Title*:	PoC proposal for Predictive Fault management of E2E Multi-domain Network Slices
from **Source***:	Portugal Telecom
Contact:	Cale@telecom.pt, agamelas@telecom.pt
input for **Committee***:	ENI

Decision/action requested:	For your consideration and eventual approval

ABSTRACT: *This document proposes a PoC project on Network Slice Management where an end to end (E2E) Network Slice, composed of several Network Slices (NS) is provided across multiple administrative domains. In this PoC the prediction of a faulty behaviour on one of these NS is performed by making use of AI/ML mechanisms, and will trigger policy based actions that will proactively make the necessary modifications to guarantee the E2E Network Slice availability with the committed SLA.*

1 PoC Project Details

1.1 PoC Project

PoC Number (assigned by ETSI):	
PoC Project Name:	**Predictive Fault management of E2E Multi-domain Network Slices**
PoC Project Host:	**Portugal Telecom**

This PoC aims to demonstrate the use of AI, in the context defined by ENI, for proactive closed loop assurance of the operational capabilities of E2E network slices provided across multiple administrative domains. In particular, fault prediction and avoidance are addressed, as the prediction of a fault situation on a Network Slice (NS) will lead to policy-determined actions, e.g. the replacement of that particular NS by another healthy one in order to keep the offer of E2E Network Slice service according to the agreed SLA.

This PoC targets network management Use Cases, both at a Network Service Provider level (NSP) as well as at, what is designated as a "Digital Services Provider" (DSP) level. In this context, the NSP provides Network Slices as a Service (NSaaS) to the DSP, an entity that is in charge of composing them as an end to end multi-domain slice provided to verticals like, e.g. an electrical power distribution utility.

The proposed PoC intends to test and validate AI-based approaches like those proposed by the ENI architecture [ENIARCH] for network fault prediction and policy-based actuation.

1.2 PoC Team Members

Table 1.1

	Organisation name	ISG ENI participant (yes/no)	Contact (Email)	PoC Point of Contact	Role	PoC Components
1	Portugal Telecom	Yes	António Gamelas agamelas@telecom.pt Rui Calé cale@telecom.pt	X	Service Provider	- Liaison between ENI and H2020 SliceNet
2	SliceNet Consortium	No	Maria Barros Weiss barros@eurescom.eu		H2020 Project, Note 1	- User Stories / Use Cases definition - PoC development - PoC documentation - PoC demos
Note 1: *H2020 Project* is not defined as a role in ENI PoC framework, however an option was made to identify the project as a whole as a role.						

SliceNet is a H2020 project in the scope of E2E Cognitive Network Slicing and Slice Management Framework in Virtualised Multi-Domain, Multi-Tenant 5G Networks. It is represented by the consortium of the entities indicated below:

Table 1.1a

Parner	Country	Nature
Eurescom	Germany	Program Management
Altice Labs	Portugal	Solution Provider
University of the West Scotland	United Kingdom	University
Nextworks S.R.L	Italy	Solution Provider
Ericsson Telecomunicazioni SpA	Italy	Solution Provider

IBM	Israel	Solution Provider
Eurecom	France	University/Solution Provider
Universitat Politècnica de Catalunya	Spain	University
RedZinc Service Ltd.	Ireland	Manufacturer/Solution Provider
OTE – The Hellenic Telecommunications Organisation, SA	Greece	Service Provider
Orange Romania / Orange France	Romania / France	Service Provider
EFACEC	Portugal	Manufacturer
Dell EMC	Ireland	Manufacturer
Creative Systems Engineering	Greece	Solution Provider
Cork Institute of Technology	Ireland	University

Other details on SliceNet may be obtained in https://SliceNet.eu/.

All the PoC Team members listed above declare that the information in this proposal is conformant to their plans at this date and commit to inform ETSI timely in case of changes in the PoC Team, scope or timeline.

