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Core Network and Interoperability Testing (INT/ WG AFI)
Generic Autonomic Network Architecture;
Part 1: Business drivers for autonomic networking

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Core Network and Interoperability Testing (INT).

The present document is part 1 of a multi-part deliverable covering the Generic Autonomic Network Architecture, as identified below:

ETSI TR 103 195-1:	**"Business drivers for autonomic networking";**
ETSI TS 103 195-2:	"An Architectural Reference Model for Autonomic Networking, Cognitive Networking and Self-Management";
ETSI TR 103 195-3:	"Guidelines for instantiation and implementation".

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The scope of the present document is to identify key actors and related roles and responsibility demarcation within autonomic, cognitive and self-managed network ecosystem. Business drivers behind this Autonomic Management & Control (AMC) ecosystem as described through Generic Autonomic Network architecture (GANA) framework is at the heart of the present document. Monetary value creations in terms of measurable metrics (e.g. OPEX) that reflect cost benefit brought by the use of autonomics.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Ranganai Chaparadza: "Requirements for a Generic Autonomic Network Architecture (GANA), suitable for Standardizable Autonomic Behaviour Specifications for Diverse Networking Environments". International Engineering Consortium (IEC), Annual Review of Communications, 61, 2008.

[i.2] ETSI White Paper No. 16 (First edition - October 2016): "GANA - Generic Autonomic Networking Architecture - Reference Model for Autonomic Networking, Cognitive Networking and Self-Management of Networks and Services". ISBN No. 979-10-92620-10-8.

[i.3] ETSI GS AFI 002: "Autonomic network engineering for the self-managing Future Internet (AFI); Generic Autonomic Network Architecture (An Architectural Reference Model for Autonomic Networking, Cognitive Networking and Self-Management)".

[i.4] R. Chaparadza, Tayeb Ben Meriem, Benoit Radier, Szymon Szott, Michal Wodczak, Arun Prakash, Jianguo Ding, Said Soulhi, Andrej Mihailovic: "SDN Enablers in the ETSI AFI GANA Reference Model for Autonomic Management & Control (emerging standard), and Virtualization Impact". In the proceedings of the 5th IEEETM MENS Workshop at IEEE Globecom 2013, December, Atlanta, Georgia, USA.

[i.5] R. Chaparadza, Tayeb Ben Meriem, Benoit Radier, Szymon Szott, Michal Wodczak, Arun Prakash, Jianguo Ding, Said Soulhi, Andrej Mihailovic: "Implementation Guide for the ETSI AFI GANA Model: a Standardized Reference Model for Autonomic Networking, Cognitive Networking and Self-Management". In the proceedings of the 5th IEEETM MENS Workshop at IEEE Globecom 2013, December, Atlanta, Georgia, USA.

[i.6] Accepted PoC proposals.

[i.7] TMForum: "Promoting a trusted telco data space to drive new opportunities".

[i.8] ETSI TS 103 195-2 (V1.1.1): "Autonomic network engineering for the self-managing Future Internet (AFI); Generic Autonomic Network Architecture; Part 2: An Architectural Reference Model for Autonomic Networking, Cognitive Networking and Self-Management".

[i.9] ETSI GANA White Paper N 1: "C-SON Evolution for 5G, Hybrid SON Mappings to the ETSI GANA Model, and achieving E2E Autonomic (Closed-Loop) Service Assurance for 5G Network Slices by Cross-Domain Federated GANA Knowledge Planes".

[i.10] ETSI TR 103 195-3: "Core Network and Interoperability Testing (INT/ WG AFI); Generic Autonomic Network Architecture; Part 3: Guidelines for instantiation and implementation".

[i.11] ETSI TS 103 194: "Network Technologies (NTECH); Autonomic network engineering for the self-managing Future Internet (AFI); Scenarios, Use Cases and Requirements for Autonomic/Self-Managing Future Internet".

[i.12] ETSI TR 103 473 (V1.1.2): "Evolution of management towards Autonomic Future Internet (AFI); Autonomicity and Self-Management in the Broadband Forum (BBF) Architectures".

