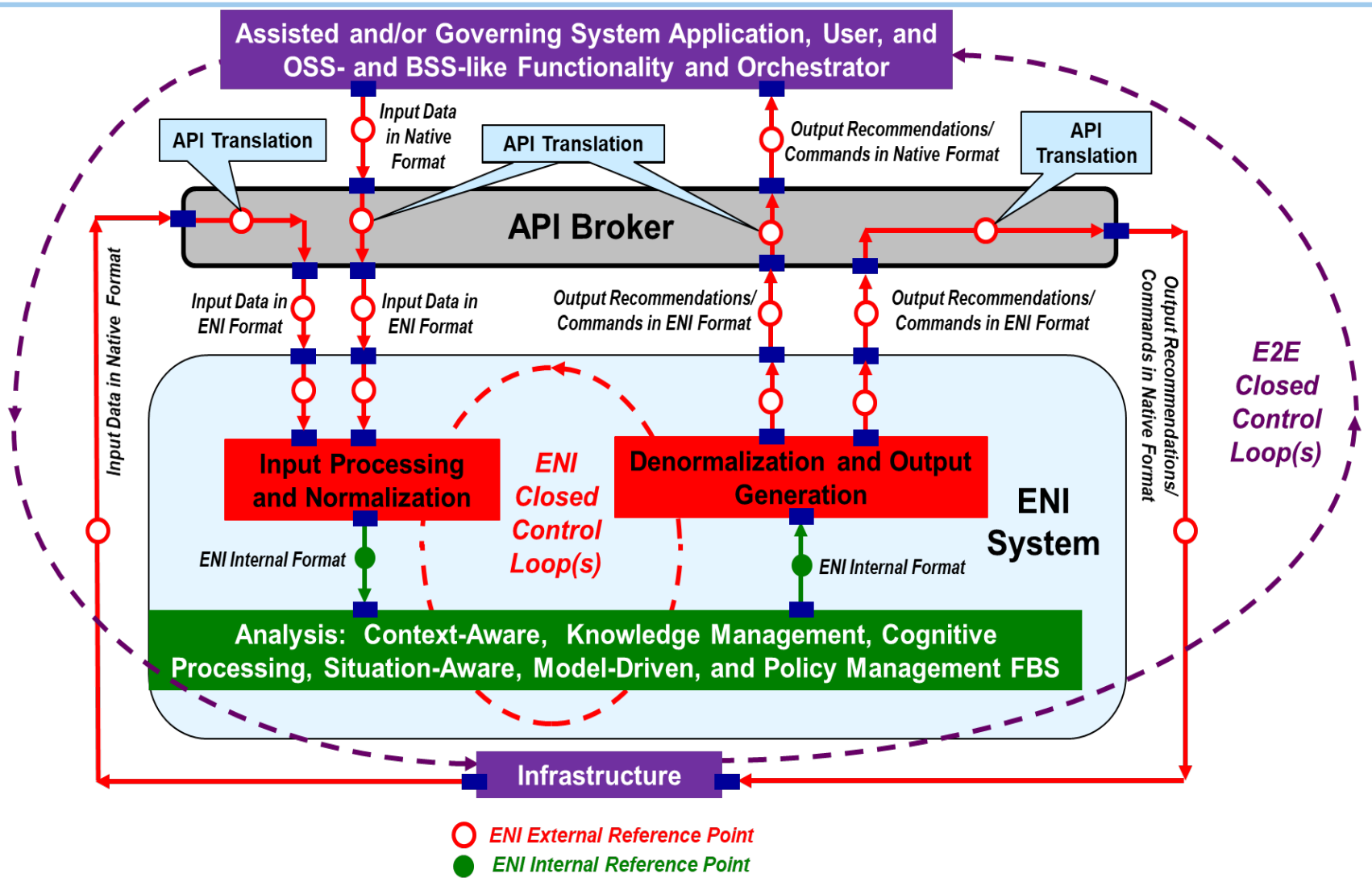






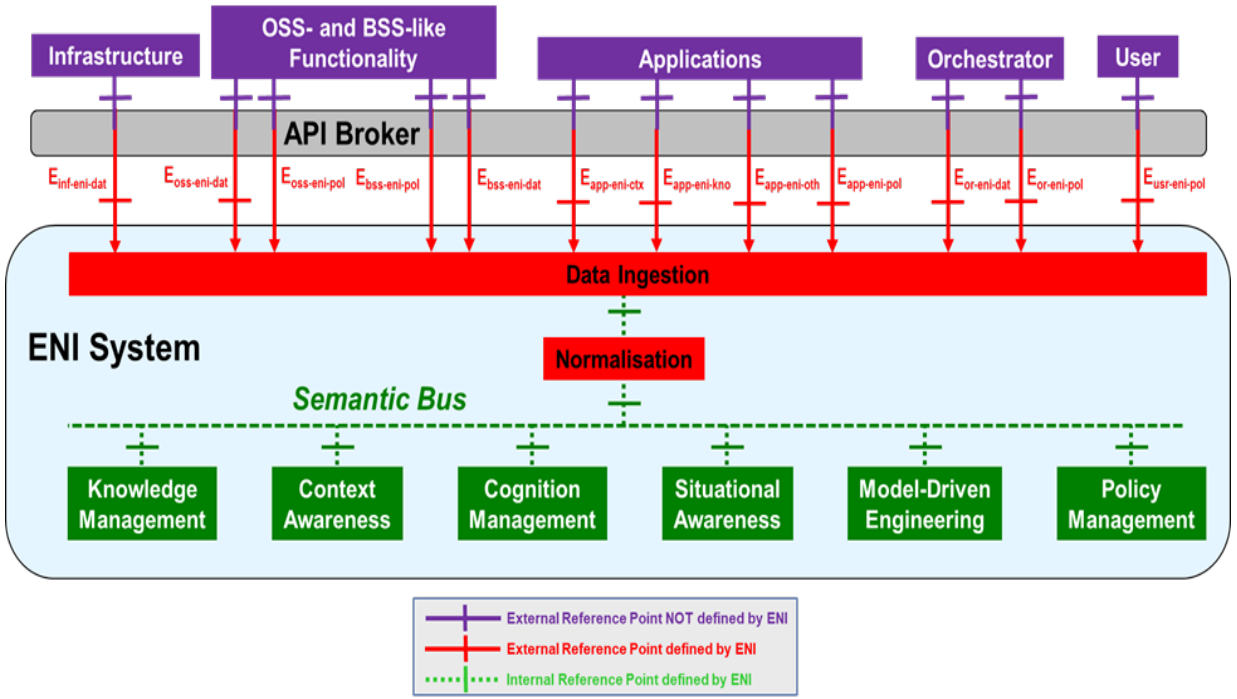
- In each case, ENI requires data from the Assisted System.
- Changes to the Assisted System are not required for any class of Assisted System in order to facilitate the use and rapid adoption of ENI.
- ENI shall use the API Broker to mediate between ENI and the Assisted System
- ENI provides actionable decisions back to the assisted system (autonomous or recommendatory)
- ENI monitors the effect

ENI High-Level Functional Architecture

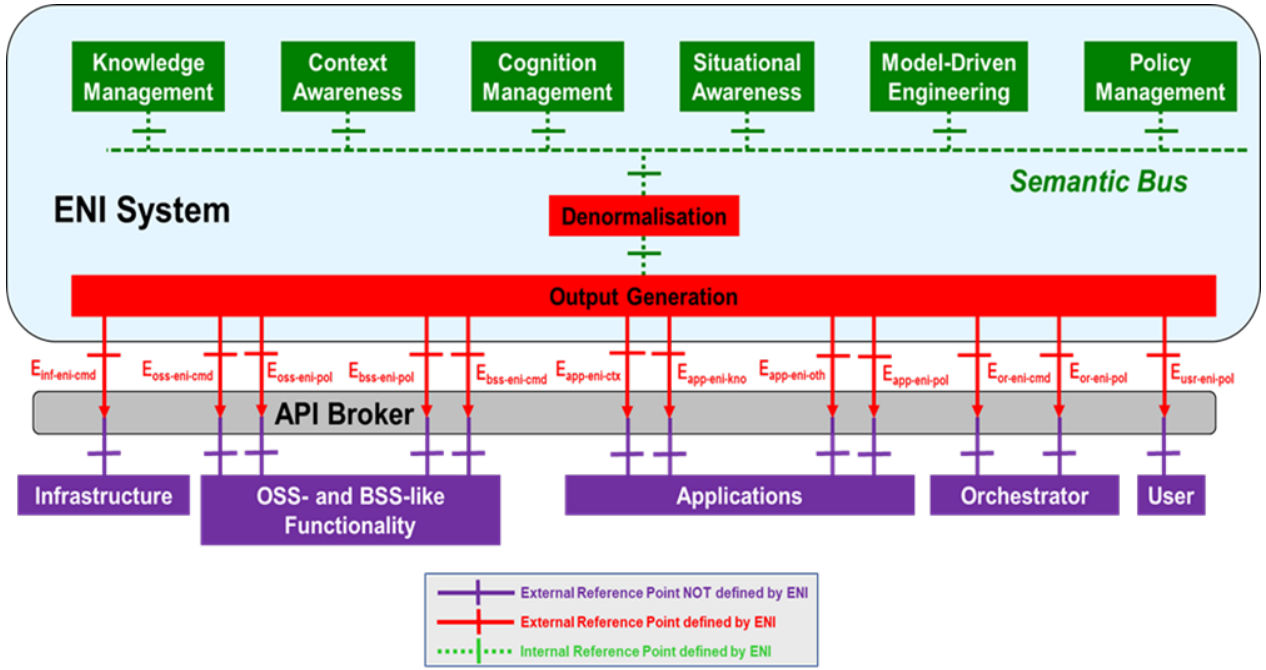


High-Level Functional Architecture Diagram in GS ENI 005 (GS ENI 005) published in 2019, revision 2 available https://docbox.etsi.org/ISG/ENI/Open/0016

Architecture External Reference Points (Inputs & Outputs)



Functional Architecture with its Input Reference Points

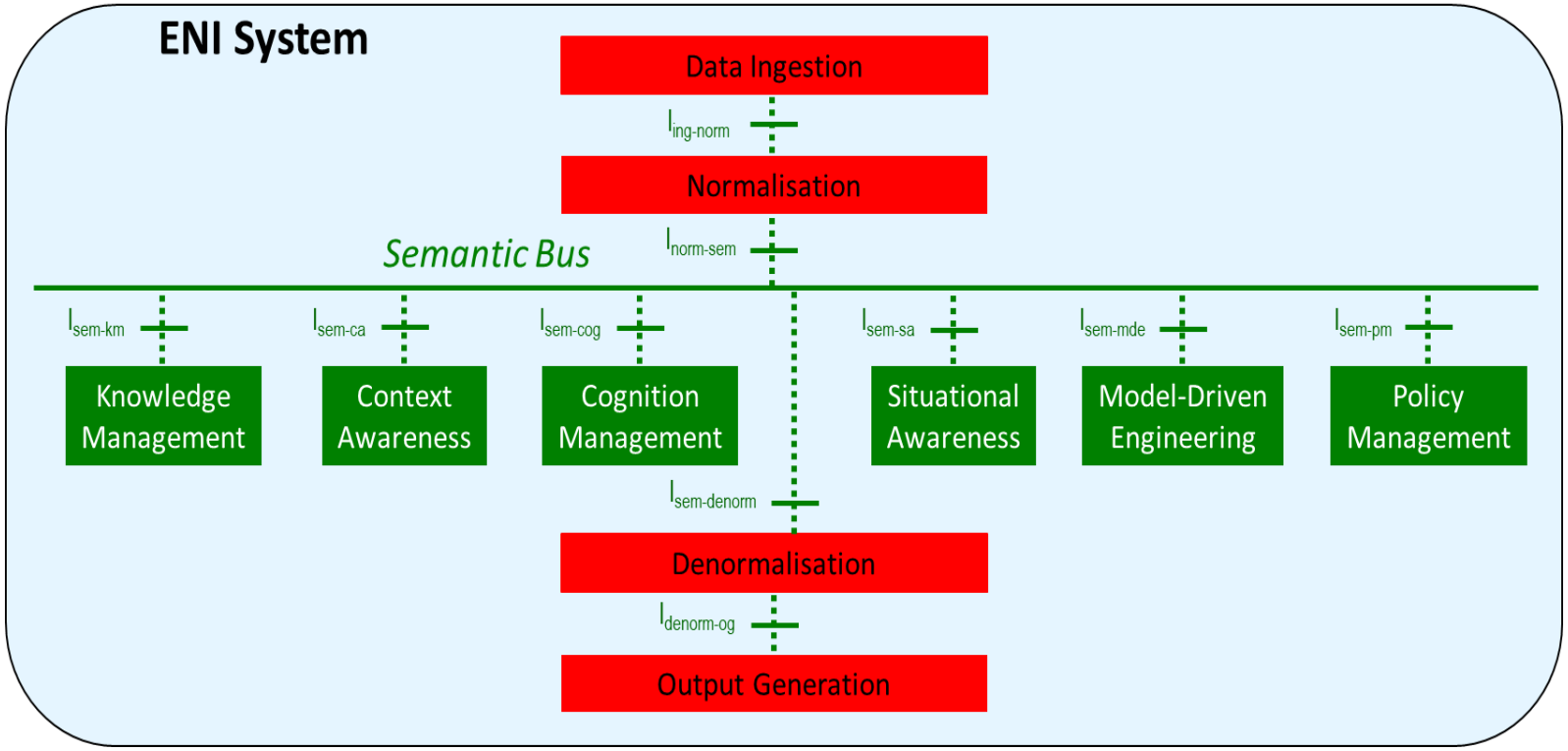


Functional Architecture with its Output Reference Points

Imperative, Declarative, and Intent Policies *are handled within the same architecture, with no additional RP or FB needed*

Source: ETSI GS ENI 005 , ENI System Architecture

Architecture Internal Reference Points



Source: ETSI GS ENI 005 , ENI System Architecture

Definition of Categories for AI Application to Networks

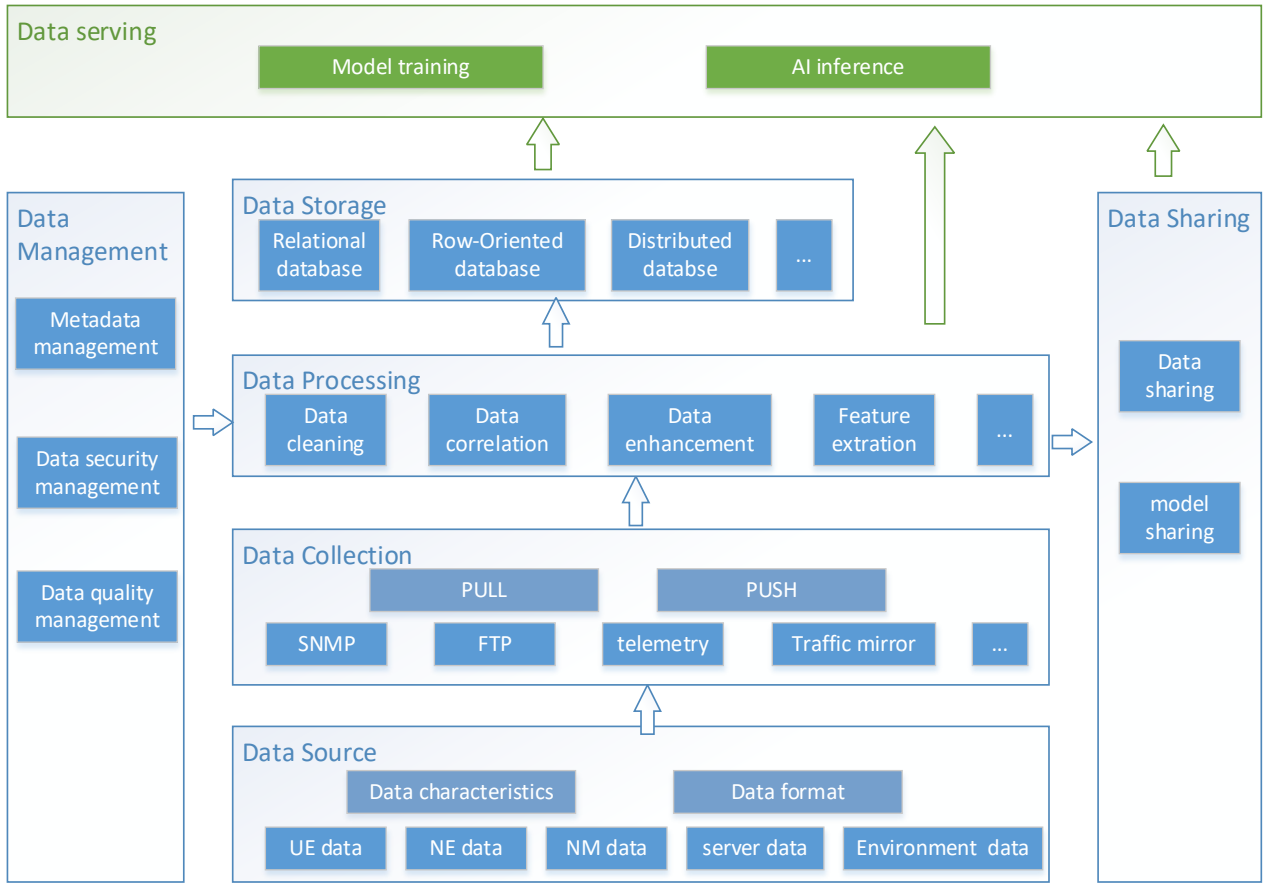
Autonomicity capability
Continuous improvement

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

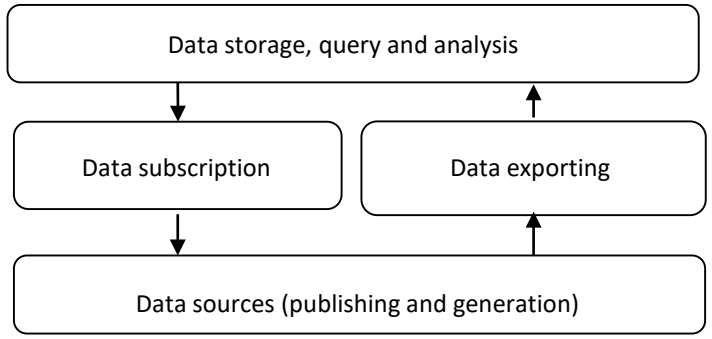
Data Mechanism Framework



Data Mechanism Framework collects together data acquiring mechanisms from different sources and data processing mechanisms for different network applications. This makes it possible to assemble a comprehensive data mechanism supporting AI enabled network O&M and service management

Main Contents of the Data Mechanisms WI

Network Telemetry



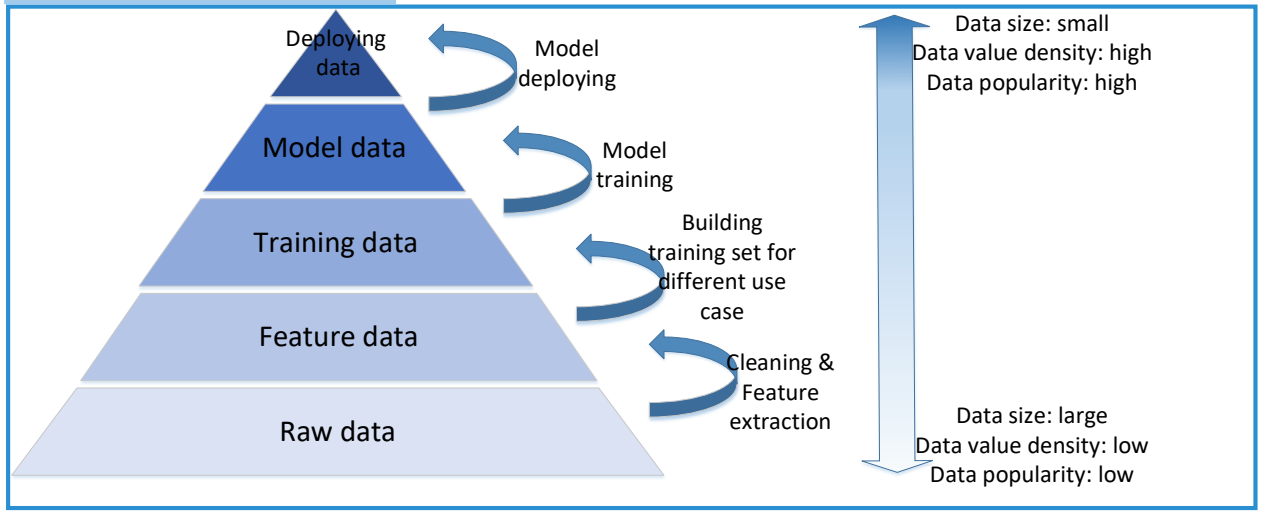
✓**Data subscription:** is responsible for data querying deployment on devices.

✓**Data source:** determines the monitoring object and data source..

✓**Data exporting:** is responsible for determining methods of data delivery from data sources to data storage and generation to the analysis component.

✓**Data storage, query and analysis:** is responsible for storing and processing the returned data from network devices.

Data Storage



Data Mechanism in Example Scenarios

Description requirements of data processing in the selected use cases proposed in ENI 001, supporting analysis in ENI System, e.g., data cleansing, data correlation, etc.