1.3 PoC Project Scope

1.3.1 PoC Goals

The PoC will demonstrate aspects of various Use Cases that were identified by ENI, namely:

- Use Case #3-2: Intelligent network slicing management
- Use Case #4-1: Network fault identification and prediction
- Use Case #4-2: Assurance of Service Requirements

The PoC will also demonstrate aspects of various requirements that were identified by ENI, namely:

- Service orchestration and management
- Network optimization
- Resilience and reliability
- Data Collection and Analysis
- Policy Management
- Data Learning

The detailed goals include:

- **PoC Project Goal #1: Network Slice Fault Prediction**. Demonstrate the use of AI on performance data to be able to accurately predict failure (Note 2) situations on Network Slices and estimate their impact on an E2E multi-domain 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.

Note 2: In this particular context, *Failure* comprises both fault situations leading to service unavailability and failure to comply with particularly restrictive service requirements, e.g. the maximum latency allowed in a URLLC slice. This common approach makes UC#4.1 and UC#4.2 very similar in this scenario.

1.3.2 PoC Topics

PoC Topics identified in this clause need to be taken for the PoC Topic List identified by ISG ENI and publicly available. PoC Teams addressing these topics commit to submit the expected contributions in a timely manner.

Table 1.2

PoC Topic Code	PoC Topic Description	Related WI	Expected Contribution	Target Date, Note 3
	Use Case → Service Orchestration and Management → Intelligent network slicing management	[ENIUC]	P.C1	TBD
	Use Case → Network Assurance → Network fault identification and prediction		P.C1	TBD
	Use Case → Network Assurance → Assurance of service requirements		P.C1	TBD
	Requirements → Service orchestration and management	[ENIREQ]	P.C2	TBD
	Requirements → Network optimization		P.C2	TBD
	Requirements → Resilience and reliability		P.C2	TBD
	Requirements → Data Collection and Analysis		P.C2	TBD
	Requirements → Policy Management		P.C2	TBD
	Requirements → Data Learning		P.C2	TBD
	Architecture, Note 4	[ENIARCH]	P.C3	TBD

Note 3: These contributions will be elaborated and discussed during the PoC lifetime in accordance with the obtained results.
Note 4: Set of architecture topics common to ENI Reference Architecture and SliceNet Architecture, for which the latter may provide added value.

1.4 PoC Project Milestones

Table 1.3

PoC Milestone	Milestone description	Target Date	Additional Info
P.S1	PoC Project Submission	02/2019	Official PoC submission
P.S2	PoC Project Approval	03/2019	
P.US.1	PoC User Story delivery	04/2019	Detailed description of the use case story board regarding the smart grid technical scenario, involved players and their roles. Detailed description of the operations involving the NSP and DSP in the PoC context.
P.TP.1	PoC Test Plan 1	05/2019	Test Plan based on the User Story
P.DI	PoC development initiation	06/2019	
P.D1	PoC Demo 1	>10/2019	Demo at an ENI plenary meeting, Note 5
P.D2	PoC Demo 2	>01/2020	Webinar demo at an ENI plenary meeting, Note 5
P.C1	PoC Committed Contribution 1	TBD	(Set of) contribution(s) to ENI use-cases above identified.

			Definition/updating proposal by using the PoC outcomes. Note 6
P.C2	PoC Committed Contribution 2	TBD	(Set of) contribution(s) to ENI requirements above identified. Definition/updating proposal based on SliceNet requirements and principles, as applied to the DSP. Note 6
P.C3	PoC Committed Contribution 3	TBD	(Set of) contribution(s) to ENI reference architecture topics above identified. Definition proposal based on SliceNet own cognition system architecture, as implemented on the DSP. Note 6
P.R	PoC Final report	06/2020	Feedback with final presentation, Note 7
P.E	PoC Project End	06/2020	
Note 5: The ISG ENI plenary meeting for PoC demos has still to be settled and agreed with the ISG ENI management team. Note 6: These contributions will be elaborated and discussed during the PoC lifetime in accordance with the obtained results. Note 7: The date for the final report is just indicative.			

1.5 Additional Details

Two Demos are currently planned but the detailed dates are to be confirmed. Other Demos can be scheduled if the PoC team and ENI find appropriate dates.

2 PoC Technical Details

2.1 PoC Overview

It is expected that the capability of providing Network Slices as a Service (NSaaS) will be an opportunity for the "Digital Services Provider" (DSP), a Functional Entity provided by the SliceNet project that acts as a customer to the Network Services Providers (NSP), consuming their offer of Network Slices (NSs) and composing and enhancing the product with value-added services especially adapted to be consumed by a particular kind of end user: Business Verticals.