[i.13] ETSI TR 103 404: "Network Technologies (NTECH); Autonomic network engineering for the self-managing Future Internet (AFI); Autonomicity and Self-Management in the Backhaul and Core network parts of the 3GPP Architecture".

[i.14] ETSI TR 103 495: "Network Technologies (NTECH); Autonomic network engineering for the self-managing Future Internet (AFI); Autonomicity and Self-Management in Wireless Ad-hoc/Mesh Networks: Autonomicity-enabled Ad-hoc and Mesh Network Architectures".

[i.15] ETSI TR 103 747: "Core Network and Interoperability Testing (INT/ WG AFI); Federated GANA Knowledge Planes (KPs) for Multi-Domain Autonomic Management & Control (AMC) of Slices in the NGMN(R) 5G End-to-End Architecture Framework".

[i.16] ETSI TR 103 627: "Core Network and Interoperability Testing (INT/WG AFI) Autonomicity and Self-Management in IMS architecture".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 195-2 [i.8] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 103 195-2 [i.8] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 195-2 [i.8] and the following apply:

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence components
AMC	Autonomic Management and Control
BBF	BroadBand Forum
BSS	Business Support System
CAPEX	CAPital EXpenditure
CHOP	Configuration Healing Optimization Protection

NOTE: In autonomics, Self-CHOP refers to these Self-* features: Self-Configuration, Self-Healing, Self-Protection, etc.

CPE	Customer Premises Equipment
CSP	Communication Service Provider
DE	Decision making Element
FB	Functional Block
GANA	Generic Autonomic Network Architecture

IEEE	Institute of Electrical and Electronics Engineers
ISV	Independent Software Vendor
KPI	Key Performance Indicators
ME	Managed Entity
NE	Network Element
NFV	Network Functions Virtualization
NGMN	Next Generation Mobile Network
OPEX	OPerational Expenditure
OSS	Operations Support System
PoC	Proof of Concept
QoE	Quality of Experience
QoS	Quality of Service
SDN	Software-Defined Networking
SDO	Standardization Development Organization
SLA	Service Level Agreement
USP	Unique Selling Point

4 Business Value of Autonomics for Management and Control of Networks and Services

4.1 Definition of the Autonomic Management & Control paradigm

4.1.1 Autonomic Management & Control

Autonomic networks enable product innovation, network services innovation, operational efficiency for networks and services and smart and intelligent networks that exhibit self-* features such as self-configuration, self-repair/healing, self-protection, self-optimization, and self-awareness. The industry consensus is that as networks evolve, networks and services need to be operated based on principles for dynamically adaptive "automated" and "autonomic" management & control.

Autonomic Management & Control (AMC) is about Decision-making-Elements (DEs) as autonomic functions (i.e. control-loops) with optionally cognition introduced in the management plane as well as in the control plane (whether these planes are distributed or centralized).

Cognition (learning, analysing, and reasoning used to effect advanced adaptation) in DEs, enhances DE logic and enables DEs to manage and handle even the unforeseen situations and events detected in the environment around them.

Control is about control-logic as the kernel of the DE that uses a control-loop to dynamically adapt network resources and parameters or services in response to changes in network goals/intent/policies, context and challenges in the network environment that affect service availability, reliability, and quality.

DEs realize self-* features (self-configuration, self-optimization, etc.) as a result of the decision-making behaviour of a DE that performs dynamic/adaptive management and control of its associated Managed Entities (MEs) and their configurable and controllable parameters. Such a DE can be embedded in a Network Element (NE) or higher at a specific layer of the outer overall network and services management and control architecture. An NE may be physical or virtualised (such as in the case of the Network Function Virtualisation (NFV) paradigm).

From an architecture perspective, a control-loop can be based on a distributed model (for fast control-loops). In this case the DE is embedded in the NE (physical or virtualised). Whereas in a centralized model (for slow control-loops), the DE is embedded (implemented) outside of the NEs. Both kinds of control-loops act towards a global goal to ensure a stable state of the network. A DE can negotiate with another DE to realize dynamic adaptation of network resources and parameters, or services, via reference points.