✓AI-enabled Traffic Classification

✓Network Fault Root-Cause Analysis and Intelligent

✓Intelligent Service Experience Evaluation

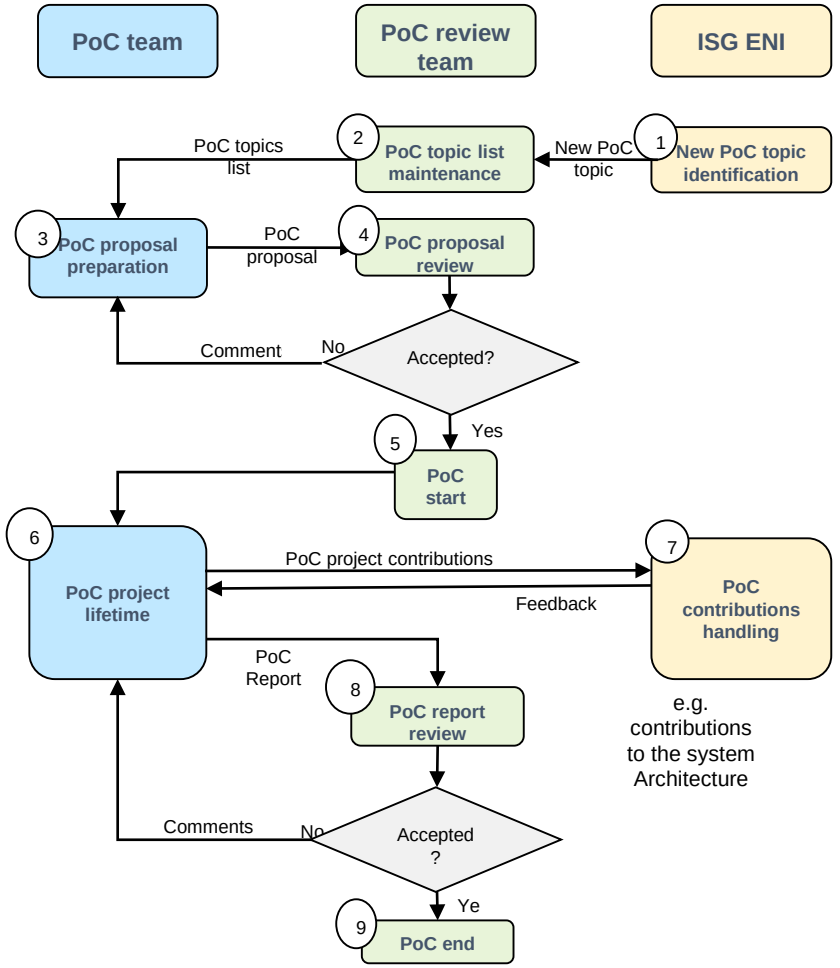
PoC Team and ENI Work-Flow proposal

using the process under definition in ETSI

Procedures:

- ISG ENI approve & published a PoC framework (2nd version)
- Form a PoC review group to receive and review PoC proposals with formal delegation from ISG
- Publish the PoC proposals (on ETSI Portal wiki) according to the PoC framework
- PoC teams (the proposers – which may include non-members) shall present an initial proposal and a final report, according to the templates given by ISG for review
- PoC Team(s) are independent of the ISG – use the process and template of the ISG – Choose a POC Team Leader and draft the proposal

ENI PoC review team:



PoC project wiki: https://eniwiki.etsi.org/index.php?title=Ongoing_PoCs

ENI PoC List - Completed

Title	PoC Team Members	Main Contact	Start Time	Current Status (Nov.-2020)
PoC#1: Intelligent Network Slice Lifecycle Management	**China Telecom** Huawei, Intel, CATT, DAHO Networks, China Electric Power Research Institute	Haining Wang	Jun-2018	Completed
PoC#2: Elastic Network Slice Management	**Universidad Carlos III de Madrid** Telecom Italia S.p.A., CEA-Leti, Samsung R&D Institute UK, Huawei	Marco Gramaglia	Nov-2018	Completed
PoC#3: SHIELD, security through NFV	**Telefonica** Space Hellas, ORION, Demokritos (NCSR)	Diego R. Lopez Antonio Pastor	Jan-2019	Completed
PoC#4: Predictive Fault management of E2E Network Slices	**Portugal Telecom/Altice Labs** SliceNet Consortium	António Gamelas Rui Calé	Mar-2019	Completed
PoC#5: AI Enabled Network Traffic Classification	**China Mobile** Huawei, Intel, Tsinghua University	Weiyuan Li	Jun- 2019	Completed
PoC#6: Intelligent caching based on prediction of content popularity	**China Unicom** Beijing University of Posts and Telecommunications, Samsung, Cambricon, Huawei	Bingming Huang	Sep-2019	Completed
PoC#7: Intelligent time synchronization of network	**China Unicom** Beijing University of Posts and Telecommunications, Samsung, Cambricon, Huawei	Bingming Huang	Sep-2019	Completed

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

ENI PoC List

Title	PoC Team Members	Main Contact	Start Time	Current Status (Nov.-2020)
PoC#8: Intent-based user experience optimization	**China Telecom/Huawei Technologies** China Telecom, Huawei Technologies, AsiaInfo, Beijing University of Posts and Telecommunications	Dong Li	Jan-2020	Ongoing
PoC#9: Autonomous Network Slice Management for 5G Vertical Services	**Nextworks** TIM, Nextworks, Samsung, WINGS, UC3M	Gino Carrozzo / Marco Gramaglia	Jan-2020	Ongoing
PoC#10: Intelligent Telecom Network Energy Optimization	**China Mobile** China Mobile Research Institute, Intel, Quanta Cloud Technology, Hong Kong ASTRI	Liexiang Yue	Jan-2020	Ongoing
PoC#11: Intelligent Energy Management of DC	**China Telecom:** China Telecom, Intel, AsiaInfo, Samsung, Huawei	Yu Zeng	April-2020	Ongoing
PoC #12: Intelligent Transmission Network Optimization	**China Mobile** China Mobile Research Institute, China Mobile Group Zhejiang Co., Ltd., Huawei, Intel	Chen Shaofan	Sept.-2020	Started
PoC#13: Intelligent Coverage Optimization of 5G Massive MIMO BS	**China Telecom** China Telecom, Intel, Inspur	Xueqi Yuan	October-2020	In Review

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

ENI PoC #1: Intelligent Network Slice Lifecycle Management

AI-based predictor:

- For generating new scale up/down and converting the intent to suggested configuration.
- LSTM is used for traffic prediction.

TNSM:

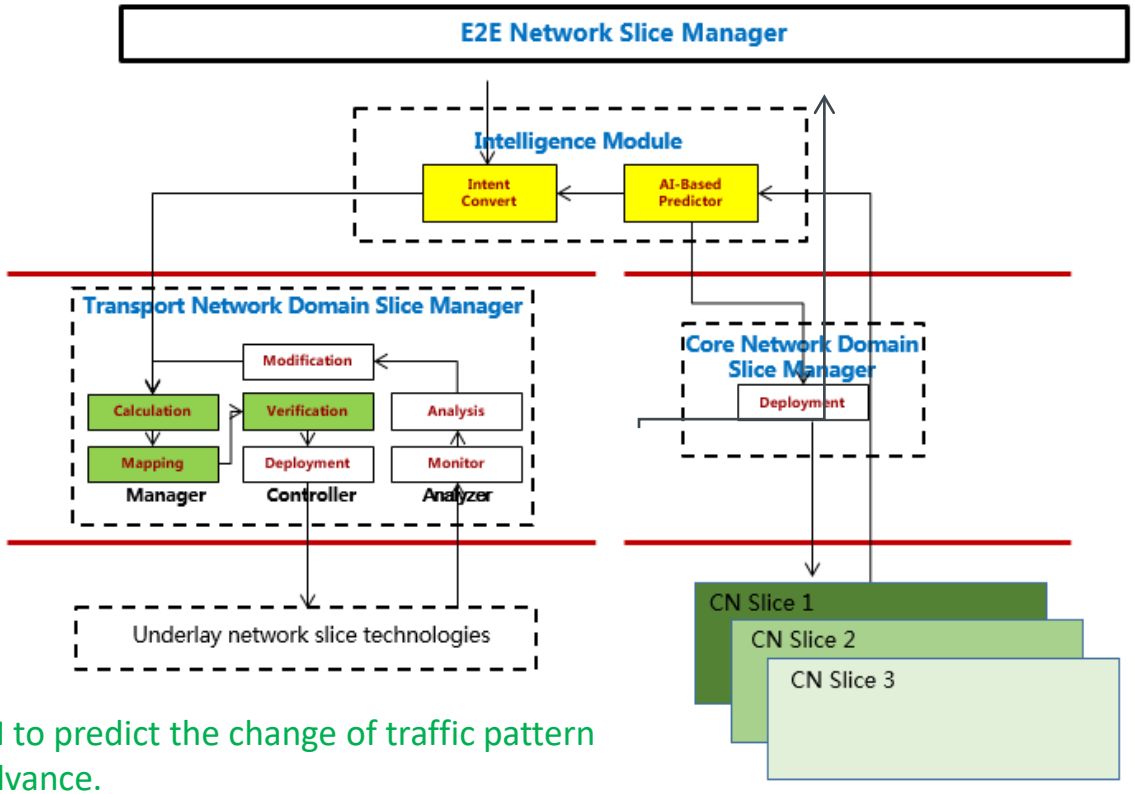
- Provides underlay network control to satisfy the network slice requests.
- FlexE and a FlexE-based optimization algorithm are used for underlay network slice creation and modification.

CNSM:

- Provides core network control to satisfy the network slice requests

Host/Team Leader: CHINA TELECOM

Team members: HUAWEI, intel, DTT, DAHO 大河云联, 国家电网 STATE GRID, 中国电力科学研究院有限公司



Showcases:
Beijing, Sep 19-20, 2018
Nanjing, Nov 14-16, 2018
Warsaw, Apr 10, 2019

✓ PoC Project Goal #1: Demonstrate the use of AI to predict the change of traffic pattern and adjust the configuration of network slice in advance.

✓PoC Project Goal #2: Demonstrate the use of intent based interface to translate tenant requirements to network slice configuration and intelligent network slice lifecycle management on demand.

https://eniwiki.etsi.org/index.php?title=PoC#PoC.231:_Intelligent_Network_Slice_Lifecycle_Management

ENI PoC #2: Elastic Network Slice Management

Main Features

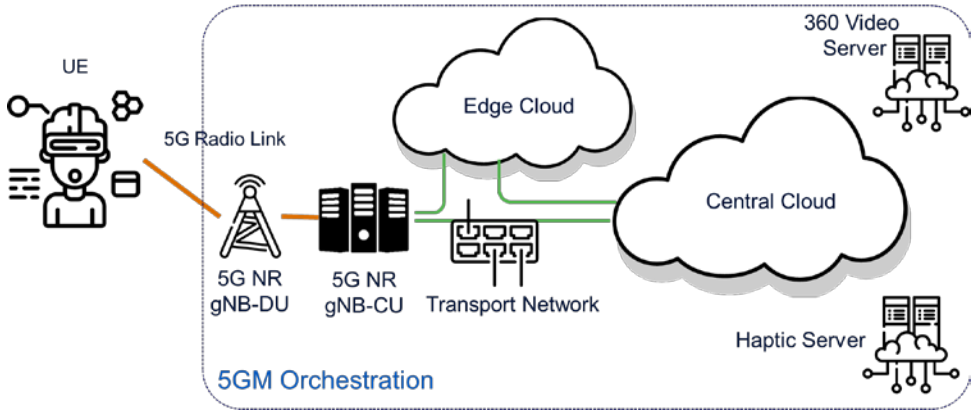
Network Slice Blueprinting & Onboarding

Elastic Intelligent Features:

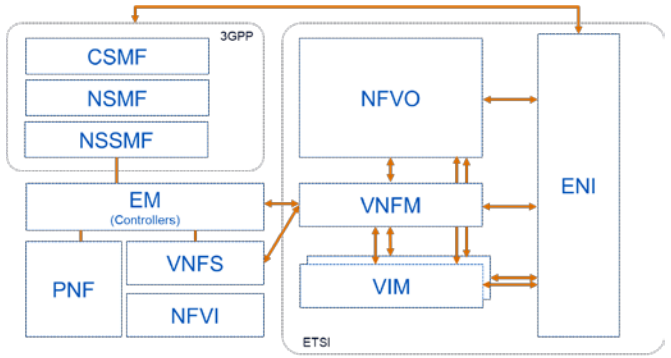
- Horizontal and Vertical VNF Scaling
- Intelligent Admission Control

One innovative service through 2 network slices

- Virtual Reality application
- One eMBB slice for 360 video
- One URLLC slice for haptic interaction



Hardware and Software Setup



Orchestration Architecture

PoC Team

VR Service

Goals:

- Provide enhanced AI-based mechanisms to provide novel 5G Services
- Design, test and validate new interfaces with MANO

Showcases:

- Turin: May 20th-24th 2019
- Valencia: June 17th-21st 2019
- https://youtu.be/L-5XzBvAZyY

https://eniwiki.etsi.org/index.php?title=PoC#PoC.232:_Elastic_Network_Slice_Management

ENI PoC project #3: Securing against Intruders and other threats through a NFV-enabled Environment (SHIELD)

Status: PoC public demo 23-25th Feb. 2019, and **finished**.

Host/Team Leader: Telefónica

Team members:: SPACE, ORION, Ubitech

SHIELD
https://www.shield-h2020.eu/

Goals

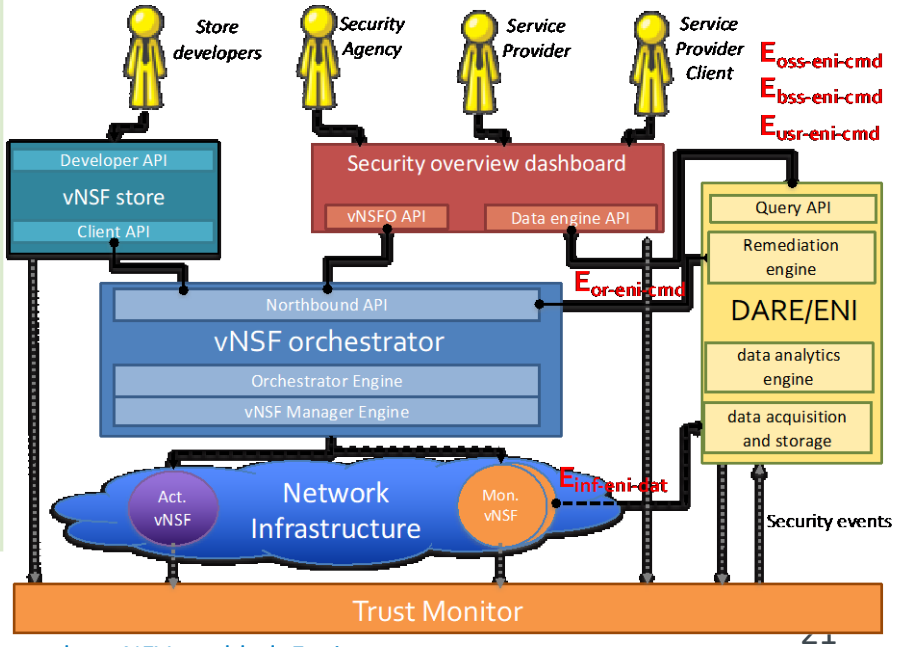
- PoC Goal #1: Demonstrate an AI framework able to detect network attacks over NFV network combining several ML algorithms
- PoC Goal #2: Recommend intent-based security policy
- PoC Goal #3: Remote attestation for data collectors.

Gaps identified

- Coordination between AI models / ENI systems.
  - Support 3rd party AI models
  - Information sharing between ENI systems
- Data collection integrity and security with Trust Monitoring
- Synchronization between intent-based and configuration policies API

Contribution

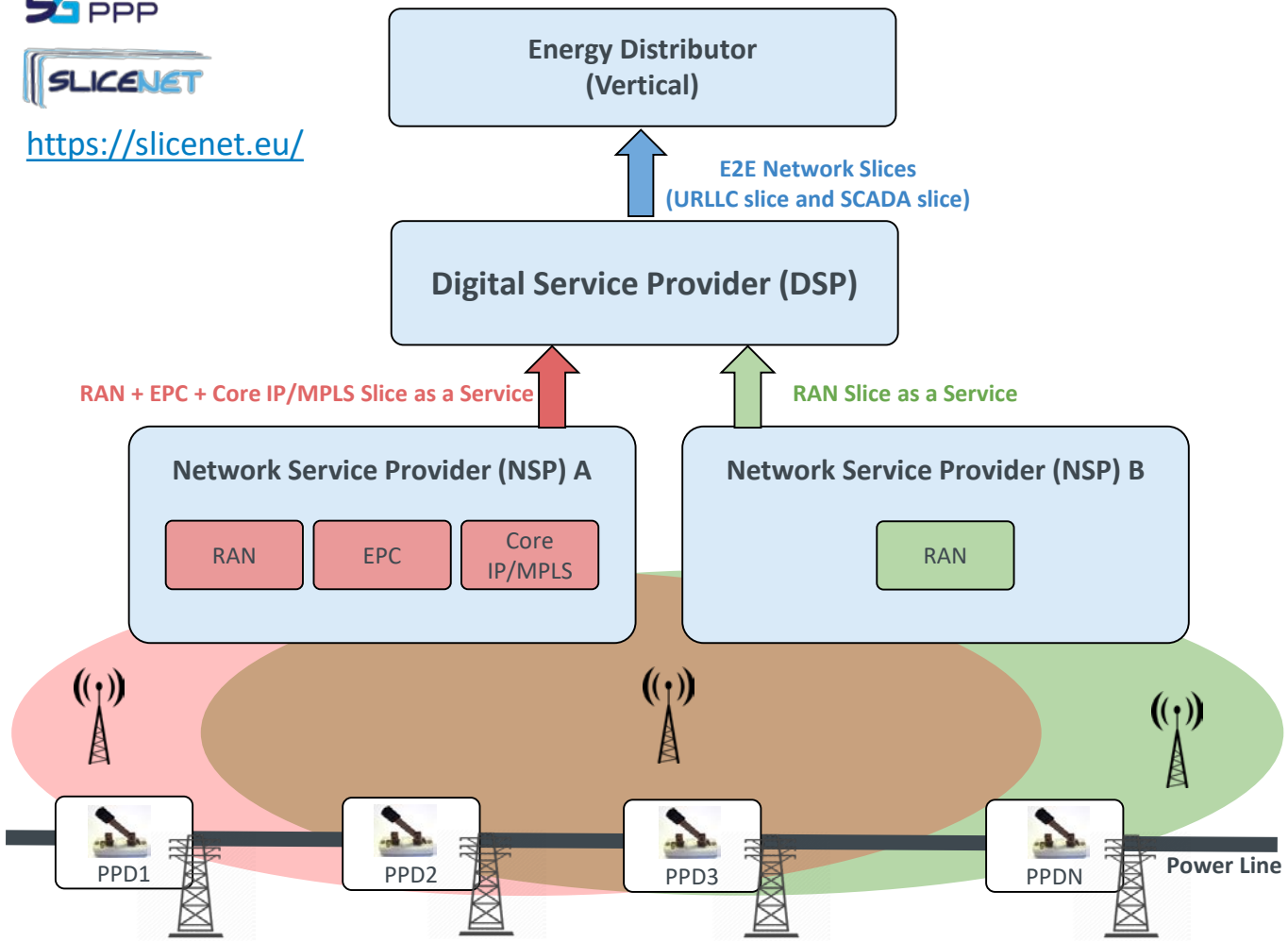
- New type of use cases related with malware in ENI 001



https://eniwiki.etsi.org/index.php?title=PoC#PoC.233:_Securing_against_Intruders_and_other_threats_through_a_NFV-enabled_Environment

ENI PoC #4: Predictive Fault management of E2E Network Slices

https://slicenet.eu/



- PoC scenario is a power grid vertical, that uses 5G to provide time sensitive communications for grid protection mechanisms. A Network Slice is provided by a DSP for that effect.

- PoC is focused on the **NSP** functions
  - NSP A provides an E2E slice
  - NSP monitors Sub-slices behaviour
  - NSP predicts Sub-slice failure
  - NSP decides best proactive mitigation strategy
  - NSP enforces the actions necessary to keep the E2E slice operational

PoC Project Goal #1: Network Slice Fault Prediction. Demonstrate the use of AI on performance data to be able to accurately predict failure situations on Network Slices and estimate their impact on an E2E slice performance.

PoC Project Goal #2: Policy-based Network Slice Management. Evaluate the use of a policy-based structure for slice composition decisions, as well as the mechanisms for policy definition on that same context in a single domain.

https://eniwiki.etsi.org/index.php?title=PoC#PoC.234:_Predictive_Fault_management_of_E2E_Multi-domain_Network_Slices

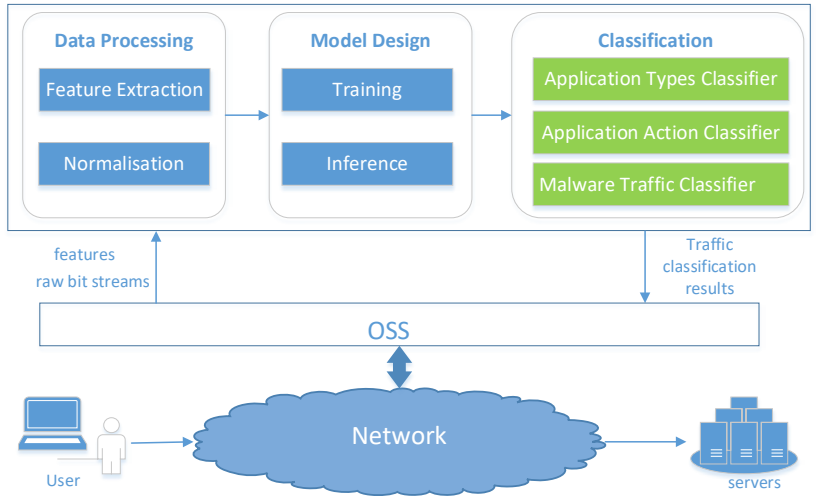
ENI PoC #5: Intelligent Traffic Profiling

Status: Completed

Host/Team Leader: 中国移动 China Mobile

Team members:

HUAWEI, intel, 清華大學 Tsinghua University, vodafone



This PoC aims to verify the feasibility and the benefits of the use of AI/ML for network traffic classification, including the encrypted traffic, and demonstrate in a testbed environment that how ENI system can support intelligent traffic profiling and mechanism generalization.

This PoC consists of three scenarios:

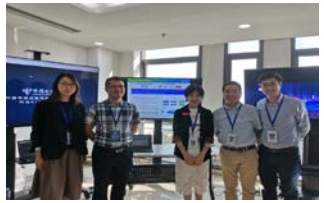
✓ **The first scenario** demonstrates that the AI/ML-based technique enables network traffic to be categorized into classes of application types, e.g. high-throughput data, real-time interactive, multimedia streaming, low-priority data.

✓ **The second scenario** shows that traffic flows generated by a specific application can be classified into classes of subactions types , e.g. query action, call action etc.

✓ **The third scenario** shows that the malware traffic and normal traffic can be identified based on the AI/ML algorithms.