In this scenario, several NSPs expose different NSaaS according to their specific capabilities. These NS are used by a DSP to compose an E2E slice. For instance, the DSP may purchase mobile access from NSP#1 for a region, from NSP#2 for another region, and purchase transport between NSP#1 and NSP#2 from NSP#3.

The E2E slice, eventually together with other business relevant features, is offered by the DSP as part of the service that it exposes to business verticals, according to their specific needs.

Error! Reference source not found. represents the roles described above. These roles may be represented by different business actors or – in some cases – the same actor may represent various roles, e.g., an NSP may also be a DSP.

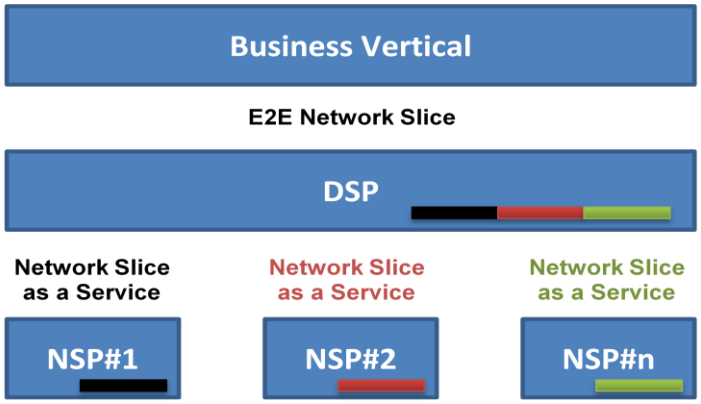

Figure 1 – Business Roles

SliceNet scope covers both the DSP and the NSP roles, but the DSP was chosen as the scenario for this PoC because of the level of abstraction that it offers. DSP faces the network slices that are "offered" by the NSPs as services, and so it doesn't have to deal with the complexity involved in building and maintaining an actual (infrastructure) network slice.

In the proposed scenario, the vertical, a energy distributor owning a power smart grid, has a network of active Powerline Protection Devices (PPD) that communicate with each other and with a Supervisory Control And Data Acquisition System (SCADA) to provide the protection mechanisms for a self healing power distribution network. These devices are deployed on power distribution line nodes and require two types of connectivity requirements:

- Reliable low latency communications between the devices (URLLC slice)
- Common management communications between the devices and the SCADA system (SCADA slice)

As stated before, the DSP will be providing the required communications network by "composing" an end to end slice with a certain number of NSs provided by various NSPs. These NS are picked from a choice of offers, based on their nominal characteristics and also on their performance history, as well as other criteria that can be applied to enhance the choice.

The following figure illustrates the PoC scenario:

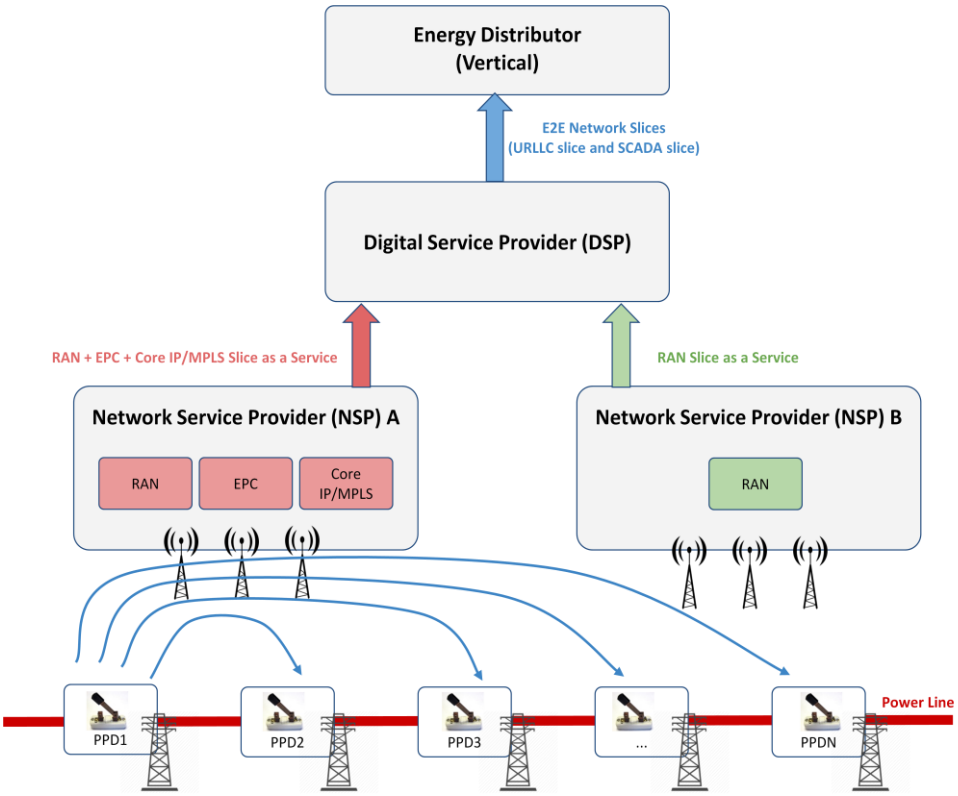

Figure 2 - SliceNet PoC scenario

For the proposed scenario, the DSP is seen as the active, decision-making, entity. It will act as the “host” of the PoC.

2.2 PoC Architecture

The proposed PoC is meant to be implemented by using the SliceNet Architecture as a working basis. Nevertheless, eventual adaptations may be imposed by the architectural model being developed in ISG ENI, especially as the model gets itself more and more mature. The subsections that follow briefly expose the instantiation of the SliceNet Architecture for the Use Case that this PoC addresses, which is then complemented with a prospective view of the mapping between that and the ENI Reference Architecture defined so far.

2.2.1 High-level SliceNet Architecture for the PoC scenario

SliceNet features a number of different scenarios applicable to the DSP and the NSP, with a common architecture for slice management. The present scenario, which is focused in DSP, is proposed to ENI because it represents slice management at the most abstract level: NS are seen here as Services provided by NSPs, and the DSP has no insight on the technical implementation and resources used for them. Hence, when composing an E2E Slice the DSP is actually combining a number of services (NSaaS – Network Slice as a Service) provided by other entities.

The high-level SliceNet Architecture view that is most relevant for ENI and for the proposed PoC is the one that represents AI-based autonomic behavior at the DSP level as illustrated below in Figure 5.

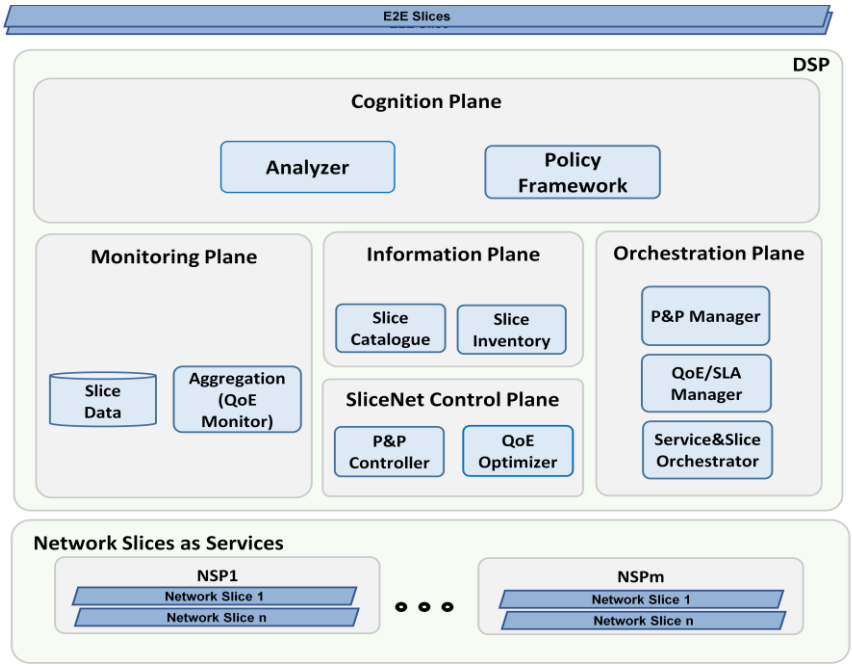

Figure 2 – High-level SliceNet Architecture for this PoC

The final goal of this architecture is to provide the DSP with the mechanisms to manage and control multiple NS provided as services across multiple administrative domains. With such management and control, the DSP will be able to compose an E2E network slice that permanently fulfills the requirements of a Business Vertical by using cognition-based mechanisms to autonomously and proactively adjust in order to overcome expected/predicted failures. The proposed PoC scenario maps exactly to this architecture.