This leads to the notion of global network autonomics, a result of interworking DEs as collaborative manager components that perform AMC of their associated MEs within NEs and their parameters.

From an implementation perspective, a DE, as a software module or an executable behavioural specification that enhances intelligence capabilities, may be (re)-loaded or replaced in NEs and in the network's centralized management and control plane. This is directly related to the notion of software-driven networks or software-empowered networks.

DEs (software components) are meant to empower the networks and the management and control planes to realize self-* properties: auto-discovery of information/resources/capabilities/services; self-configuration; self-protecting; self-diagnosing; self-repair/healing; self-optimization; self-organization behaviours; as well as self-awareness.

AMC also includes the following aspects for dynamic, intelligent, and adaptive management and control of networks and services (even when considering the emergence of SDN (Software-Defined Networking)):

- Real-time reactive and proactive network analytics that should be instrumented at various layers of the management and control realms for networks. Network analytics involves strategies and techniques to gather various data (e.g. monitoring data) and analyse the data, so as to infer changes in the state of network resources and deduce any patterns that help build knowledge pertaining to network state transitions, event predictions, and forecasts. The analysis process and the knowledge built is used to decide actions that can be performed to achieve certain objectives.

- Dynamic network policing and dynamic service(s) policing.

- Self-* features such as self-organizing network behaviours, self-configuration; self-protection; self-diagnosis; self-repair; self-healing; self-optimization; self-awareness.

- Autonomic services management (on-demand orchestration and dynamic adaptation/re-programming of services).

- Network applications that provide for network intelligence by controlling the network via the northbound API of a Software-Defined Networking SDN controller (e.g. a hybrid SDN controller-one that exhibits a multi-protocol southbound interface to diverse virtual and physical networks).

- In-network management for aspects requiring in-network reaction and self-adaptation by a thinly instrumented in-network control plane. The in-network control plane could be complemented by an outer and more complex logically centralized control plane that is split from the data plane as in the case of SDN.

In a nutshell, AMC is the key to designing the network and management & control intelligence (software logic) that enables the network and associated management and control operations to dynamically self-adapt to operator's high level business goals/intents/objectives and policy changes, challenges to the network (i.e. manifestations of faults, errors, failures, performance degradation) and workload conditions of operation. To achieve AMC, real-time and predictive network analytics (also including predictive and proactive actions) for dynamic network policing and services (re-) programmability as driven by changes in context, workload scenarios, security, and services requirements, should be introduced in the network architecture designs and the resulting network infrastructures that get deployed.

4.1.2 Automated Management

Automated management is about workflow reduction and automation i.e. automation of the processes involved in the creation of network configuration input using specialized task automation tools (e.g. scripts, network planning tools, policy generators for conflict-free policies).

4.1.3 Autonomic Management & Control vs Automated Management

Autonomic management can be contrasted to automated management. The former emphasizes learning, reasoning, and adaptation, while the latter focuses on efficient workflow implementation and automation of the processes involved in the creation of network configuration and monitoring tasks. Figure 1 illustrates the positioning of both paradigms and highlights the interaction between them.