Showcases:

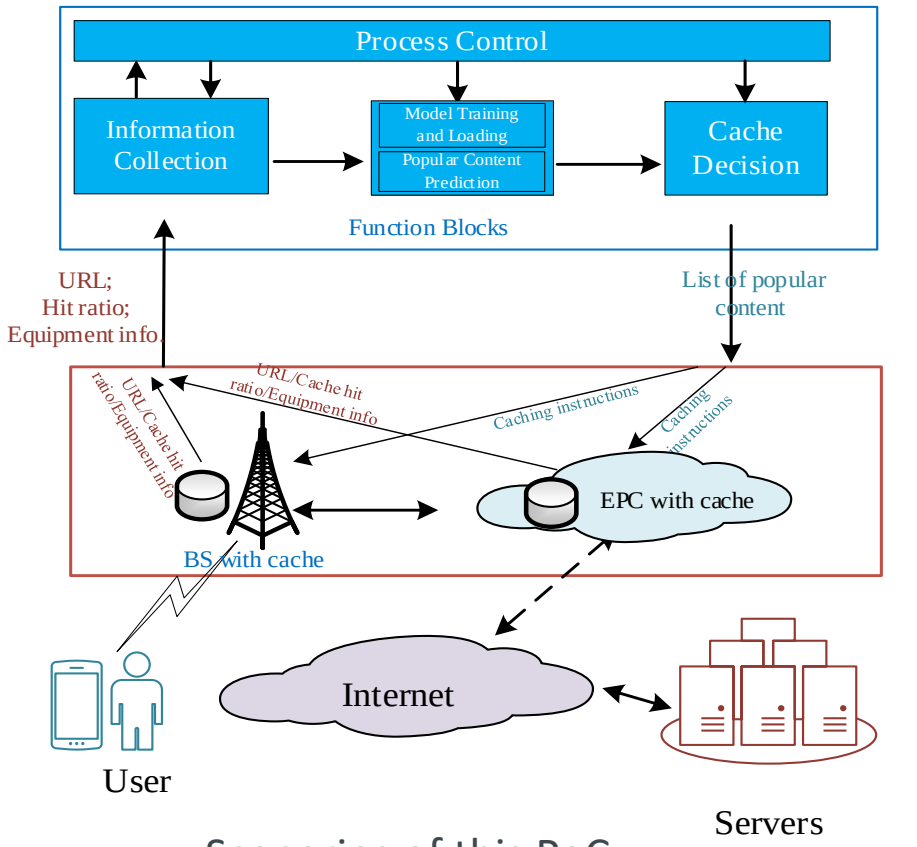
- Beijing, Sep 27, 2019
- Guangzhou, Nov 14-16, 2019
- Sophia Antipolis France, **Dec**9-10, 2019



https://eniwiki.etsi.org/index.php?title=PoC_05:_Intelligent_Traffic_Profiling

ENI PoC #6: Intelligent caching based on prediction of content popularity

PoC Team



Scenarios of this PoC

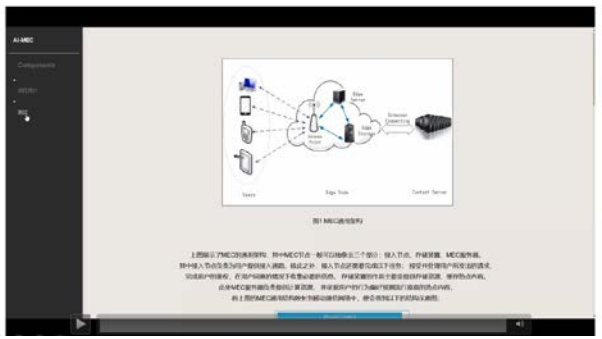
This PoC is meant to show the feasibility and the benefits of an intelligent mobile edge cache, especially when there are large amount users request the same content, and demonstrate in a testbed environment that how ENI system can support intelligent caching based on prediction of content popularity.

Goal #1:

- ✓ The first scenario demonstrates how the system, which is called intelligent caching based on prediction of content popularity, predicts popular content.

Goal #2:

- ✓ The second scenario shows the functionality of this system in the network, specifically to reduce the latency and reduce the core network load.



Showcases:
Sophia Antipolis France, **December** 9-10, 2019

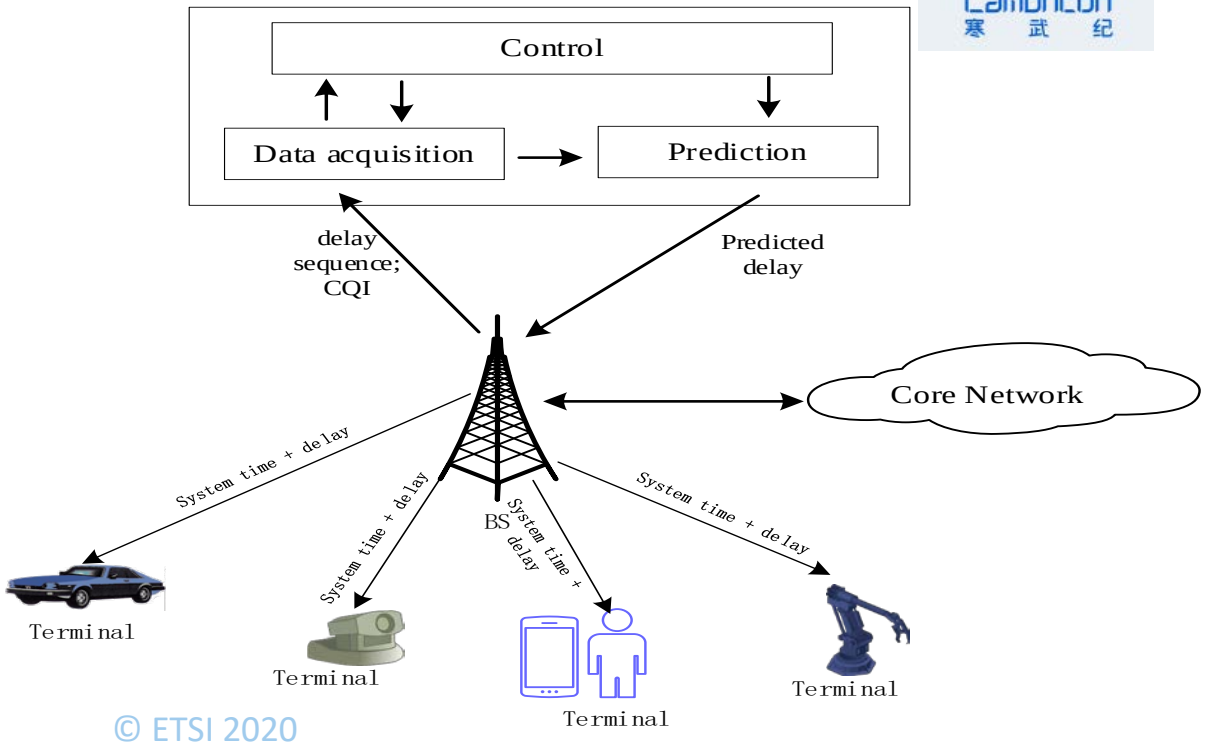
https://eniwiki.etsi.org/index.php?title=PoC_06:_Intelligent_caching_based_on_prediction_of_content_popularity

ENI PoC #7: Intelligent time synchronization of network

Status: Completed

Host/Team Leader: China unicom 中国联通 创新·改变世界

Team members: HUAWEI, SAMSUNG, Cambricon 寒武纪

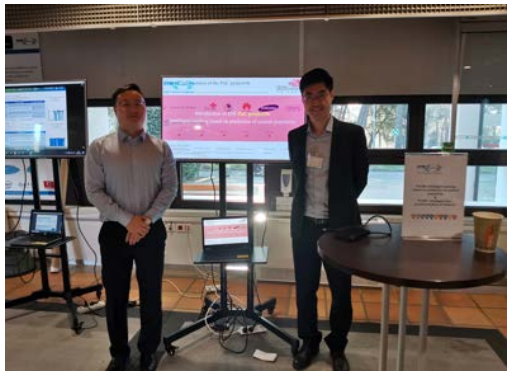


This PoC is meant to Demonstrate the use of ML algorithms to be able to predict future delays based on past delays. Achieve time synchronization accuracy of network on the order of hundreds of ns

Goal #1: Design the structure of the hardware and algorithms. Analyze the feasibility and improve it.

Goal #2: Build the hardware platform and design software system, then propose the detection methods

Goal #3: Deploy software and hardware to get test data. Analyze the experimental results and improve the algorithm



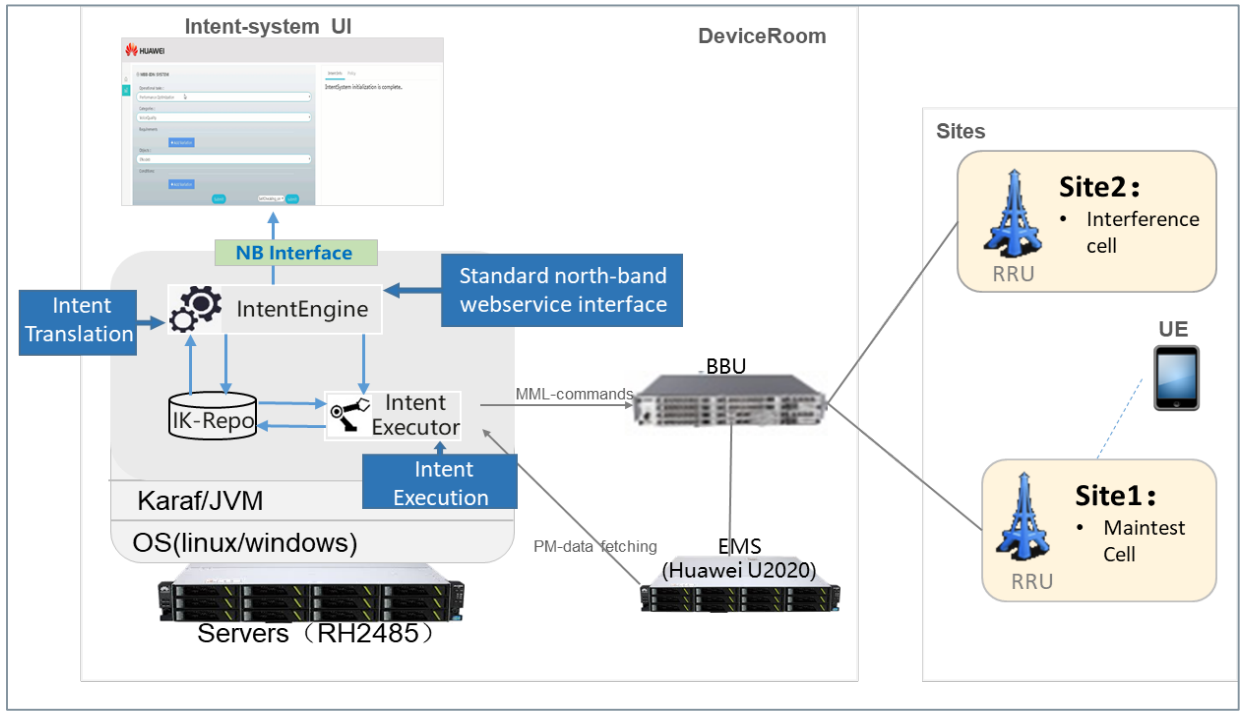
Showcases:
Sophia Antipolis
France, **December** 9-10, 2019

https://eniwiki.etsi.org/index.php?title=PoC_07:_Intelligent_time_synchronization_of_network

ENI PoC #8: Intent-based user experience optimization

Host/Team Leader: 中国电信 CHINA TELECOM, HUAWEI

Team members: AsiaInfo 亚信科技



The PoC project demonstrates the use of intent policy in the wireless domain as defined in GS ENI 002 and GR ENI 008.
In particular, the PoC aims to verify that when the network state changes, the intent requirements of the user can still be satisfied by the ENI system.
Automatic closed-loop management and intra-RAN autonomy can be achieved through intent policy translation and maintenance.

Scenario1: basic intent translation and execution
UE connects to the LTE network, and receives data stream from the test server.
Verify the procedure of translation and execution for the intent.

Scenario2: Intent maintenance under weak coverage

Scenario3: Intent maintenance under high loading

ENI PoC #9: Autonomous Network Slice Management for 5G

Targeted Use Cases:

Use case #2-8: Automatic service and resource design framework for cloud services

Use case #3-2: Intelligent network slice management

Involved EU projects

5G EVE

5G-TOURS

5GROWTH

TIM

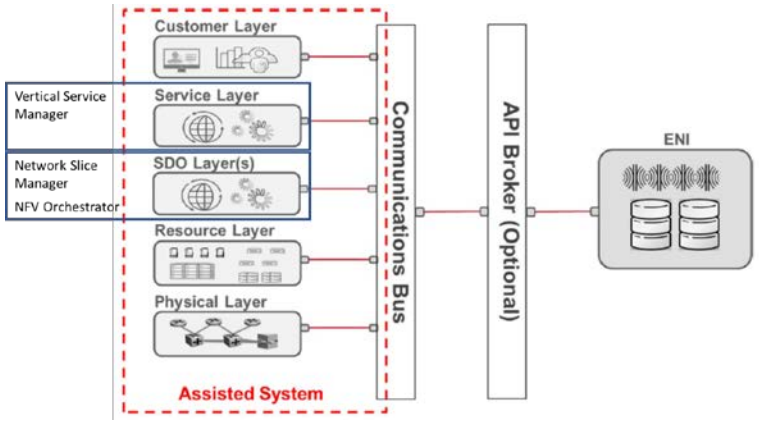
WINGS ICT SOLUTIONS

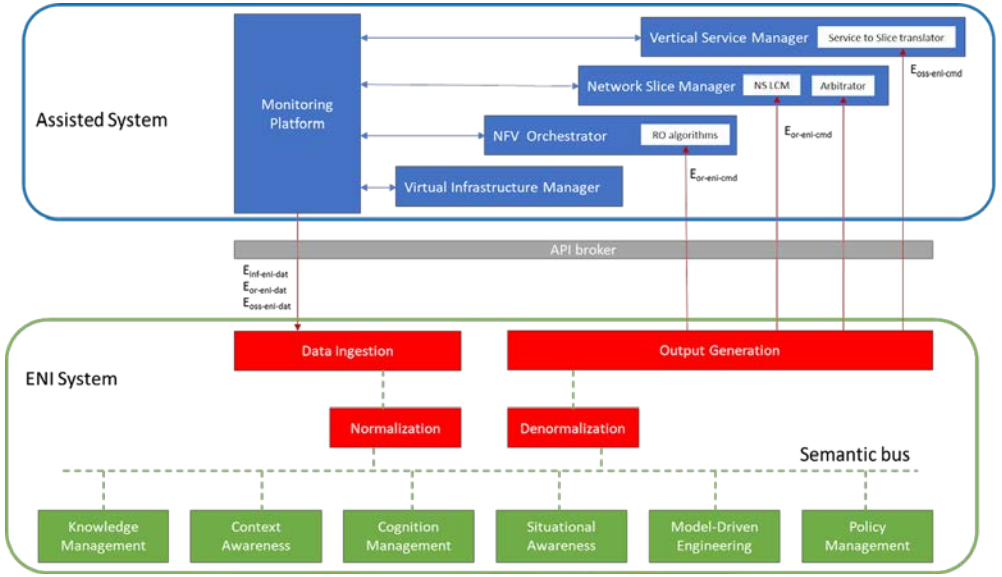
SAMSUNG

NEXTWORKS ENGINEERING FORWARD

uc3m | Universidad Carlos III de Madrid

Members





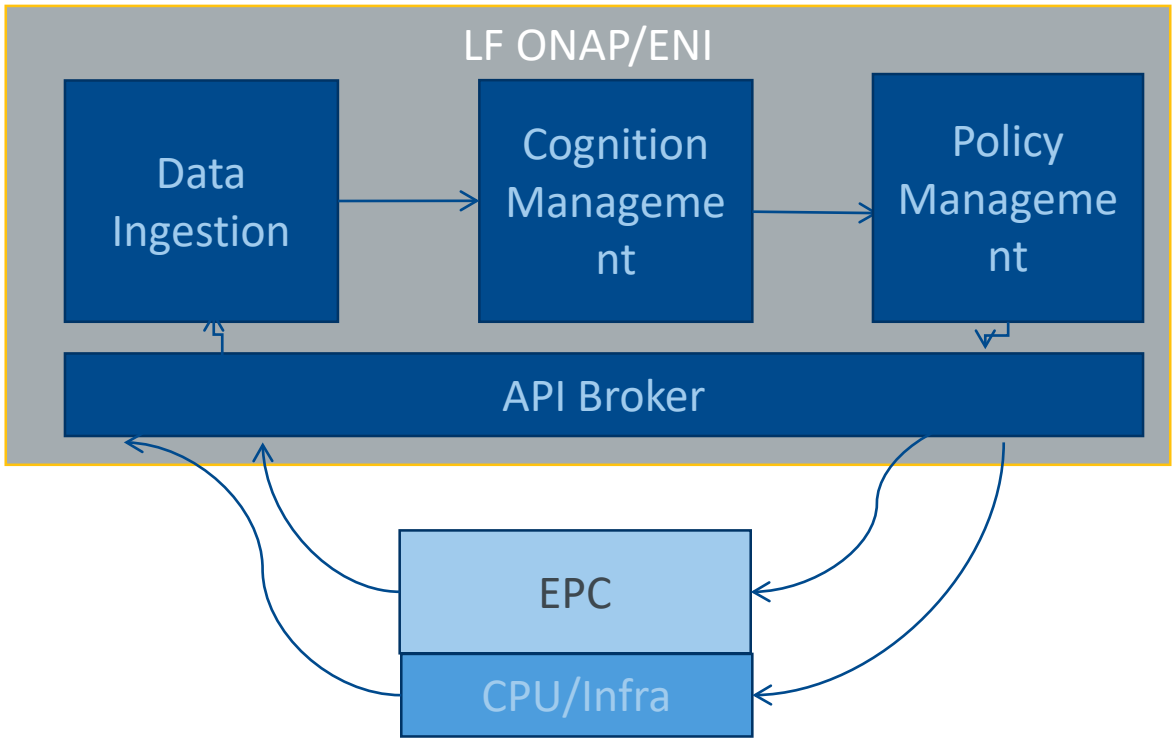
The system will include:

- Validation of intent based interface between verticals and network operators
- Strategies for sharing and composition of slices
- Automation of scaling and migration procedures

ENI PoC #10: Intelligent Telecom Network Energy Optimization

Host/Team Leader: 中国移动 China Mobile

Team members: intel, QCT, ASTRI



This PoC consists of two scenarios:
Scenario#1: demonstrates that the AI/ML-based approach enables VNF to be scaled horizontally and vertically , as well as PNF on and off ,etc.
Scenario#2: shows that CPU frequency can be tuning up or down to save CPU power, etc.

Goal #1: Policy-based Network Service Self-Organization.
Demonstrate the use of AI on metric data to be able to orchestration and automation of physical or virtual network functions

Goal #2: Policy-based Network Service Energy Optimization.
Demonstrate the use of ML algorithms to evaluate the use of a policy-based structure for network service energy wise management decisions.

Next : Public demo
LF Open Networking and Edge Summit 2020
Sep.2020
Demo proposal has been accepted.

PoC#11: Intelligent Energy Management of DC

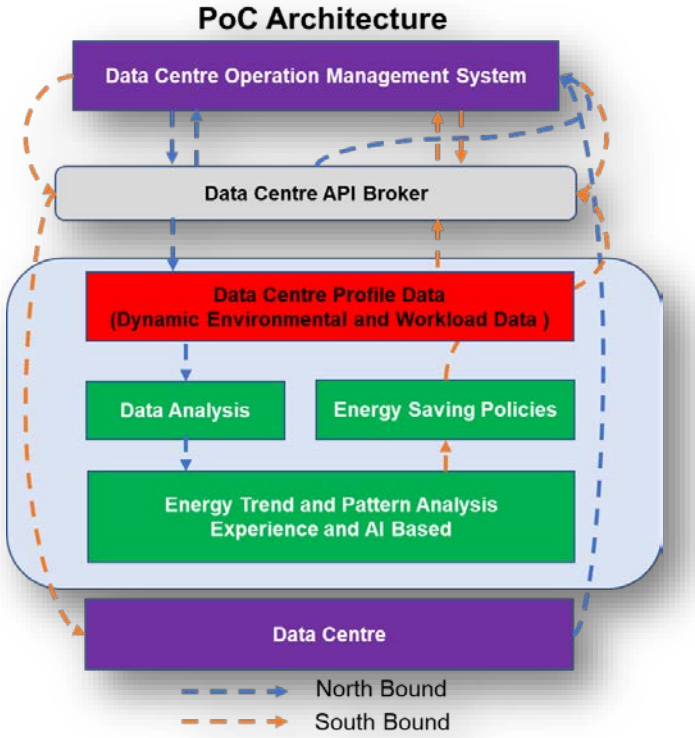
PoC Goals and PoC members tasks

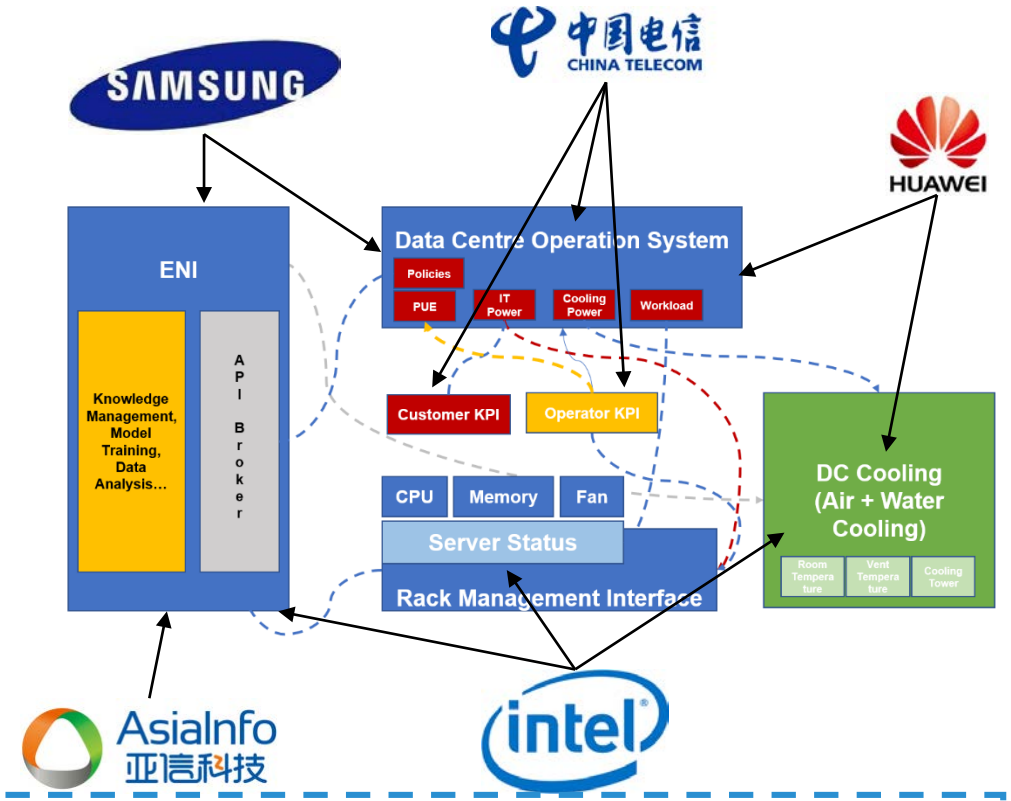
Host/Team Leader:

中国电信 CHINA TELECOM

Team members:

intel HUAWEI SAMSUNG AsiaInfo 亚信科技





- ✓ **PoC Project Goal #1:** DC profile analysis. Demonstrate the use of AI-based methods to analyze energy related data, e.g. DC dynamic environment and IT workload data etc..
- ✓ **PoC Project Goal #2:** Policy-based DC Energy Management. Demonstrate the use of AI algorithms to enable policy-based energy management..