In this PoC context, the main features associated to each Functional Plane are the following:

- **Monitoring Plane:** Exposes monitoring data and metrics, providing some level of aggregation, from network, infrastructure, services, etc. Provides some mechanisms to control the flow of data
- **Information Plane:** Provides information on the topology of the network, available resources, services, active and available slices, etc.
- **Orchestration Plane:** generically translates decisions into sets of actions across the Managed Domain
- **SliceNet Control Plane:** Exposes the ability to control aspects of the network slices

- **Cognition Plane:** Includes the capabilities of analyzing the available data and of learning from it, and manages the policies that are applied at various levels. These policies are human defined, but are subject to controlled change by autonomic, cognition based mechanisms

The various NSPs provide NS as Services to the DSP. Obviously they will have slice management mechanisms of their own, but those are not addressed by this PoC.

2.2.2 SliceNet Architecture at the Functional Plane level

The next figure and the description that follows specifies the functional flow across the high-level SliceNet Architecture presented above.

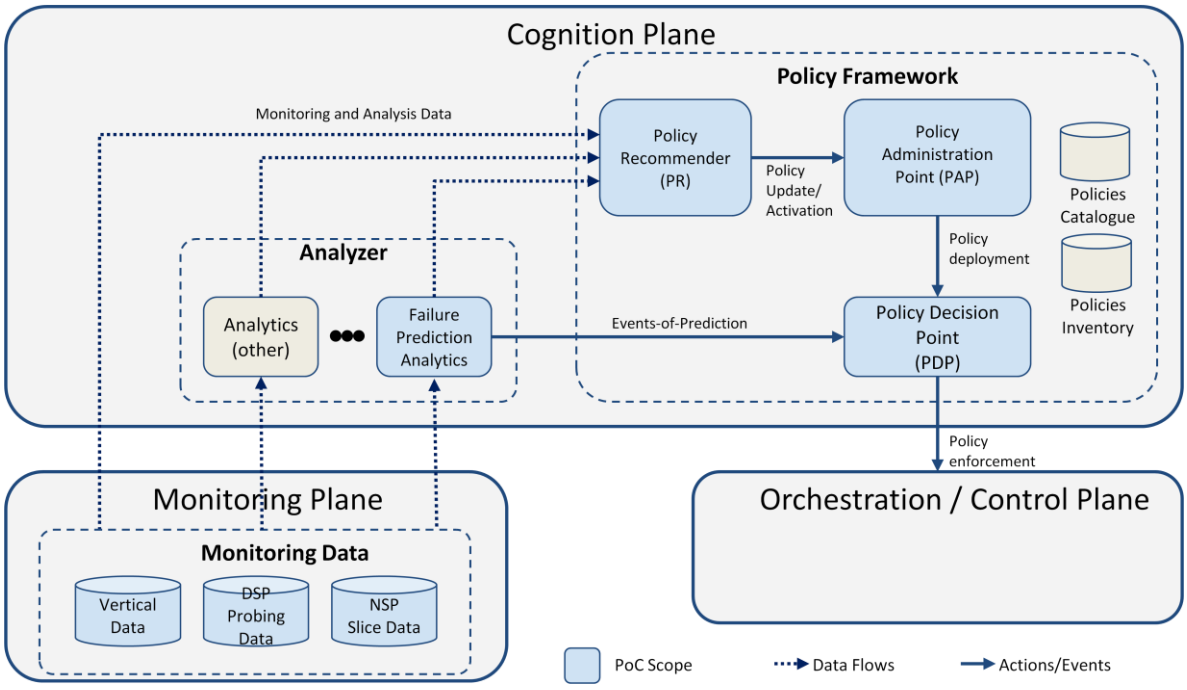

Figure 4 – SliceNet Architecture with Functional Planes

The DSP continuously monitors each NS through various means:

- NSP provided monitoring
- DSP probing into NSP slices
- End-user (vertical) feedback

The gathered information is analysed by the DSP through the use of AI mechanisms to discover NS failure patterns enabling thus the prediction of potential further dangerous occurrences, e.g., unavailability, excessive latency, mobile coverage, etc, which may lead to potentially hazardous situations such as the failure of the power distribution protection mechanisms.