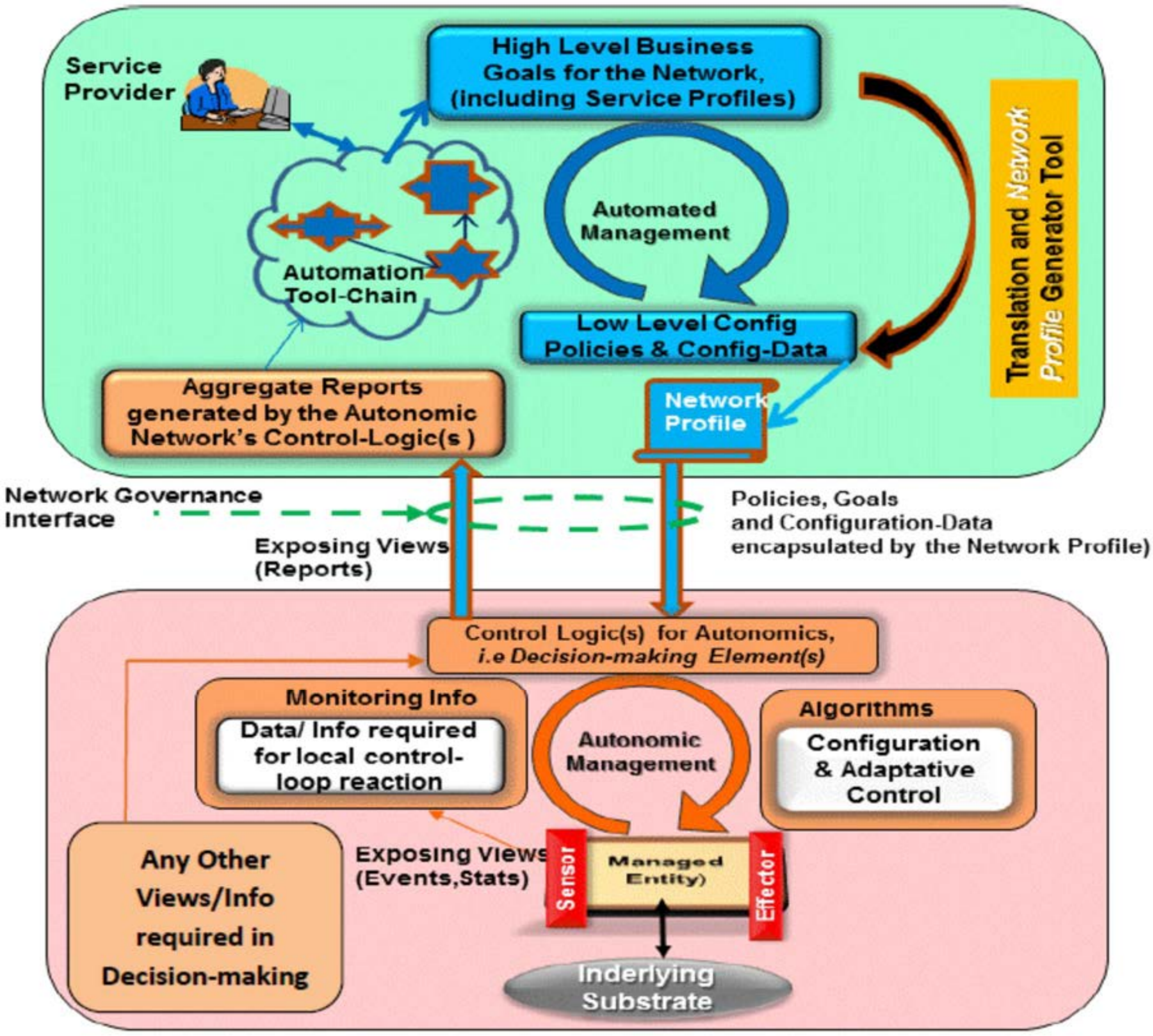

Figure 1: Automated Management vs Autonomic Management illustration (their interaction and complementarity)

Automated management provides input to the AMC. Indeed, autonomic management exhibit a network governance interface through which the input that governs the configuration of an autonomic network should be provided. Thanks to automation tools and mechanisms, by using a high-level language the operator can define the features of the network services that should be provided by the underlying network infrastructure. Such a business language that can help the operator express high level business goals required of the network may be modelled using an ontology to add semantics and enable machine reasoning on the goals. The human operator defined features relate to business goals, technical goals, and some input configuration data that an autonomic network is supposed to use for network resources and parameter configuration.

4.2 A Combined View on Business drivers for AMC, SDN and NFV

New Networks and associated Services are becoming increasingly complex to manage, resulting in excessive OPEX consumption. Operators have two mains business drivers:

1) define a set of cost saving methods and technologies that have the potential to achieve substantial Operational Expenditure (OPEX) savings;

2) introduce dynamicity in the Operations Support System (OSS) and Business Support System (BSS) to cope with the lack of Services agility, provide better Customer experience, and reduce time-to-deploy and time-to-market.