New PoC: Intelligent Transmission Network Optimization

Host/Team Leader: 中国移动 China Mobile

Team members: cea HUAWEI

This PoC is meant to showcase the intelligent optimization for transmission network by applying Artificial Intelligence / Machine Learning (AI/ML) algorithm. Based on information data, including the topology of network and detailed configuration parameters of virtual network function (VNF), and the pre-determined optimization policy, the ENI system shall intelligently analyse the overall topology reaching globally optimum utilization rate of capacity, and output the optimization plan automatically.

The PoC will demonstrate the following Use Case identified by in GS ENI 001, namely:

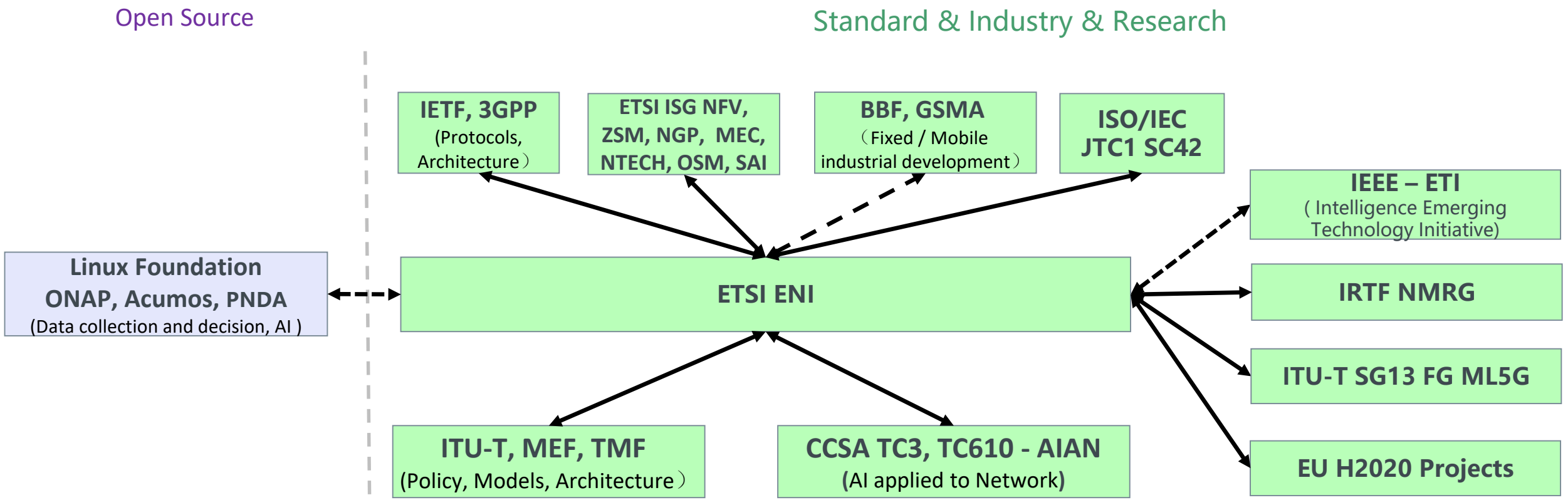
- **Use Case: Intelligent Optimization for Transmission Network.**

The PoC will also demonstrate aspects of various requirements identified in GS ENI 002, including:

- **Network optimization**
- **Data Collection and Analysis**
- **Policy Management**
- **Data Learning**

https://portal.etsi.org/ngppapp/ContributionCreation.aspx?primarykeys=205952&source=NGEUCYYQRKWS

Ecosystem



- Cooperate with mainstream operators, vendors and research institutes in Europe, USA and Asia
- Collaborate with other SDOs and industry ad-hocs
  - Liaisons exchanged with IETF, BBF, MEF, ITU-T, ISO/IEC
  - Liaisons with other ETSI groups: NFV, NGP, MEC, NTECH, OSM, ZSM, SAI
- Position ETSI ENI as the home of network intelligence standards
- Guide the industry with consensus on evolution of network intelligence
- Boarder between different categories are becoming vague.

Network Intelligence Activities in 2016 - 2019

Past Activities:

- **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**

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

Please Contribute

ETSI ENI#15 meeting will be hosted by TBC in London UK, on Sept 14-18, 2020.

You are welcome to join us!

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

+44 771 851 1361

Useful links:

ENI Terms of Reference	ENI membership list	ENI High Level Notice
ENI Member Agreement	ENI Published Deliverables	ENI White Paper
ENI Participant Agreement	ENI Presentation	ENI Blog
ENI Activity Report	ENI Wiki and PoC info	ENI Webpage

Acknowledge the assistance of

Dr. LIU Shucheng (Will) liushucheng@huawei.com

Thank you!

ENI
Use Cases

Dr. Yue Wang (Samsung), Rapporteur, Use Cases

Overview of the Use Case Work Item

Identify and describe appropriate use cases

Release 1, V1.1.1 (April 2018)

Scope - use cases and scenarios that are enabled with enhanced experience, through the use of network intelligence.

Group report (GR) produced: **ETSI GR ENI 001 V1.1.1**

Details where intelligence can be applied in the fixed and/or mobile network

Gives the baseline on how the studies in ENI will substantially benefit the operators and other stakeholders.

Release 1, V2.1.1 (Sept 2019)

Group specification (GS) published: **ETSI GR ENI 001 V2.1.1**

Gives baseline on how the studies in ENI can be applied as solutions of the identified use cases in accordance with the ENI Reference Architecture, and will substantially benefit the operators and other stakeholders.

Release 2 v3.0.0 (Nov 2020)

Use cases on intent based network

The use of ENI system, including the capability exposure from ENI

Use Cases

Infrastructure Management
Policy-driven IDC traffic steering
Handling of peak planned occurrences
Energy optimization using AI

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

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

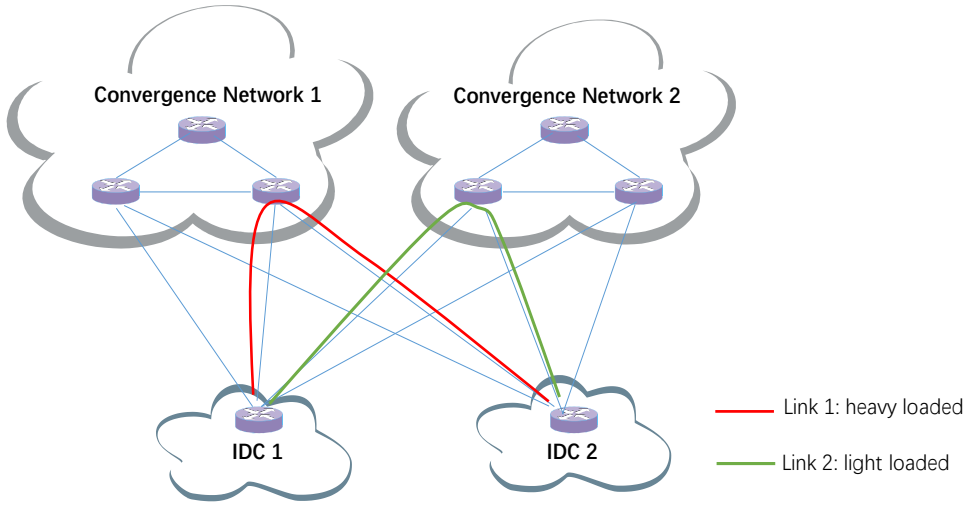
Service Orchestration and Management
Context aware VoLTE service experience optimization
Intelligent network slicing management
Intelligent carrier-managed SD-WAN
Intelligent caching based on prediction of content popularity

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

Source: ETSI RGS/ENI-0014 , Experiential Networked Intelligence (ENI); ENI use cases; – Wang, Yue (Samsung)

ENI Use Case:

Policy-driven IDC traffic steering



The challenges:

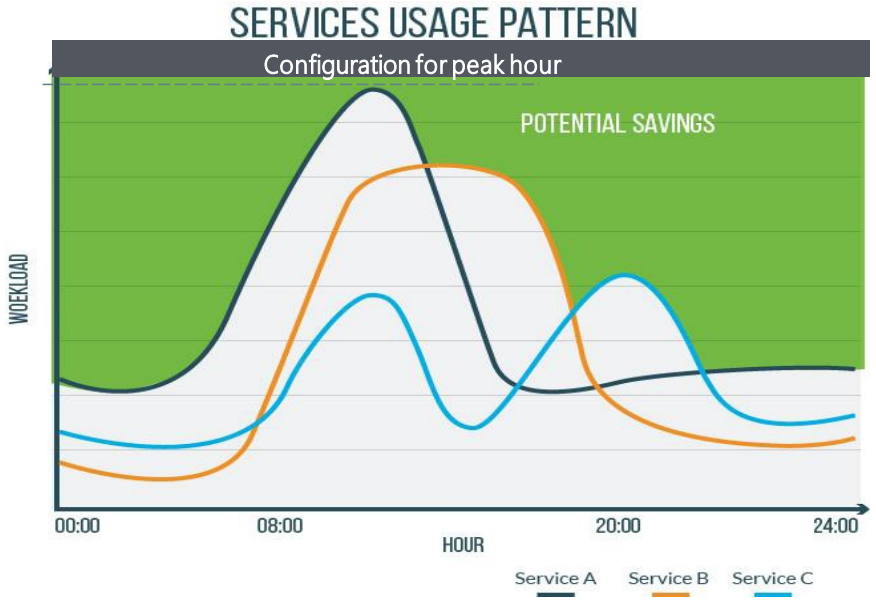
- Multiple links between IDCs, allocated by network administrator, e.g., shortest path strategy
- Link load not sufficiently considered when calculating the traffic path
- Bandwidth allocated to a tenant is not always fully used all time

The role of AI and ENI:

- Autonomous service volume monitoring
- Network resource optimization through historical data and prediction in real-time
- Network traffic via different links is balanced
- Network resource, such as bandwidth, will be used more efficiently

ENI Use Case:

Energy optimization using AI



The challenges:

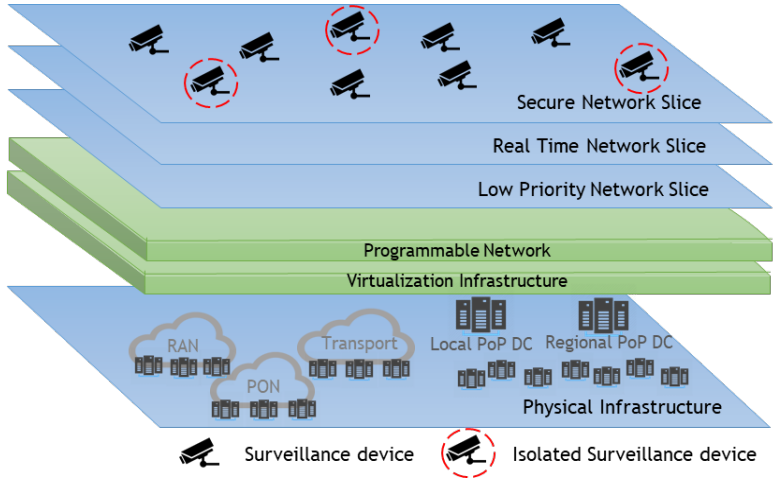
- The servers in a DC take 70% of the total power consumption
- Servers are deployed and running to meet the requirement of peak hour service – 100% powered-up full time.

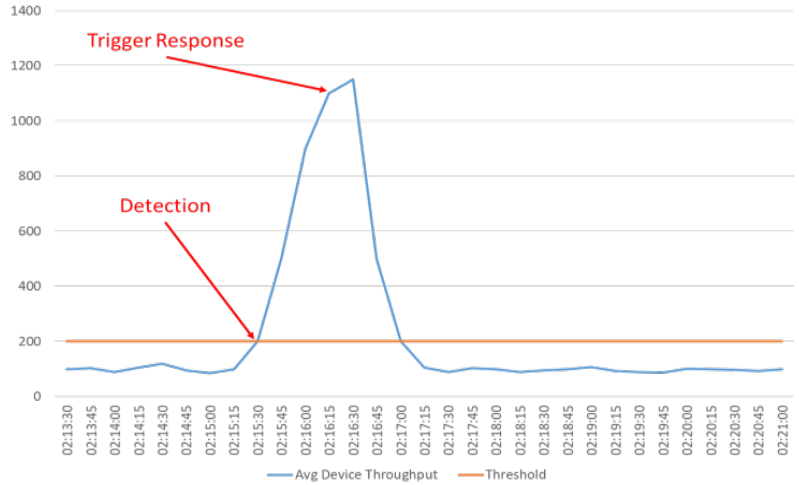
The role of AI and ENI:

- Learn and update the usage pattern of the services
- Autonomously turn the spare servers to idle state
- Predict the peak hours and wake up the necessary number of servers

ENI Use Case:

Policy-based network slicing for IoT security





The challenges:

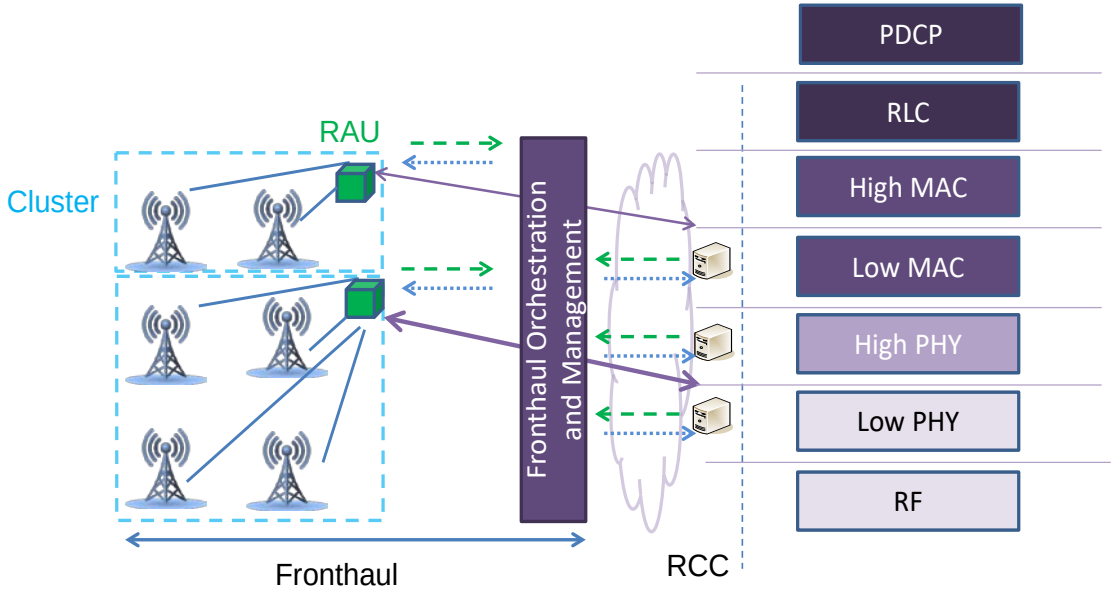
- Massive deployment of devices
- Slices may be dynamically expansible and adaptable in a changing context
- Methods and technologies of attacks are widely changing

The role of AI and ENI:

- Signal specific traffic patterns indicating Distributed Denial of Service (DDOS) attack or other type of attacks
- Automatically isolate the attacked devices

ENI Use Case:

Intelligent Fronthaul Management and Orchestration



The challenges:

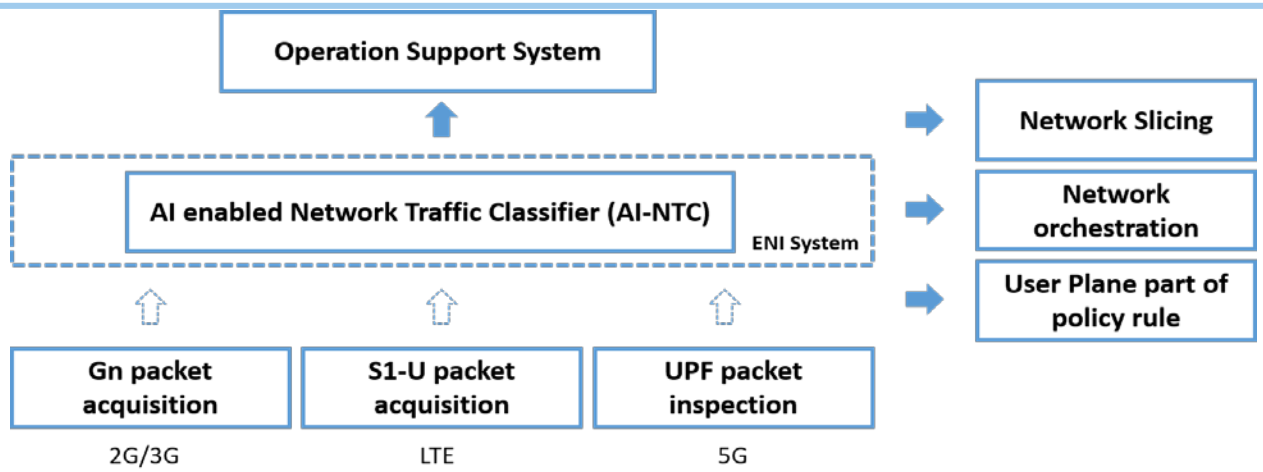
- Multiple factors and changing contexts
- Dimensionality of solution space on network resources (power, processing capability, radio resources, buffering memory, route to be selected across multiple fronthaul nodes)

The role of AI and ENI:

- An optimisation framework at the fronthaul
- Enables flexible and dynamic resource slicing and functional split
- Real-time optimisation according to, e.g., the changing traffic demand and requirements

ENI Use Case:

AI enabled network traffic classification



The challenges:

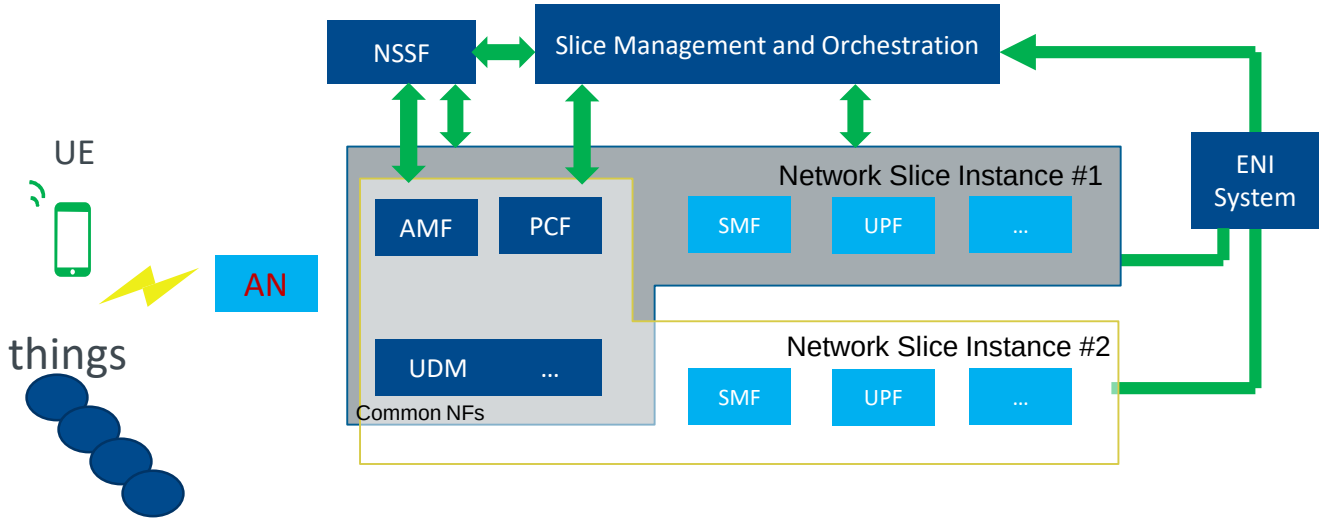
- Network traffic classification can support numerous network closed-loop control in terms of network security, traffic engineering, Quality of Service (QoS)
- By providing traffic change or distribution information at network or service level, classification results support policy-making processes and sever as the guideline for Operations support system (OSS) and traffic forecast.

The role of AI and ENI:

- Current classification methods cannot sufficiently (or fail to) support the growth in the diversity of applications, traffic volume and the proportion of encapsulated traffic
- AI enabled Network Traffic classifier transforms bit streams or extracted features into images and models the network traffic classification as the ‘traffic image’ classification.
- By collecting data at the transport level (instead of application level) and applying machine learning algorithms, the ENI system is able to achieve accurate classification result with a relatively low overhead.