When such an Event of Prediction (EoP) occurs, the DSP will be able to activate an alternate NS at runtime, eventually from a different NSP, and perform a switchover in order to keep the E2E slice operating conditions.

The choice of an alternate NS, or the decision to update any NS operating parameters, will be determined by a policy, which may be itself the result of other higher level policies, and will applied autonomously at a management level.

Besides from being used to trigger policies, EoPs, together with other operational information, feed a Policy Recommender, which is aware of the available policies, and also aware of the policies being enforced and the information that they generate. The Policy Recommender learns from the available information, and may:

- Propose the update of some (open) conditions in policies that are in force
- Propose the deployment and enforcement of policies from a Policy Catalogue

The loop is closed by the enforcement of the proposed policies. For this PoC, a single Policy Decision Point (PDP) will make the decisions that will be enforced by the SliceNet Orchestration and Control entities, briefly presented in next section.

2.2.3 Mapping to ENI Architecture

The proponents believe that the SliceNet approach to policy based autonomic behavior is strongly aligned with the view that ETSI ISG ENI is building. Nevertheless, one major architectural principle is different.

While ETSI ISG ENI is describing an "Assistant System" that can be added to an already existing reality, eventually governing the gradual introduction of Artificial Intelligence, SliceNet is focused on exploring the mechanisms for multi-domain slice management, also based on AI mechanisms, but considering that those mechanisms exist from the beginning. Instead of an assisting system as is the case of ENI, SliceNet is defining a whole framework that already incorporates the ENI principles.

Taking this in consideration the SliceNet PoC proposes to operate a framework scenario where some parts of its architecture, e.g. the DSP, integrates and operates as an ENI System. In this context, the work will have to be done to individualize this ENI part within the SliceNet Architecture, namely:

- Identify the ENI scope in the SliceNet architecture and make the necessary adjustments
- Map the ENI external interfaces to interfaces within SliceNet

Different modes of operation, as proposed in [ENIARCH] are not exercised in SliceNet. Hence, for this PoC only closed loop operations, as referred for the "Management mode" will exist. In the future, the Policy Recommender Functional Block (FB) may be evolved in order that SliceNet also operates in "Recommendation mode", however this is not the case at the moment.

Figure 5 shows a high level view of the expected mapping between the SliceNet architecture for the proposed PoC and the ENI system. In this tentative view, ENI is assuming the functions related to the "Cognition Plane".