ENI Use Case:

Intelligent Network Slicing Management



3GPP Functions

NSSF – Network Slice Selection Function
AMF – Access Management Function
AN – Access Network
SMF – Session management Function
UE – User Equipment
PCF – Policy Control Function
UDM – User Data Management
UPF – User Plane Function
NF – Network Function

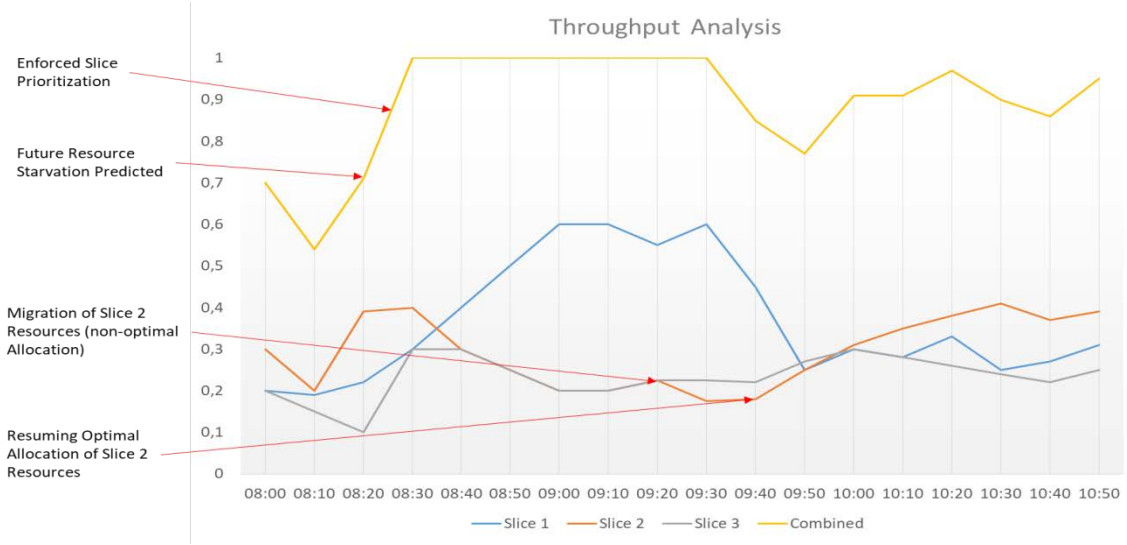
The challenges:

- Dynamic traffic
- Allocation of network resources intra/inter slices (VNF scale in/out, up/down)

The role of AI and ENI:

- Analyze collected data associated to e.g., traffic load, service characteristic, VNF type and constraints, infrastructure capability and resource usage, etc.
- Produce a proper context aware policy to indicate to the network slice management entity when, where and how to place or adjust the network slice instance (e.g., reconfiguration, scale-in, scale-out, change the template of the network slice instance)
- Dynamically change a given slice resource reservation

ENI Use Case:
Assurance of Service Requirements



The challenges:

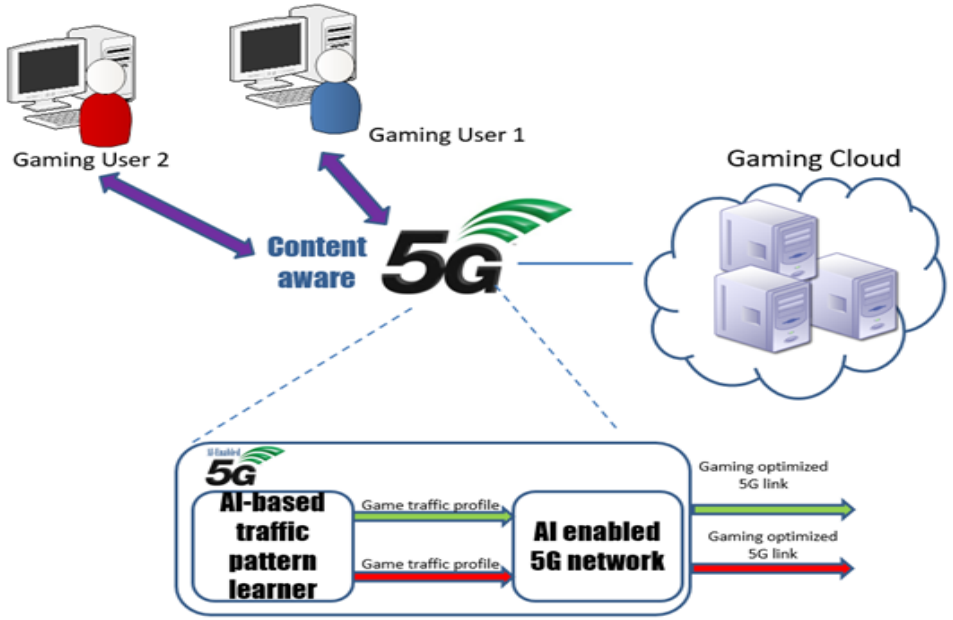
- Dedicated slice (e.g., banking, energy provider company)
- Vital applications of the network to operate core business
- Very strict requirements (e.g., a personalized SLA)

The role of AI and ENI:

- Predict situations where multiple slices are competing for the same physical resources and employ preventive measures
- Predict or detect requirements change and make decisions (e.g., increasing the priority of a given network slice over neighbouring slices) at run time

ENI Use Case:

Intelligent Content-Aware Real-Time Gaming Network



The challenges:

- Network latency plays a crucial role in user experience for a number of real time online games, as this can directly affect the performance of a player in these games
- Current 5G network does not have the signalling or protocol in place for end-to-end link optimization to the granularity of contents - different ‘genre’ of games

The role of AI and ENI:

- Bring generate tailor-made QoS requirements for each mobile gaming wireless link
- Smartly allocate radio resources to provide optimization on these links

Benefits

- Optimized energy and network resource usage
- Enhanced security
- Simplified operations
- Guaranteed services

The role of AI and ENI:

- Adaptive to changing context
- Enabling autonomous and policy driven operation
- Dynamic
- Real-time

Contact

Questions or interest in other use cases:

Contact: Yue Wang (Samsung UK)
yue2.wang@samsung.com

Thank you!

ENI Requirements and Terminology

Haining Wang (intel), Rapporteur, Requirements

Yu Zeng (China Telecom), Rapporteur, Terminology

Overview of ENI requirements Work Item

General information:

Creation Date:	2019-09-25	**Type:**	Group Specification
Work Item Reference:	RGS/ENI-0015	**Latest version:**	3.0.6
Rapporteur:	Haining Wang	**Technical Officer:**	Christine Mera

Scope:

The present document captures the requirements of how intelligence is applied to the network and applications in different scenarios to improve experience of service provision and network operation. Also, how intelligence enables dynamic autonomous behaviour and adaptive policy driven operation in a changing context. The ENI requirements are based on the ENI use case document and identified requirements from other SDOs. These requirements will form the base for the architecture design work. This work includes:

- Requirements derived from API descriptions
- Requirements derived from System Architecture
- Requirements derived from new use cases

Requirements

Level 1	Level 2
Service and network requirements	General requirements
	Service orchestration and management
	Network planning and deployment
	Network optimization
	Resilience and reliability
	Security and privacy

Level 1	Level 2
Functional requirements	Data collection and analysis
	Policy management
	Data learning
	Interworking with other systems
	Mode of operations
	Model training and iterative optimization
	API requirements

Level 1	Level 2
Non-functional requirements	Performance requirements
	Operational requirements
	Regulatory requirements

Source: ETSI RGS/ENI-007 , Experiential Networked Intelligence (ENI); ENI Requirement – Wang, Haining (China Telecom)

Overview of ENI Work Item - Terminology

General information:

Creation Date:	2019-11-08	**Type:**	Group Report
Work Item Reference:	RGR/ENI-0018	**Latest version:**	3.0.4
Rapporteur:	Yu Zeng	**Technical Officer:**	Christine Mera

Scope:

The WI will provide terms and definitions used within the scope of the ISG ENI, in order to achieve a "common language" across all the ISG ENI documentation. This work item will be updated with the general terminology required as the ENI specifications develop.

Work Plan and Next Steps

ENI Requirements – Release 2

- Early draft: October 2019
- Stable draft: November 2020
- Draft for approval: December 2020
- Published: March 2021

Contact Details:
Haining Wang
(Intel)
haining.wang@intel.com

ENI Terminology – Release 2

- Early draft: November 2019
- Stable draft: November 2020
- Draft for approval: December 2020
- Published: March 2021

Contact Details:
Yu Zeng
(China Telecommunications)
zengyu@chinatelecom.cn

Thank you!

ENI Intelligent Policy Management

Dr. John Strassner, (Huawei), Rapporteur, Context-Aware Policy Management

Overview of ENI Work Item – Context Aware Gap-Analysis

General information:

Creation Date:	2017-04-10	**Type:**	Group Report
Work Item Reference:	DGR/ENI-003	**Latest version:**	1.1.1
Rapporteur:	John Strassner	**Technical Officer:**	Sylwia Korycinska

Scope:

A critical foundation of experiential networked intelligence is context- and situation-awareness. This WI will analyze work done in various SDOs on network policy management in general, and context-aware network policy management specifically, to determine what can be reused and what needs to be developed. The requirements documented in this report will be considered during the architecture design work.

Main Contents of the Context-Aware Policy Management WI

Content

- Introduction and Approach
  - Including Introduction to Policy Management, The Policy Continuum, Types of Policy Paradigms, etc.
- Analysis of the MEF PDO Model
  - Including Characteristics, Supported Policy Paradigms, Imperative/Declarative/Intent Policy, etc.
- Analysis of the IETF SUPA policy Model
  - Characteristics, Supported Policy Paradigms, etc.
- Analysis of the TM Forum SID Policy Model
  - Characteristics, Supported Policy Paradigms, etc.

The Policy Continuum

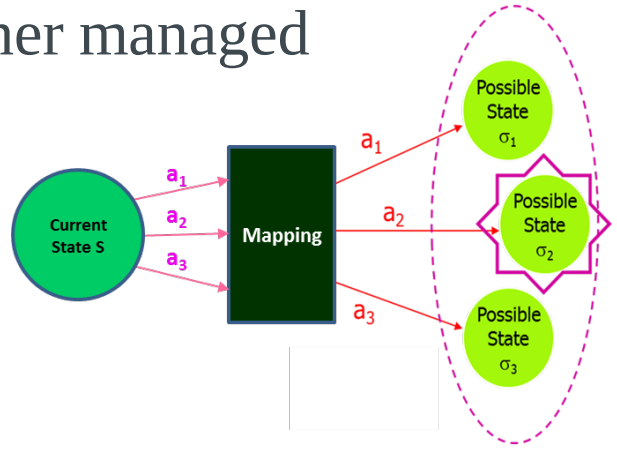
The number of continua in the Policy Continuum should be determined by the applications using it. There is no fixed number of continua.

Policy Examples: Intent

Intent policies describe the set of computations that need to be done without describing how to execute them

- Policies are written in a *restricted natural language*
- The flow of control is *not* specified
- *The order in which operations occur are irrelevant*
- Each statement in an Intent Policy may require the translation of one or more of its terms to a form that another managed functional entity can understand.

Express **What** should be done, not **How** to do it.



Intent policy is an ongoing work in MEF, ENI may reuse some of the output

Work Plan and Next Steps

The report had been published:
GR ENI 003 v1.1.1 “Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis”

Contact: Dr. John Strassner (FutureWei)
strazpdj@gmail.com

Thank you!

Experiential Networked Intelligence *System Architecture*

Dr. John Strassner (FutureWei, Rapporteur)

Overview of ENI Work Item – System Architecture

General information:

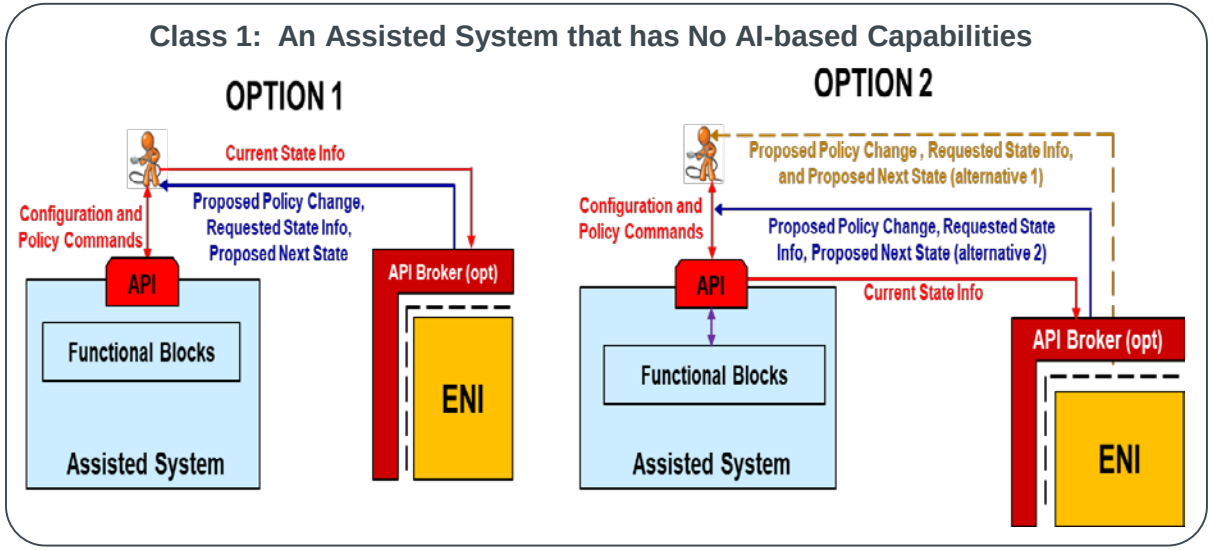
Creation Date:	2019-09-30	**Type:**	Group Specification
Work Item Reference:	DGS/ENI-0016	**Latest version:**	2.0.18
Rapporteur:	John Strassner	**Technical Officer:**	Christine Mera

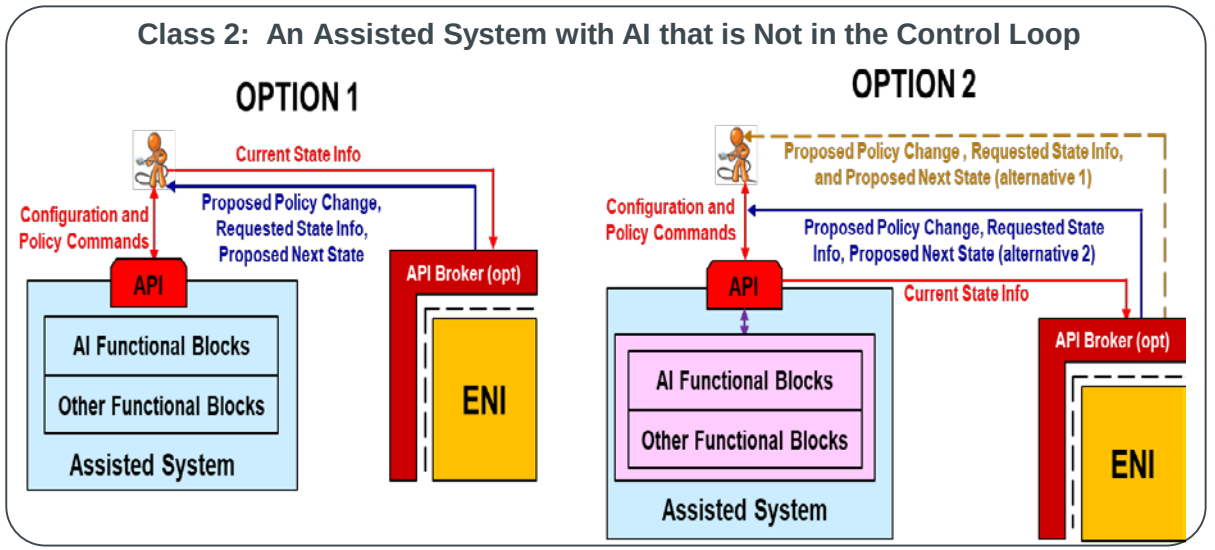
Scope:

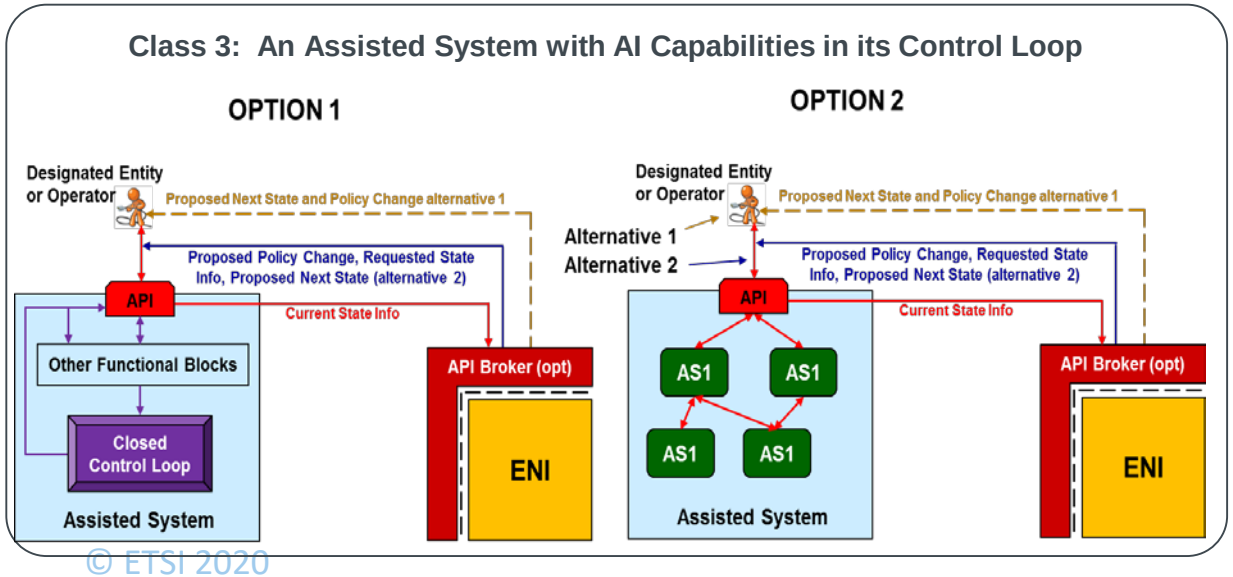
The purpose of this work item is to define the software functional architecture of ENI. This includes:

- defining the functions and interactions that satisfy the ENI Requirements
- defining an architecture, in terms of functional blocks, that can meet the needs specified by the ENI Use Cases
- defining Reference Points that the above functional blocks use for all communication with systems and entities

ENI System Architecture - Mode of Operation and Class

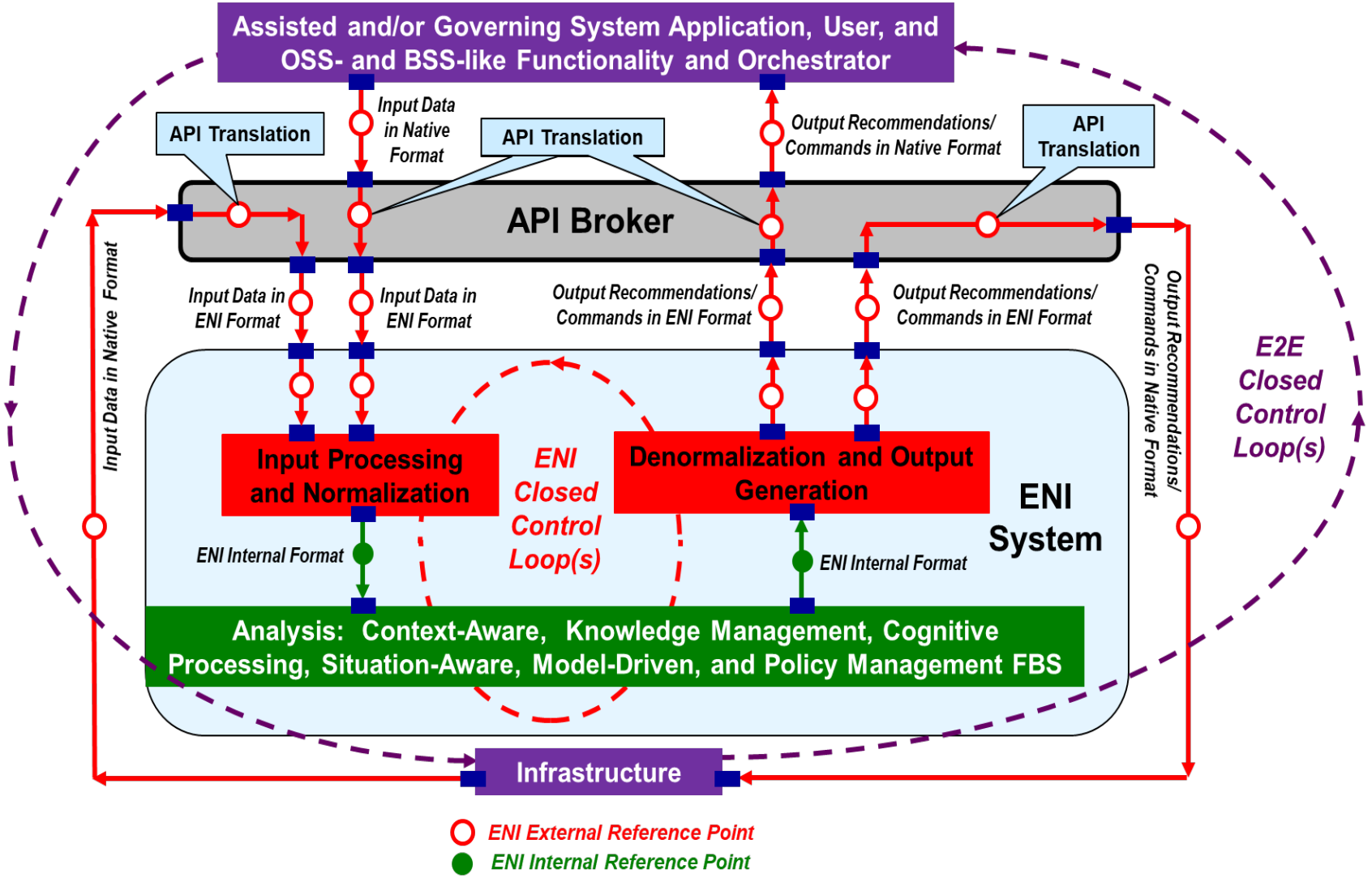






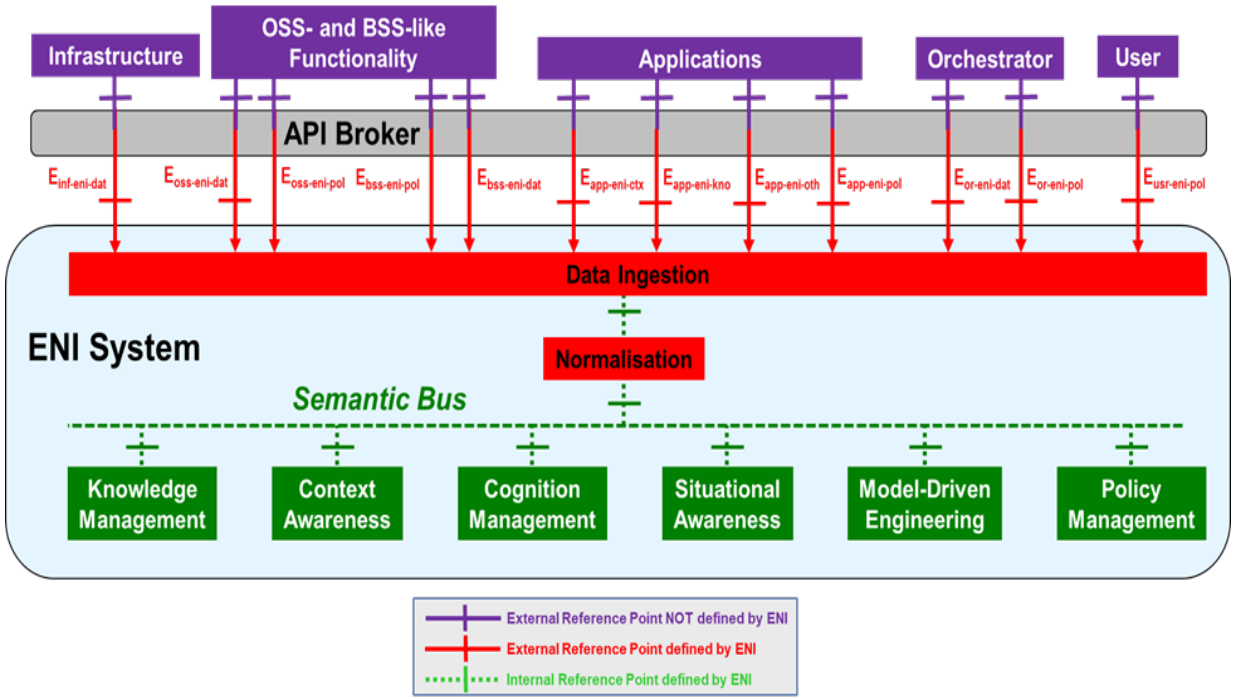
- In each case, ENI requires data from the Assisted System.
- Changes to the Assisted System are not required for any class of Assisted System in order to facilitate the use and rapid adoption of ENI.
- ENI shall use the API Broker to mediate between ENI and the Assisted System
- ENI provides actionable decisions back to the assisted system (autonomous or recommendatory)
- ENI monitors the effect

ENI High-Level Functional Architecture

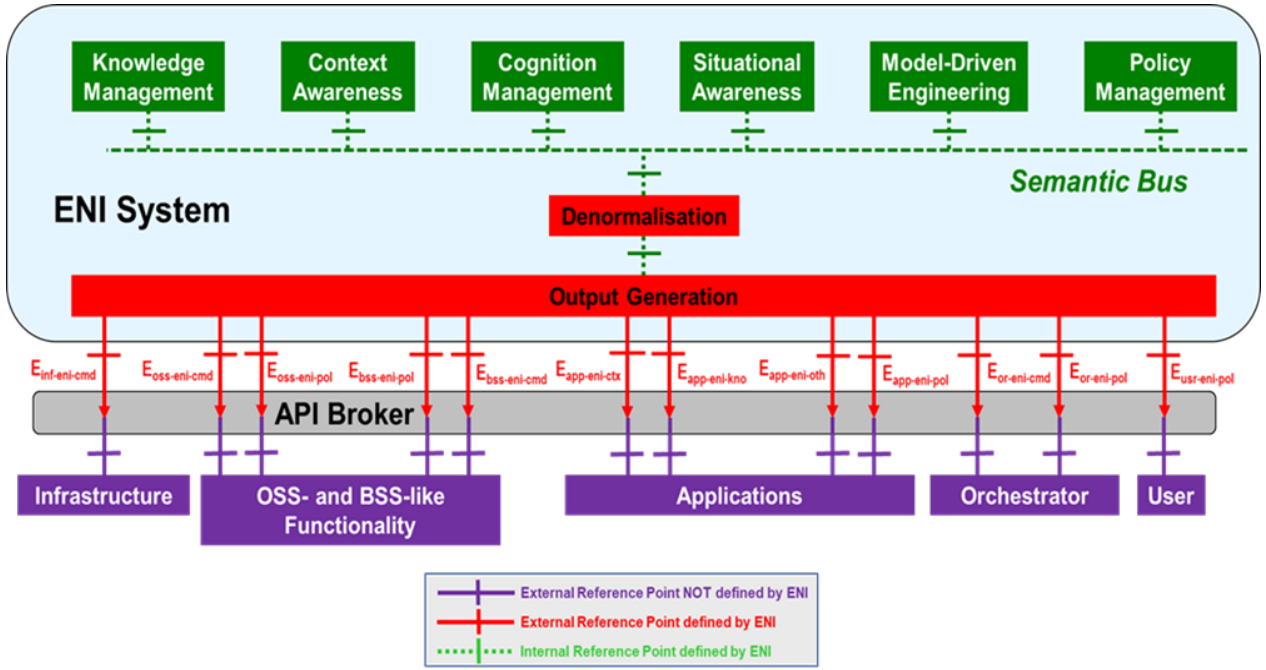


High-Level Functional Architecture Diagram in DGS/ENI-005 (GS ENI 005) v1.1.1

Architecture External Reference Points (Inputs & Outputs)



Functional Architecture with its Input Reference Points

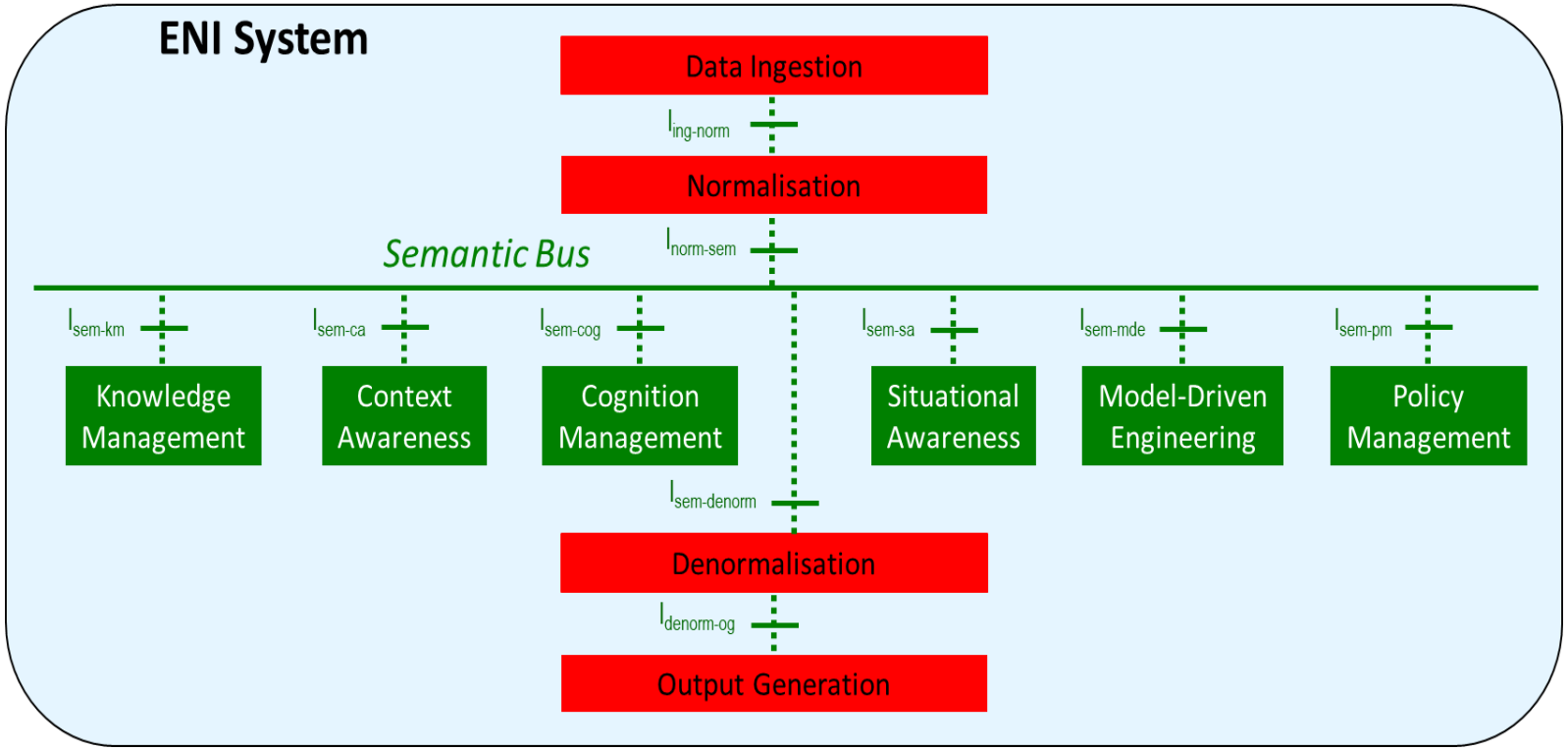


Functional Architecture with its Output Reference Points

Imperative, Declarative, and Intent Policies *are handled within the same architecture, with no additional RP or FB needed*

Source: ETSI GS ENI 005 , ENI System Architecture

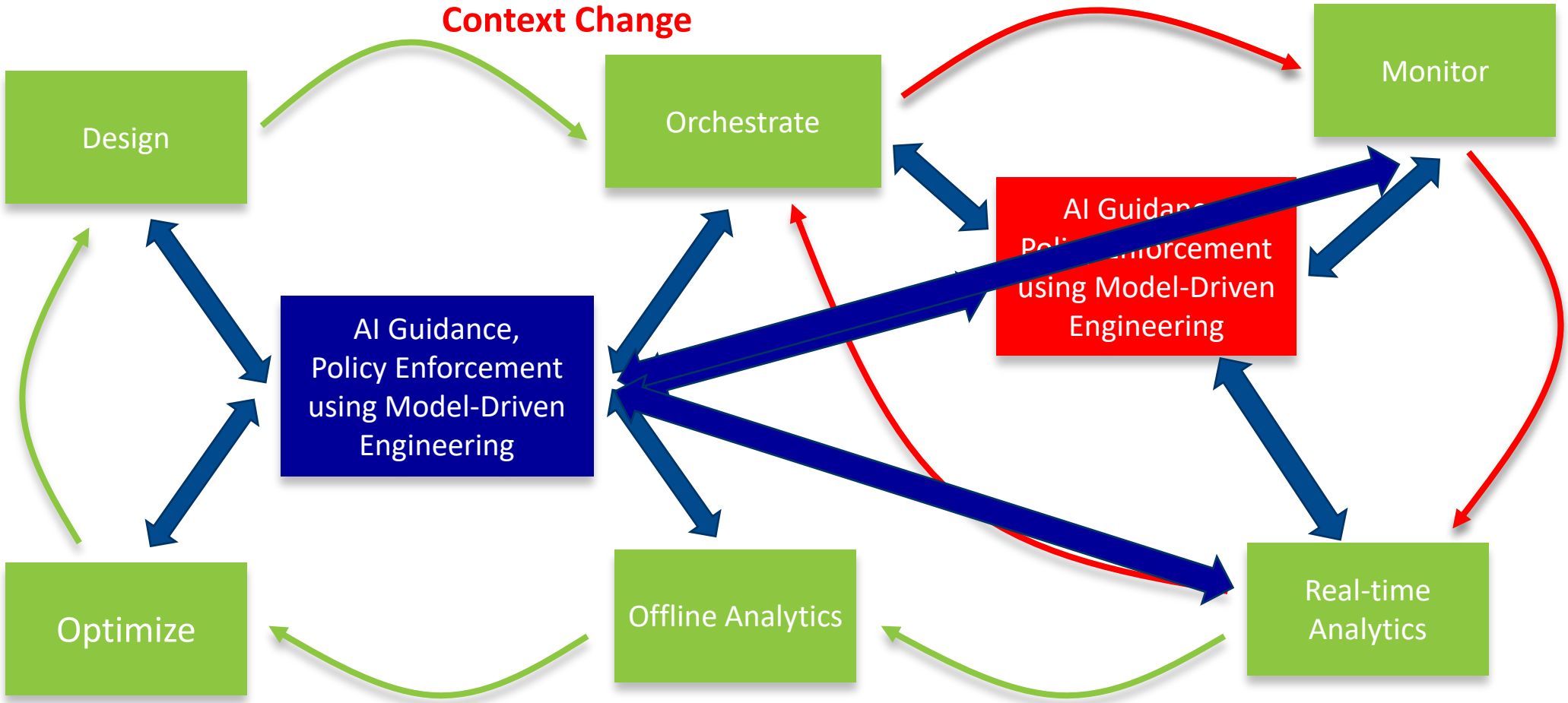
Architecture Internal Reference Points



Source: ETSI GS ENI 005 , ENI System Architecture

Closed Loop Control in FOCALE

1. **Outer Closed Control Loop for a Given Context and Long-Term Optimization**
2. **Inner Closed Control Loop Triggered by Context Change**



Knowledge Management & Context-Aware Management

Functional Blocks

Knowledge Management

The purpose of the Knowledge Management Functional Block is to represent information about both the ENI System as well as the system being managed. Knowledge representation is fundamental to all disciplines of modelling and AI. It also enables machine learning and reasoning – without a formal and consensual representation of knowledge, algorithms cannot be defined that reason (e.g., perform inferencing, correct errors, and derive new knowledge) about the knowledge. Knowledge representation is a substitute for the characteristics and behaviour of the set of entities being modelled; this enables the computer system to plan actions and determine consequences by reasoning using the knowledge representation, as opposed to taking direct action on the set of entities.

There are many examples of knowledge representation formalisms, ranging in complexity from models and ontologies to semantic nets and automated reasoning engines.

Context-Aware Management

The purpose of the Context-Aware Management Functional Block is to describe the state and environment in which an entity exists or has existed. Context consists of measured and inferred knowledge, and may change over time. For example, a company may have a business rule that prevents any user from accessing the code server unless that user is connected using the company intranet. This business rule is context-dependent, and the system is required to detect the type of connection of a user, and adjust access privileges of that user dynamically.

Situation-Awareness Management

Functional Block

The purpose of the Situation Awareness Functional Block is for the ENI system to be aware of events and behaviour that are relevant to the environment of the system that it is managing or assisting. This includes the ability to understand how information, events, and recommended commands given by the ENI system will impact the orchestration and operational goals and behavior, both immediately and in the near future. Situation awareness is especially important in environments where the information flow is high, and poor decisions may lead to serious consequences (e.g., violation of SLAs).
The working definition of situation awareness for ENI is:

The perception of data and behaviour that pertain to the relevant circumstances and/or conditions of a system or process ("the situation"), the comprehension of the meaning and significance of these data and behaviours, and how processes, actions, and new situations inferred from these data and processes are likely to evolve in the near future to enable more accurate and fruitful decision-making.

Cognition Management

Functional Block

Cognition, as defined in the Oxford English Dictionary, is “the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses”.
The purpose of the Cognition Framework Functional Block is to enable the ENI system to understand ingested data and information, as well as the context that defines how those data were produced; once that understanding is achieved, the cognition framework functional block then provides the following functions:

- change existing knowledge and/or add new knowledge corresponding to those data and information
- perform inferences about the ingested information and data to generate new knowledge
- use raw data, inferences, and/or historical data to understand what is happening in a particular context, why the data were generated, and which entities could be affected
- determine if any new actions should be taken to ensure that the goals and objectives of the system will be met.

A cognition framework uses existing knowledge and generates new knowledge.

A cognition framework uses multiple diverse processes and technologies, including linguistics, computer science, AI, formal logic, neuroscience, psychology, and philosophy, along with others, to analyse existing knowledge and synthesise new knowledge

Model Driven Engineering

Functional Block

The Model Driven Engineering (MDE) Functional Block is responsible for enabling software development to be accomplished using models that generate code. MDE represents an approach to software development where models are used in the understanding, design, implementation, deployment, operation, maintenance and modification of software systems. The advantage of MDE is that models are, by definition, machine-readable. Hence, they can be used to specify Functional Blocks, programs, and applications.

A set of models may be defined based on different viewpoints. Formally, a viewpoint is an abstraction of the function and behaviour of a system using a selected set of architectural concepts; this facilitates focusing on a particular aspect or set of responsibilities of the system. ENI defines a number of viewpoints, including business, system, and implementation. Model transformation tools and services are used to align the different models (e.g. deriving a set of data models from an information model), and for generating code.

The function of the MDE Functional Block is to decide how to implement the selected actions from the Situational Awareness Functional Block. It uses model-driven engineering mechanisms to convert the actions into a form that enables imperative, declarative, and/or intent policies to be constructed (by the Policy Management Functional Block).

Policy-based Management

Functional Block

The purpose of the Policy Management Functional Block is to provide decisions to ensure that the system goals and objectives are met. Formally, the definition of policy is:

Policy is a set of rules that is used to manage and control the changing and/or maintaining of the state of one or more managed objects.

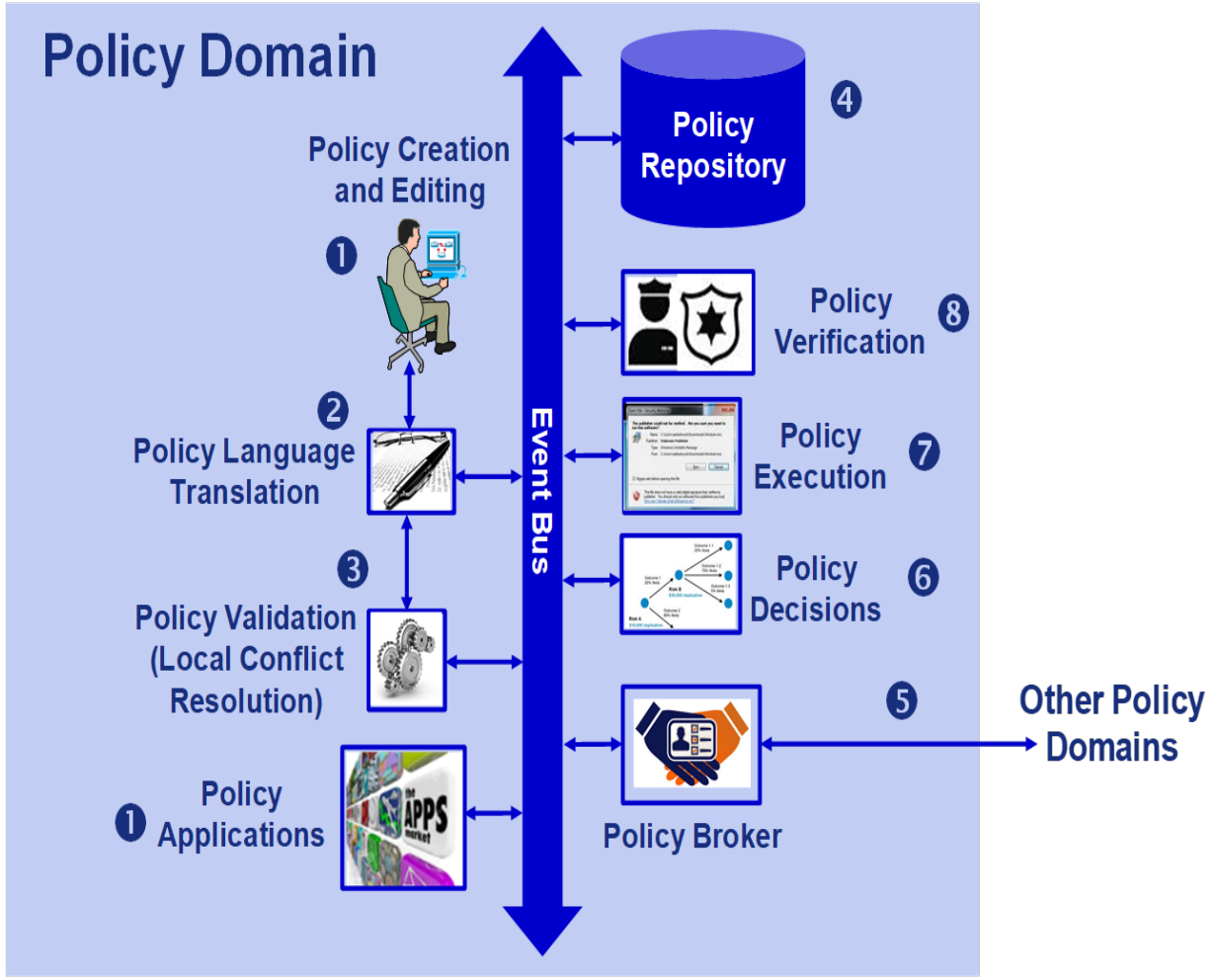
There are three different types of policies that are defined for an ENI system:

- **Imperative policy:** a type of policy that uses statements to explicitly change the state of a set of targeted objects. Hence, the order of statements that make up the policy is explicitly defined.
  In this document, Imperative Policy will refer to policies that are made up of Events, Conditions, and Actions.
- **Declarative policy:** a type of policy that uses statements to express the goals of the policy, but not how to accomplish those goals. Hence, state is not explicitly manipulated, and the order of statements that make up the policy is irrelevant.
  In this document, Declarative Policy will refer to policies that execute as theories of a formal logic.
- **Intent policy:** a type of policy that uses statements to express the goals of the policy, but not how to accomplish those goals. Each statement in an Intent Policy may require the translation of one or more of its terms to a form that another managed functional entity can understand.
  In this document, Intent Policy will refer to policies that do not execute as theories of a formal logic. They typically are expressed in a restricted natural language, and require a mapping to a form understandable by other managed functional entities.

An ENI system MAY use any combination of imperative, declarative, and intent policy to express recommendations and commands to be issued to the system that it is assisting.

Exemplary Policy Elements

High-level functional block diagram of a Policy Domain, as defined in the MEF PDO Architecture



ENI PoC Framework

Bill Wright (Redhat/IBM)

GS ENI 006 - ENI PoC Framework

General information:

Creation Date:	2018-12-20	**Type:**	Group Specification
Work Item Reference:	DGS/ENI-0012	**Latest version:**	2.1.1
Rapporteur:	Bill Wright	**Technical Officer:**	Christine Mera

Scope:

This Work Item specifies a framework for use within ETSI ENI ISG to coordinate and promote public demonstrations of Proof of Concept (PoC) validating key technical components developed in ENI.

The objective for the PoCs is to build commercial awareness and confidence and encourage development of an open ecosystem by integrating components from different players.