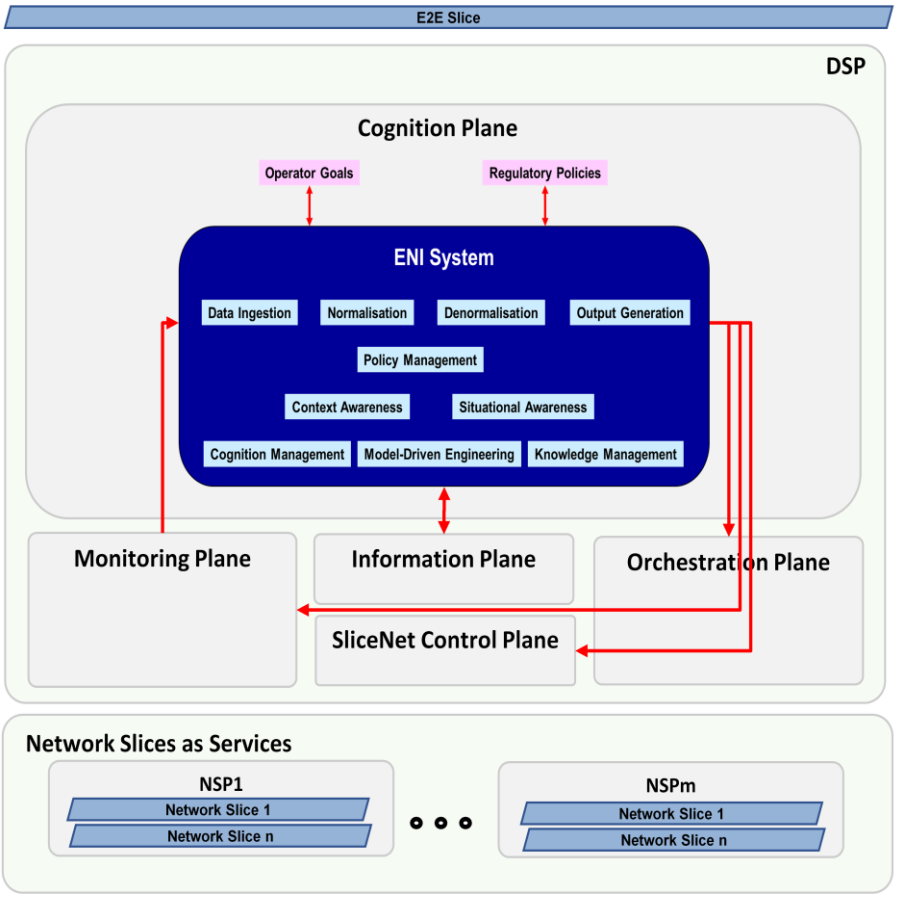

Figure 5 - Basic Mapped SliceNet Architecture for ENI PoC

The basic relations between ENI and the other main FBs of the SliceNet architecture are as follows:

- **Monitoring Plane:** Exposes the data that is to be "ingested" by ENI
- **Information Plane:** Directly provides awareness
- **Orchestration Plane and SliceNet Control Plane:** Enforcement domains for policy decisions

The preliminary architectural work at ENI, in what concerns the definition of the external reference points that characterize the boundaries of ENI as a system [ENIARCH], section 6.4 (Reference Point Overview) is represented in Figure 6. SliceNet is taking this as a reference to try a first mapping in terms of external reference points between ENI and the rest of SliceNet framework.

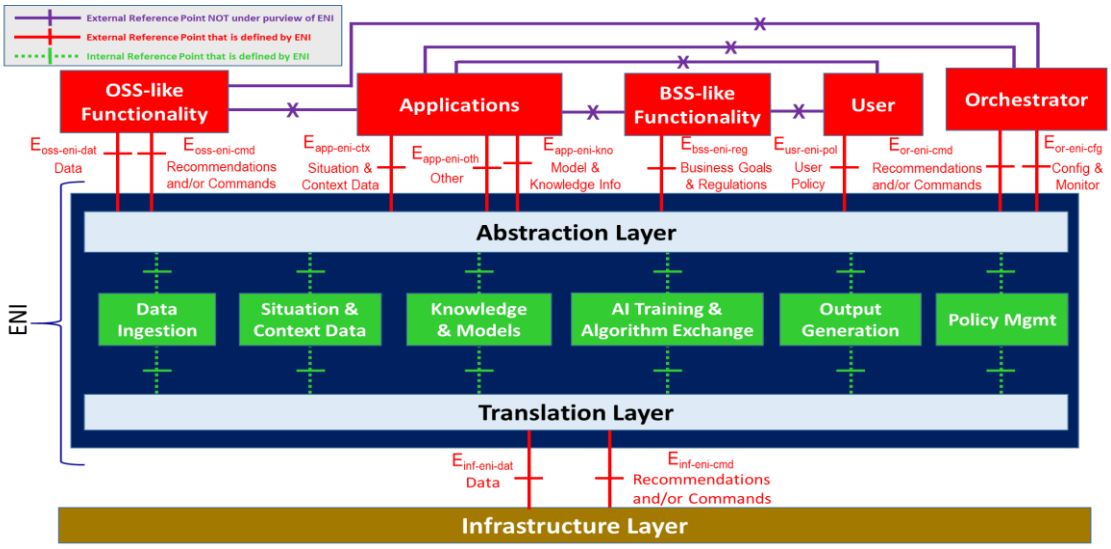

Figure 6 - ENI external interfaces [ENIARCH]

Error! Reference source not found. presents a first approach on which external reference points may be "touched" in the PoC scope. With the proposed PoC, SliceNet hopes to collaborate in the further definition of these reference points.

Table 2.1 – Mapping ENI External Reference Points into SliceNet PoC

Name [ENIARCH]	***Brief Definition [ENIARCH]***	**SliceNet PoC Scope**
$E_{oss\text{-}eni\text{-}dat}$	*Defines data and acknowledgements exchanged between ENI and the Assisted System (or its OSS-like functionality)*	Most monitoring data in SliceNet is collected, aggregated and exposed by an OSS Assurance tool, generally represented as Monitoring Plane. Hence, this reference point may aggregate (and somehow dispute) other Ref. points that convey other sources of data (applications, infrastructure). To be further investigated during the PoC.
$E_{oss\text{-}eni\text{-}cmd}$	*Defines recommendations and/or commands and acknowledgements exchanged between ENI and the Assisted System (or its OSS-like functionality)*	May be mapped to policy recommendations issued by the Policy recommender. To be further investigated during the PoC.
$E_{app\text{-}eni\text{-}ctx}$	*Defines situation- and/or context-aware data and information and acknowledgements exchanged between applications and ENI*	May be mapped to interfaces with Slicenet Information Plane (e.g. Inventory) and/or Monitoring Plane for data ingestion. To be further investigated during the PoC
$E_{app\text{-}eni\text{-}oth}$	*Defines generic application data and acknowledgements exchanged between applications and ENI, that is neither situation- or context-aware data and also is not model or knowledge information.*	May be mapped to the data that is available from the Monitoring Plane. To be further investigated during the PoC.
$E_{app\text{-}eni\text{-}kmo}$	*Defines model and/or knowledge information and acknowledgements exchanged between applications and ENI*	May be mapped to interfaces with Slicenet Information Plane – Inventory and/or Catalogue. To be further investigated during the PoC..
$E_{bss\text{-}eni\text{-}reg}$	*Defines data and acknowledgements exchanged between the BSS-like functionality and ENI*	Not in the scope of Slicenet
$E_{usr\text{-}eni\text{-}pol}$	*Defines policies and acknowledgements exchanged between applications and ENI that control behaviour (including services and resources) for a user (or an agent acting on behalf of the user)*	May map to policies exchanged with the Slicenet Control Plane
$E_{or\text{-}eni\text{-}cmd}$	*Defines recommendations and/or commands, and acknowledgements, exchanged between ENI and the Designated Entity of the Assisted System*	May be mapped to policy recommendations issued by the Policy recommender. To be further investigated during the PoC.

$E_{or\text{-}eni\text{-}cfg}$	*Defines configuration, administration, and/or monitoring commands and acknowledgements exchanged between ENI and the Designated Entity of the Assisted System*	May be mapped to policy recommendations issued by the Policy recommender. To be further investigated during the PoC.
$E_{inf\text{-}eni\text{-}dat}$	*Defines data and acknowledgements exchanged between the infrastructure and ENI*	May be mapped to the data that is available from the Monitoring Plane. To be further investigated during the PoC.
$E_{inf\text{-}eni\text{-}cmd}$	*Defines recommendations and/or commands, and acknowledgements, exchanged between the infrastructure and ENI*	May map to policies exchanged with the Slicenet Control Plane. To be further investigated during the PoC.

2.3 PoC Success Criteria

PoC success is determined by the ability to keep the operating parameters that were agreed for an E2E slice by predicting a failure on a NS and taking the necessary actions to replace or update it. In particular, the following goals must be achieved:

- **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 multi-domain 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.

References

[ENIUC] ETSI ISG ENI, “RGS/ENI-008 (GS ENI 001) version 2.0.6 – Experiential Networked Intelligence; Use Cases”, 01/2019

[ENIREQ] ETSI ISG ENI, “RGS/ENI-007 (GS ENI 002) version 2.0.3 - Experiential Networked Intelligence; Requirements”, 02/2019

[ENIARCH] ETSI ISG ENI, “ETSI GS ENI-005 V0.0.17 - Experiential Networked Intelligence; System Architecture”, 02/2019