This framework outlines: rationale for ENI ISG PoCs; ENI ISG PoC process; submission, format and criteria for ENI ISG PoC Proposals; review and acceptance criteria of PoC Proposals; ENI ISG PoC Report format and requirements; ETSI support for PoC team.

https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=57071

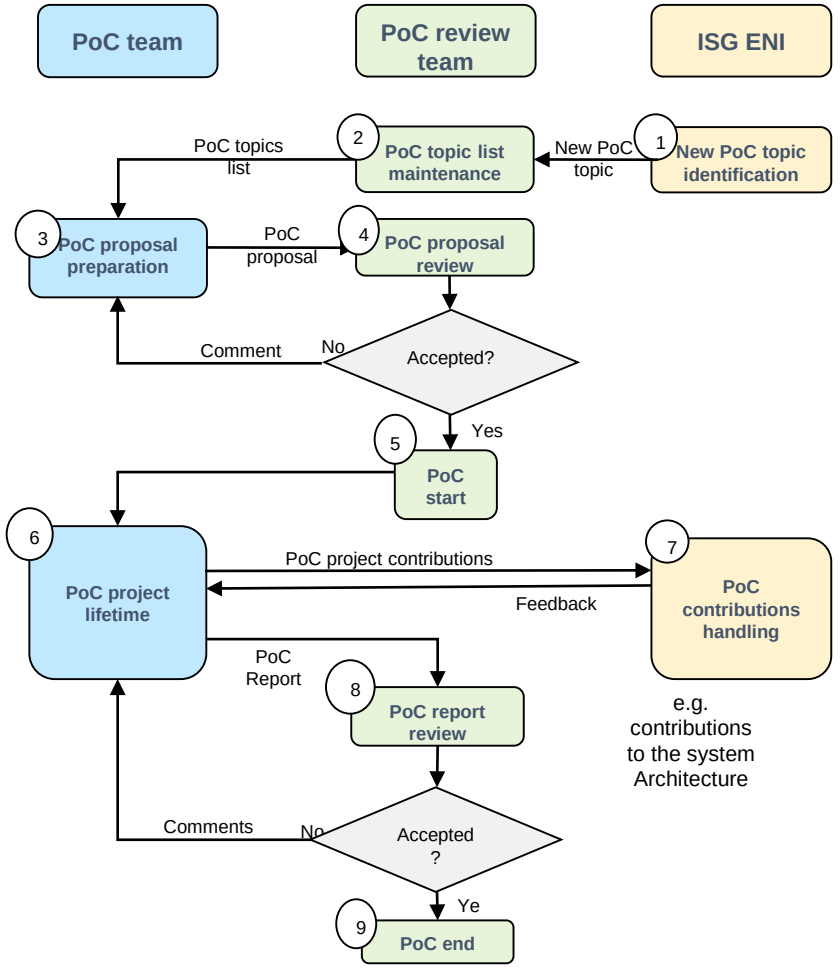
PoC Team and ENI Work-Flow proposal

using the process under definition in ETSI

Procedures:

- ISG ENI approve & published a PoC framework
- Form a PoC review group to receive and review PoC proposals with formal delegation from ISG
- Publish the PoC proposals (on ETSI Portal wiki) according to the PoC framework
- PoC teams (the proposers – which may include non-members) shall present an initial proposal and a final report, according to the templates given by ISG for review
- PoC Team(s) are independent of the ISG – use the process and template of the ISG – Choose a POC Team Leader and draft the proposal

ENI PoC review team:



PoC project wiki: https://eniwiki.etsi.org/index.php?title=Ongoing_PoCs

Definition of Categories for AI Application to Networks

Luca Pesando (TIM), Rapporteur

GR ENI 007 - Overview of ENI Work Item – Definition of Network Networked Intelligence Categorization

General information:

Creation Date:	2018-9-19	**Type:**	Group Report (GR)
Work Item Reference:	DGR/ENI-0011	**Latest version:**	1.1.1
Rapporteur:	Luca Pesando	**Technical Officer:**	Christine Mera

Scope:

This Work Item will address the aspects of gradual implementation of networked intelligence and specify a categorization framework for systems based on several different levels (e.g. 5, ranging from fully manual to fully autonomic systems as written in ENI whitepaper). This categorization framework will be based on the amount of network engineer intervention and attentiveness required and the expected interfaces with the assisted system. The details of each level will be defined according to scenarios supported and techniques needed.

Categorization of Network Intelligence

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 RGS/ENI-011 , Experiential Networked Intelligence (ENI); ENI Definition of Categories for AI Application to Networks – Luca Pesando *(TIM)*

Intent Aware Network Autonomicity

Yannan Bai(China Telecom), Rapporteur

GR ENI 008 - Overview of ENI Work Item – Intent Aware Network Autonomicity

General information:

Creation Date:	2019-06-25	**Type:**	Group Report
Work Item Reference:	DGR/ENI-0013	**Latest version:**	0.0.21
Rapporteur:	Yannan Bai	**Technical Officer:**	Christine Mera

Scope:

This Work Item will describe the motivation, requirements, and key issues of using intent policies to manage the operation of networks and networked applications in various domains. This Work Item will explore how to define and use intent policies. Options include (1) define intent using a Controlled Language and translate that to software, (2) define intent using a Controlled Language and translate that to a DSL, (3) define intent using a DSL and translate that to software, or (4) use a DSL to define and use intent.

This document will discuss various design options, in terms of a set of new stand-alone and/or nested Functional Blocks, for using intent with the ENI System Architecture. This includes accepting and validating intent statements, determining how intent affects the goals and operation of the ENI system, and how it is used by business users, application developers, and network administrators. The recommendations and conclusions of this report will be contributed to other ENI group specifications.

http://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=58217

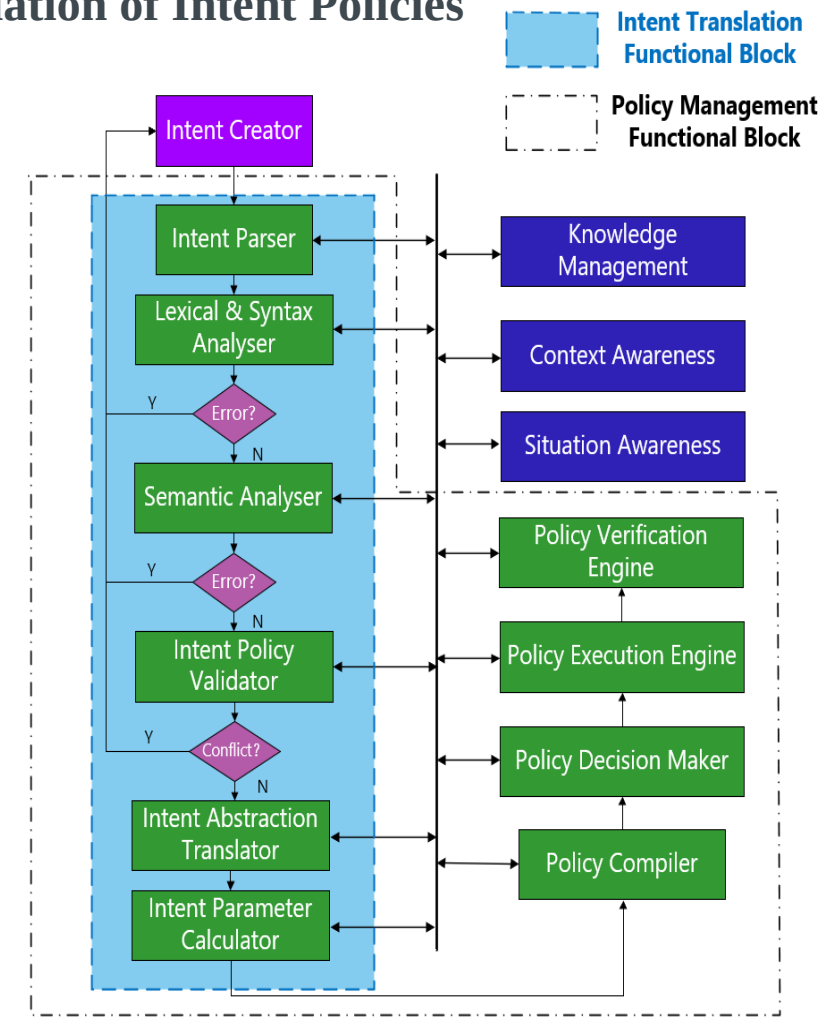
Main Contents of the Intent Aware Network Autonomicity GR

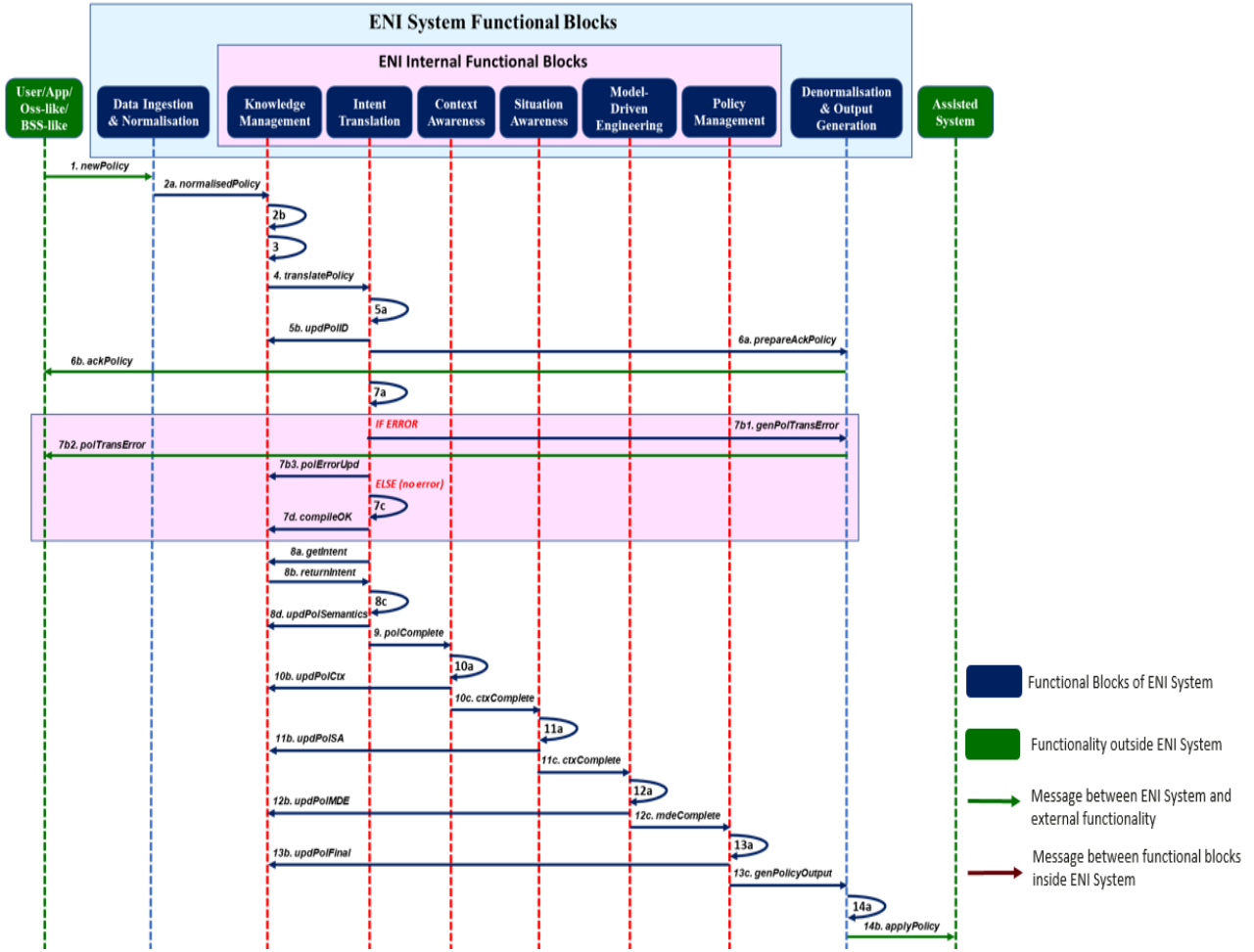
Content

- Introduction
  - ✓ Including definition of Intent Policy, background, etc.
- Description of Intent Policies
  - ✓ Including Translation of Intent Policy, Fulfillment of Intent Policy, etc.
- Use Cases of Intent Policy
  - ✓ Context-aware VoLTE Service Experience Optimization, Use Case in NFV domain, Intent Based Energy Saving, etc.
- Requirements of Using Intent Policies

Process of Intent Policy Translation and Implementation

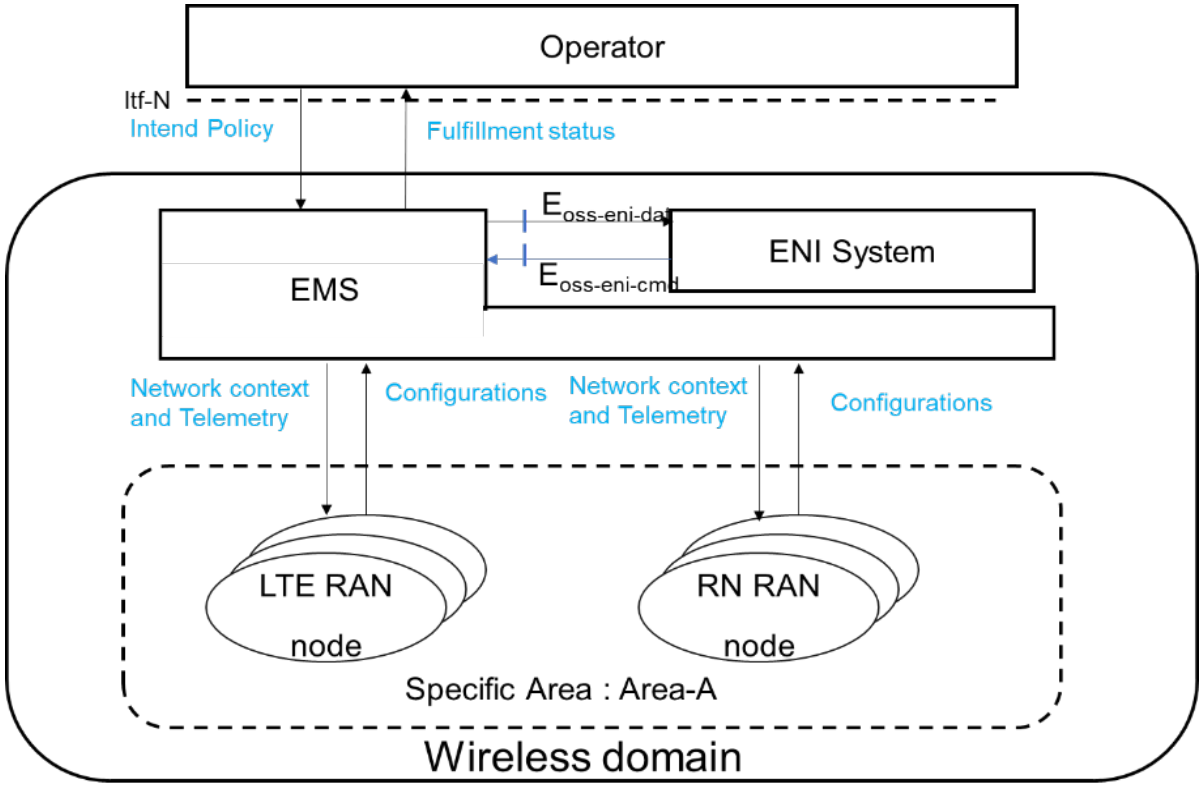
Translation of Intent Policies



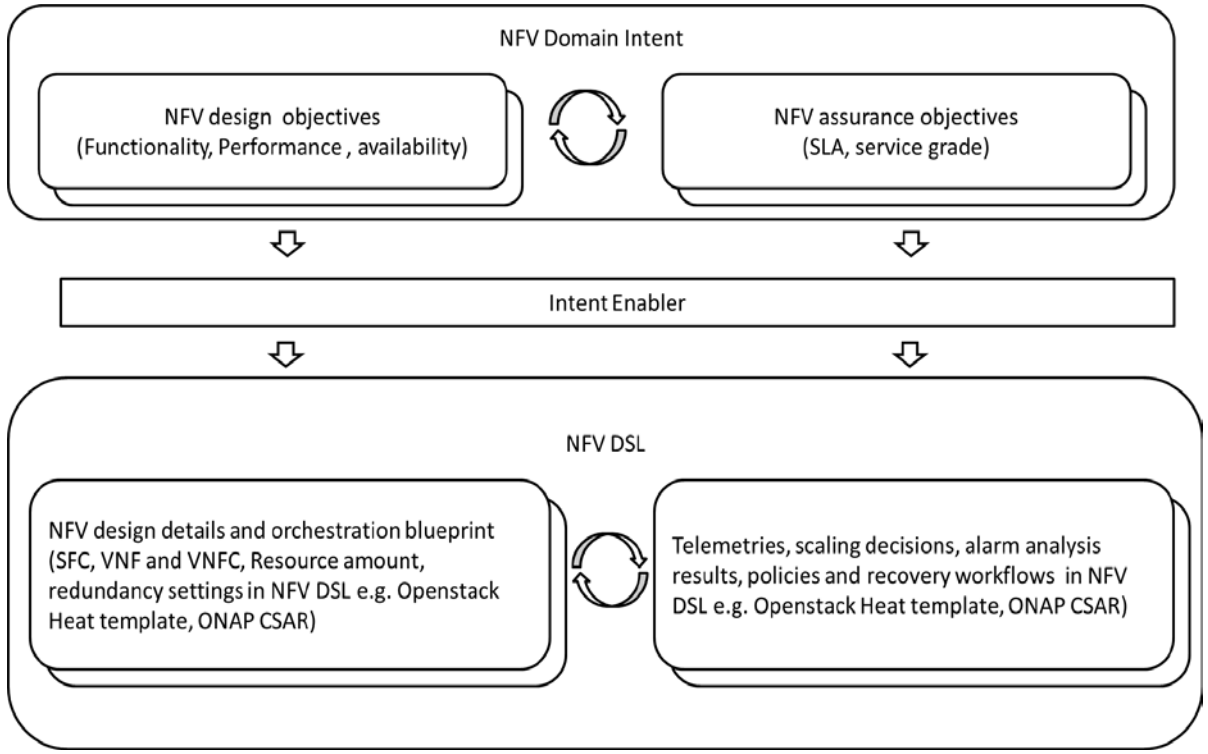


Message Sequence Diagram of Intent Translation

Use Cases of Intent Awareness



Context-aware VoLTE Service Experience Optimization



Use of intent in NFV domain

Work Plan and Next Steps

- Early draft: Jul. 2019
- Stable draft: Nov. 2020
- Draft for approval: Dec. 2020

Contact Details:
Yannan Bai
(China Telecommunications)
baiyn6@chinatelecom.cn

Thank you!

ENI Data Mechanisms

LiWeiYuan (China Mobile)

Overview of ENI Work Item – ENI Data Mechanisms

General information:

Creation Date:	2019-09-26	**Type:**	Group Report
Work Item Reference:	DGR/ENI-0017	**Latest version:**	0.0.8
Rapporteur:	Weiyuan Li	**Technical Officer:**	Christine Mera

Scope:

The realization of intelligent network depends on the big data, AI algorithms and computing resources. Therefore, effective data management and operation is extremely important. This work item is purposed to draft a GR of data operation requirements and mechanisms to better serve ENI system. This WI mainly includes the following aspects:

(1) Data classification, including classifying of the data sources in terms of domains (e.g., RAN, Core), methods (e.g., raw data, filtered data), purposes (data for training and validation), and characteristics (static data, sequential data), based on which different data format and data collection and storage methods will be defined.

(2) Data operation, including data collection, data storage, data usage and data sharing.

- Data collection, including description about collection methods, e.g. sampling, data twining, and collection requirements, e.g. sampling frequency
- Data storage, including mode of storage, data storage formats, etc.
- Data usage, including data usage for model training and model validation, and procedure of data processing including anonymous processing and normalization.
- Data sharing, including objects of sharing, methods of sharing, etc.

(3) Data requirements of the selected use cases proposed in ENI 001 for ENI systems executing intelligent tasks, including data type, data format, data quality, etc.

https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=58649

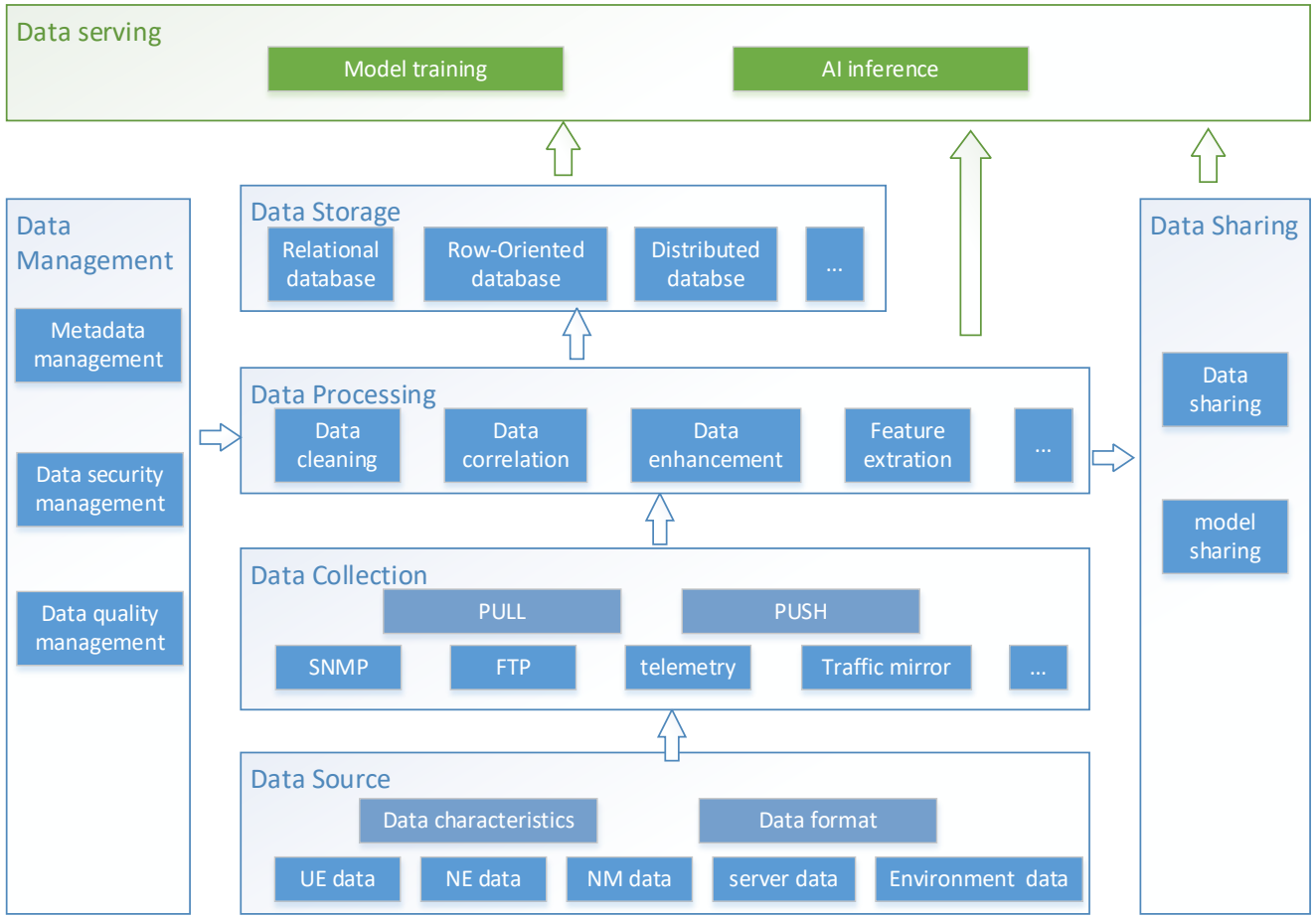
Main Contents of the Data Mechanisms WI

Content

- Overview
  - ✓ Present background and motivation of this work, etc.
- Data Mechanism Framework
  - ✓ Define components in the high-level framework of the data mechanism including data acquiring and data processing. And this clause classifies different types of data in terms of the data sources, data characteristics, and data format, as well as describes data processing mechanisms, such as data storage, usage and sharing, in order to support AI enabled network operation and service management.
- Data Mechanism in Example Scenarios
  - ✓ Present Data requirements of the selected use cases proposed in ENI 001 for ENI systems executing intelligent tasks, including data type, data format, data quality, etc.
- Recommendations to other ENI Work Items
  - ✓ Present possible contributions to other ENI Work Items.

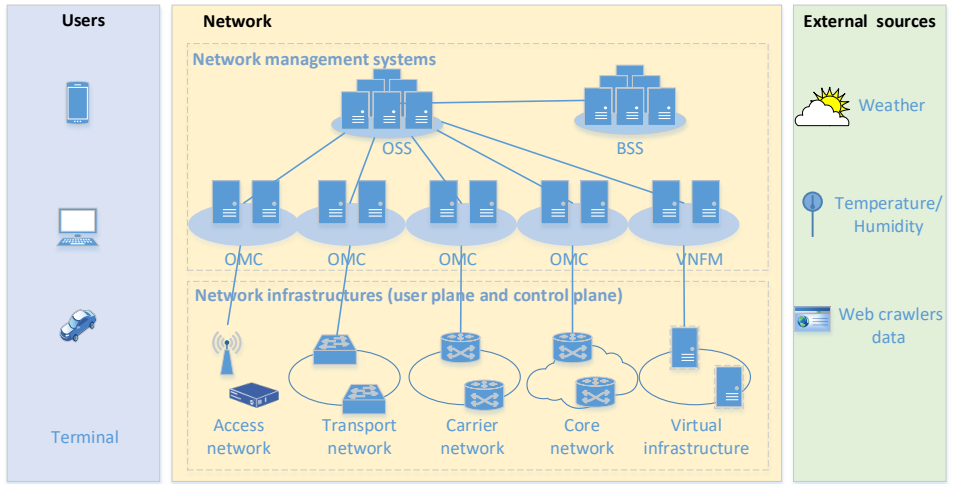
Main Contents of the Data Mechanisms WI

Components in the Data Mechanism Framework

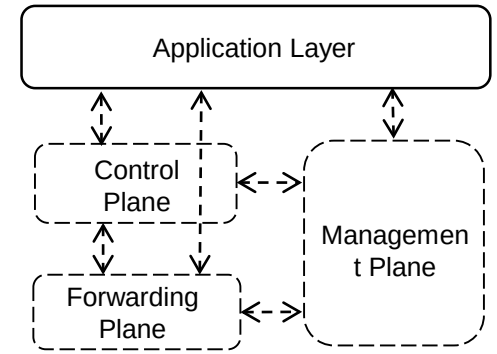


Data Sources

Data Sources Category

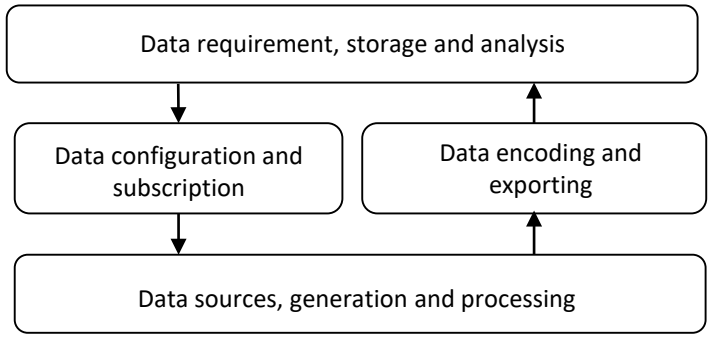


Data source in network plane category



Main Contents of the Data Mechanisms WI

Network Telemetry



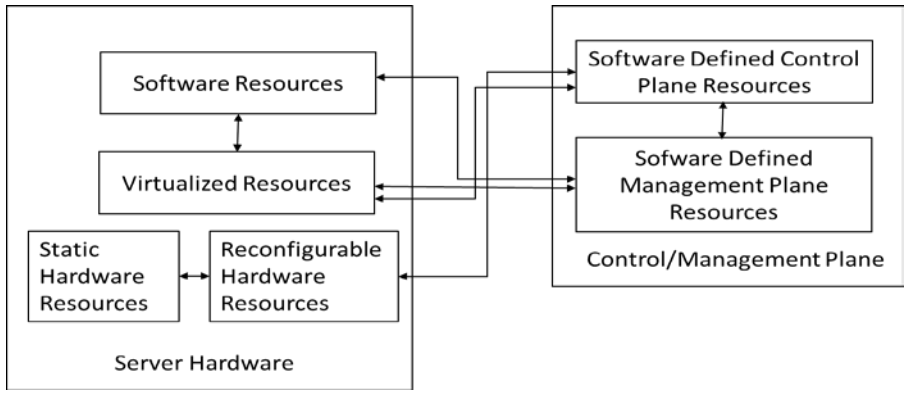
✓**Data requirement, storage and analysis**: this component issues data requirements.

✓**Data configuration and subscription**: this component configures the protocol and channel to acquire desired data

✓**Data sources, generation and processing:** determines the telemetry object which generates the requested data to be captured, processed, and formatted in the network devices from raw data sources.

✓**Data encoding and exporting:** responsible for determining methods of data delivery

Resource Telemetry



four resource descriptions within the server hardware:

✓**Data Collection from Static Hardware Resources**

✓**Data Collection from Reconfigurable Hardware Resources**

✓**Data Collection from Virtualized Resources**

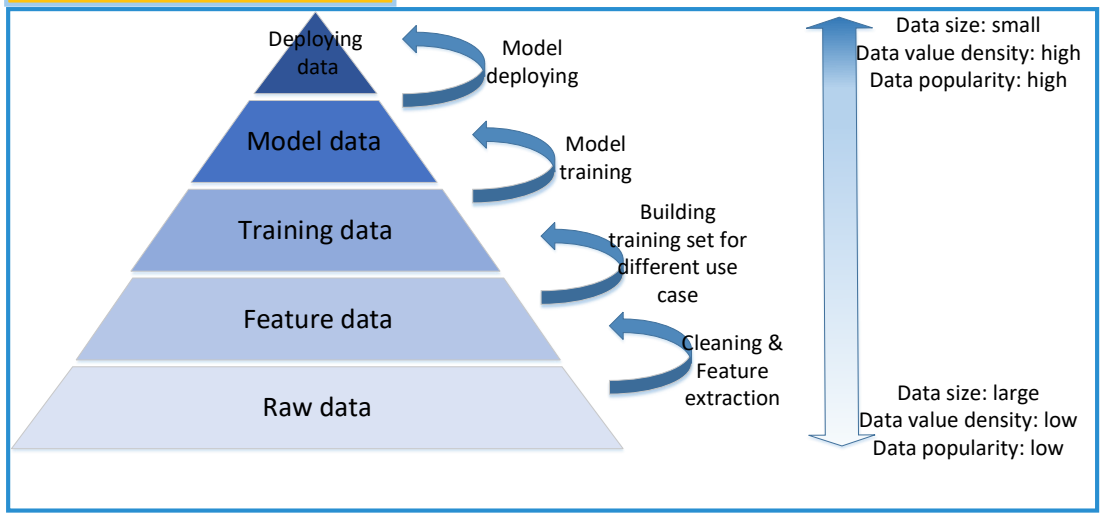
✓**Data Collection from Software Resource**.

the control and management:

✓**Data Collection from Control & Management Plane Resources**

Main Contents of the Data Mechanisms WI

Data Storage



Data Correlation

- ✓Scenario #1：Correlate data from different geographic locations
- ✓Scenario #2：Correlate data from different network domains.
- ✓Scenario #3：Correlate data from different reference points.
- ✓Scenario #4：Correlate data from different professional systems.
- ✓Scenario #5：Correlate multiple types of data.
- ✓Scenario #6：Correlate data in multiple databases
- ✓Scenario #7：Correlate multi-modal data.

Data Cleansing

Purpose	"Dirty" data	How to detect	How to process
Data accuracy	Abnormal data	Deviation analysis/ using rule libraries	Replace the outliers with the mean
Data integrity	Incomplete data	Detect missing or null values	Fill in the missing information by inferring from other information or by smooth processing Remove
Data consistency	Inconsistent data	Consistency check according to the reasonable range and relationship of each variable	Correct Remove
Data uniqueness	Duplicate data	Determine whether the values are equal	Remove
Data validity	Irrelevant data	Detect invalid value according to the rules and detect irrelevant data by correlation analysis	Remove

Main Contents of the Data Mechanisms WI

Data Sharing

✓directly sharing the collected data or raw data

✓sharing AI model or algorithm, or parameters

Data Management

✓Meta-data management is the set of processes that ensure proper creation, storage, integration, and control to support associated usage of meta-data.

✓Data security management is the planning, development, and execution of security policies and procedures to provide proper authentication, authorization, access, and auditing of data and information assets

✓Data quality management is a procedure which consistently improves data to guarantee and satisfy the requirement of data.

Data Mechanism in Example Scenarios

Description requirements of data processing in the selected use cases proposed in ENI 001, supporting analysis in ENI System, e.g., data cleansing, data correlation, etc.

✓AI-enabled Traffic Classification

✓Network Fault Root-Cause Analysis and Intelligent

✓Intelligent Service Experience Evaluation

Work Plan and Next Steps

- Early draft: November 2019
- Stable draft: December 2020
- Draft for approval: December 2020

Contact Details:
Weiyuan Li
(China Mobile)
liweiyuan@chinamobile.com

Evaluation of Categories for AI application to Network

Bingming Huang (China Unicom)

GR ENI 010 - Overview of ENI Work Item – **Evaluation of Categories for AI application to Network**

General information:

Creation Date:	2019-12-12	**Type:**	Group Report (GR)
Work Item Reference:	DGR/ENI-0020	**Latest version:**	0.0.8
Rapporteur:	Bingming Huang	**Technical Officer:**	Christine Mera

Scope:

The purpose of this work item is to specify quantitative evaluation criteria of network autonomicity categories, which are defined in the published GR ENI 007. This WI is composed of three components:

(1) to further specify the details of the existing categories including quantitative factors for 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.

Framework of quantitative evaluation process

The general process of evaluating categories of AI application to network includes five steps:

1. The Identification of the Evaluation Object

To evaluate a production system, two dimensions needs to be analyzed:
Network Resource Lifecycle: analysing the autonomy of the operative processes aiming network resource management
E2E Service Lifecycle: analysing the autonomy of the operative processes aiming at e2e service management from a customer point of view

2. The Division of the Evaluation Dimension

According to the Definition of categories for AI application to networks WI , when evaluating an object, it can be divided into five dimensions such as ManMachine Interface, Decision Making Participation, Data Collection and Analysis , Degree of intelligence and Environment adaptability,

3. The Analysis of the Evaluation Object

After defining the evaluation dimensions of the evaluation object, each evaluation dimension should be divided into several quantifiable indices

4. The Scoring of the Evaluation Dimension

Score each dimension in accordance with the defined scoring principles

5. The Acquisition of the Evaluation Result

To obtain a final score, a weighted average have to be performed

- The Autonomy of a Network depends either on technical solution and on the delegation of responsibility from the Operator to the AN
- Proper real time information flow, Digital Twin and AI are enabler to generate Recommendations and grow Knowledge Base
- Operator's trust in the recommendations from the AN is an enabler to delegate more responsibility to the Network itself growing Autonomous Level

Work Plan and Next Steps

- Early draft: March 2020
- Stable draft: December 2020
- Draft for approval: December 2020

Contact Details:
Bingming Huang
(China Unicom)
huangbm7@chinaunicom.cn

Thank you!

Mapping between ENI architecture and operational systems

Yannan Bai(China Telecom), Rapporteur

GS ENI 0011 - Overview of ENI Work Item – Mapping between ENI architecture and operational systems

General information:

Creation Date:	2019-12-12	**Type:**	Group Specification
Work Item Reference:	DGS/ENI-0021	**Latest version:**	0.0.6
Rapporteur:	Yannan Bai	**Technical Officer:**	Christine Mera

Scope:

This document specifies:
(1) the mapping of functional blocks in the ENI architecture and functionalities of the operational systems (e.g., NWDAF, 5GC and NFV MANO);
(2) how different intelligent entities of ENI and the operational system cooperate and work in parallel on assigned tasks;
(3) different metrics, such as performance, accuracy, and reliability, per capability, to ensure that recommendations and/or commands provided, can be done along with other pertinent tasks (e.g., data analysis) with respect to these metrics;
(4) how to automatically optimize the use of multiple AI models to provide a joint decision.

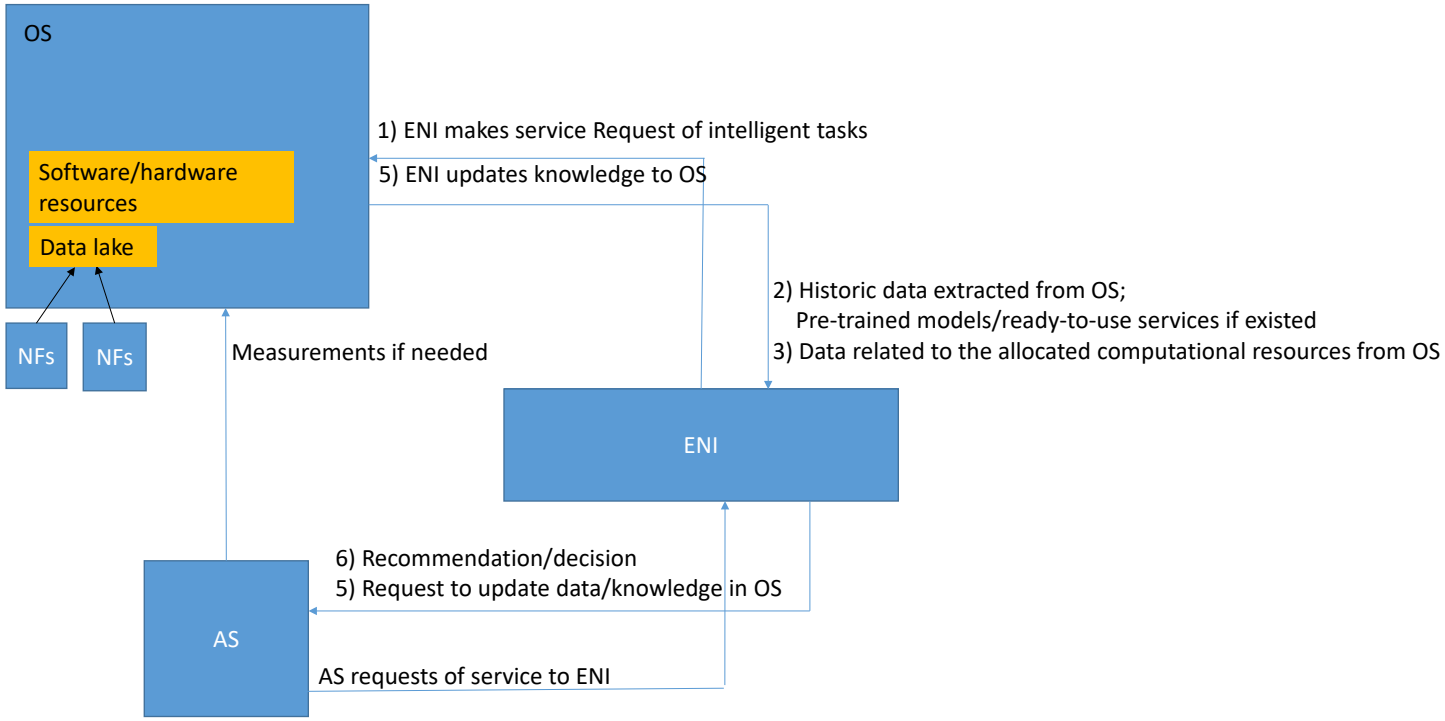
https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=58945

Main Contents of the *Mapping between ENI architecture and operational systems* GS

Content

- Overview
  - ✓ Introduce the motivation and definition of Operational System
- Mapping between ENI architecture and operational system
  - ✓ High-level Relationship between ENI System and Assisted System
  - ✓ Introduce the Interaction between OS, ENI and AS
- Mapping between ENI architecture and other operational system
  - ✓ Mapping between ENI architecture and NWDAF based data analysis system in 5GC
  - ✓ Mapping between ENI architecture and ONAP

Interaction between OS, ENI and AS



flows between the three entities

When interacting with the Operational System, the ENI system shall:

1) make a service request of intelligent tasks; these intelligent tasks include, but are not limited to, any of the use cases specified in ENI 001 e.g.: service assurance;

NOTE: If there exists pre-trained models or ready-to-use services that fit the intelligent tasks. These models / services are then sent to ENI system to reuse.

2) extract historic data from the OS data lake.

3) extract and receives data related to the computational resources allocated from OS.

4) perform corresponding intelligent tasks, and transform the pre-trained models/ready-to-use services to adapt to the current scenario;

5) update knowledge to the OS via the OS data lake

6) make recommendations to the AS and to the OS resulting from the task / services originally requested.

Work Plan and Next Steps

- Early draft: Feb. 2020
- Stable draft: Jan. 2021
- Draft for approval: Feb. 2021

Contact Details:
Yannan Bai
(China Telecommunications)
baiyn6@chinatelecom.cn

Thank you!

ENI
Reactive In-situ Flow Information Telemetry

Dr. Yali Wang (Huawei), Rapporteur

Overview of ENI Work Item-Reactive In-situ Flow Information Telemetry

General information:

Creation Date:	2020-06-25	**Type:**	Group Report
Work Item Reference:	DGR/ENI-0022	**Latest version:**	0.0.3
Rapporteur:	Yali Wang	**Technical Officer:**	Christine Mera

Scope:

The present document will describe the motivation, requirements, and challenges of using flow-oriented on-path telemetry techniques which provides relevant measurement or event reports to the AI-enabled network entities.

The present document will outline a reference framework, named as “In-situ Flow Information Telemetry (IFIT)” and identify technical requirements, including:

- modes of flow-oriented on-path telemetry;
- IFIT-based reactive telemetry framework;
- technical requirements, including intelligent flow and packet selection, intelligent data export, dynamic network probe, on-demand underlying technique selection.

https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=59544

Main Contents of the Reactive In-situ Flow Information Telemetry WI

❖ IFIT-based Reactive Telemetry Framework:

- The Application and Management System is responsible for inputting OAM measurement intent and displaying measurement analysis results.
- The Controller consists of two functional components: Configuration and Control, Collector and Analyzer.
- IFIT-enabled forwarding devices perform in-band flow quality measurement at the granularity of data packets in the IFIT domain.

❖ Technical Requirements in the framework:

- On-demand Underlying Technique Selection.
- Intelligent Flow, Packet and Data Selection.
- Intelligent Data Export.
- Dynamic Network Probe.

❖ Key concepts/terminology:

- **In-situ Flow Information Telemetry (IFIT)**: Is a term that refers to network OAM data plane on-path telemetry techniques, including In-situ OAM (IOAM), Direct Exporting (DEX) IOAM (IOAM-DEX), Postcard-based Telemetry (PBT), and Alternate Marking [RFC8321]. It can provide flow information on the entire forwarding path on a per-packet basis in real time. “In-situ” is Latin which can be translated as “in the original place”.
- **Reactive Telemetry**: A telemetry operation in a dynamic and interactive fashion.

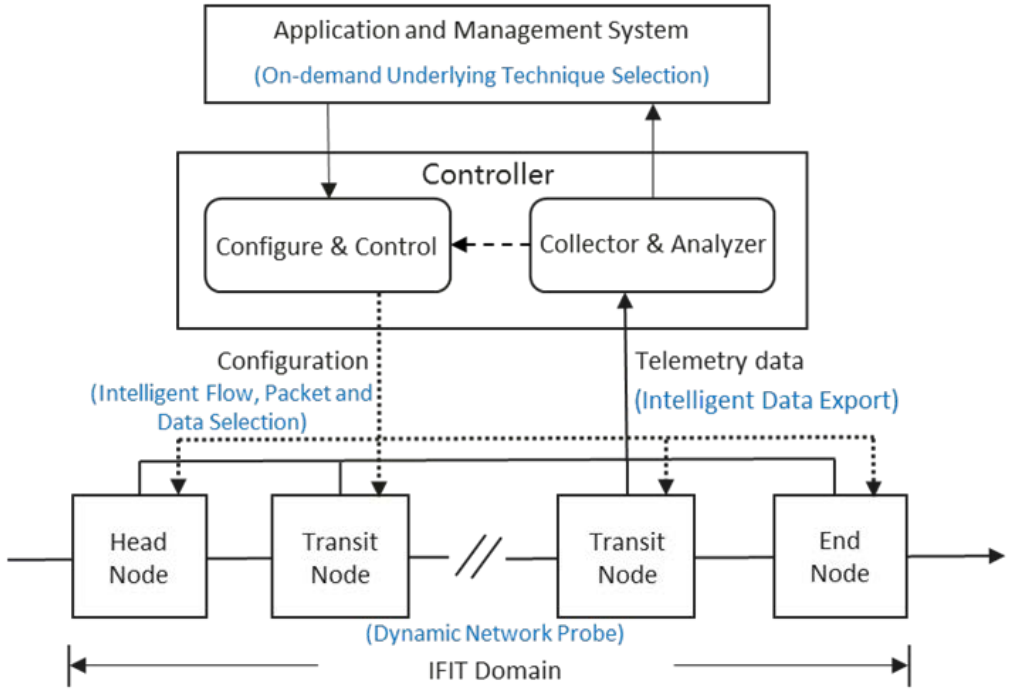


Fig. IFIT-based Reactive Telemetry Framework

Work Plan and Next Steps

- Early draft: November 2020
- Stable draft: March 2021
- Draft for approval: April 2021

Contact Details:
Yali Wang
(Huawei)
wangyali11@hauwei.com

Thank you!

Please Contribute

ETSI ENI#15 meeting will be hosted by on line, on Dec. 07-11, 2020.

You are welcome to join us!

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

+44 771 851 1361

Future expected issues:

- New release on the Categorization, Use cases & requirements
  - New Use Cases
  - Priority Use Cases demonstrated in PoCs
- Development of the system architecture
  - Data models and APIs
  - Interface definitions and External reference points
- Establishment of Implementations
  - ENI PoC Framework, Contribution to PoC,
  - Assurance of PoC, Plug-tests, Open Source &
  - Validation of the ENI System Architecture
- Standardize how the network experience is measured
- Welcome new members: especially to be active in discussions

Thank you!