The above two business drivers mandate introducing flexibility and programmability into the network. This means that management functions will be incorporated into all parts of the system, and not just confined to OSSs and BSSs. AMC provides capabilities, such as knowledge dissemination and intelligent decision-making, to achieve these business objectives. It can also be used to integrate different approaches, including Software-Defined Networkings (SDNs) which could drive the networks, Network Functions Virtualization (NFV), and Cloud-based models.

Open source and related efforts that emphasize vendor-neutral functionality and programming are providing stakeholders new **opportunities**, but also new **risks**. One way for many stakeholders, such as telecommunications network operators, to avoid the risks is to influence and quicken the development of relevant **standardization work**. The goal is to strengthen and ease deployment of new Services, improve Customer Experience, generate new revenue, and reduce OPEX. These business drivers all rely on key characteristics of autonomics:

- knowledge;
- self-management; and
- adaptability.

These advanced technical capabilities require the building of trust and confidence in their use and deployment to ensure their adoption.

However, telecommunications operators are confused by the diversity of the standardization landscape. They are asking for harmonisation of standards to get the relevant products and solutions that implement their requirements to overcome the challenges they are facing and meet their business objectives.

Operators are now in a situation where they are simultaneously assessing SDN and technologies through a "silo" approach. This fails to capitalize on the inherent strengths of each and ignores the benefits of autonomics. It is the right time to consider how AMC can provide governance for and better utilize SDN and NFV functionality through a "combined" approach from a standardization perspective. The industry noted, as discussed in [i.4], [i.1], that consolidated industry requirements for AMC (Autonomics), SDN and NFV, through unified standards (e.g. modelling and architectural frameworks), should be telecom operators-driven and/or enterprises-driven and guided by the key Standardization Development Organization and Fora (SDOs/Fora) that are addressing these topics and are seeking to collaborate with others in the now needed actions on *Industry Harmonization for Unified Standards on the Emerging Paradigms* [i.4] and [i.5]. The topic of autonomic management and control is "fundamental" to various other current hot topics, and therefore it should be considered in all the groups working on SDN, NFV, Converged Management, 5G, End to End systems architectures, and orchestration. Currently, various standardization groups are working on the current hot topics with little harmonisation and synergy efforts. Efforts to build synergies and bring about harmonisation of frameworks begin now, because there are identified relationships between AMC, SDN, NFV, and Converged Management of Fixed and Mobile Networks. Therefore, there is now a crucial need for ***harmonization of associated frameworks***. The present document describes the relationships between these complementary paradigms.

4.3 How a cross-SDO combined approach on AMC, SDN and NFV helps achieve operators' business objectives

The SDN, Network Function Virtualization (NFV) and AMC paradigms have been and continue to be addressed through separate "silo" approaches by the research community, various SDOs/Fora, and the industry. Some liaisons between SDOs have been established to try to achieve harmonisation in particular areas, which mitigates overlaps and optimizes standardization efforts. However, all three paradigms are complementary, and target a set of common business objectives and technical features. Each of the paradigms is now identified and described by at least one basic architecture, and the industry is getting prepared to progress implementations by developing early prototypes. At the same time, most of the operators are using Proof of Concepts (PoCs) [i.6] to assess the promises advertised in terms of overcoming their challenges and meeting their business requirements ETSI White paper N°16 [i.2] ETSI GANA Uses cases and requirements [i.11].

This means that operators might be simultaneously using these three technologies through three separate "silo" approaches, even though some capabilities inherent to SDN, NFV and AMC are common. Therefore, it is the right time to consider a "combined" approach that can better integrate and utilize the functions provided by these three technologies. Standardization is vital to guide the industry and operators a broader (holistic) and more efficient view in which to solve their issues. To achieve this objective a Multi- or Cross-SDO approach is the appropriate instrument as depicted in Figure 2.

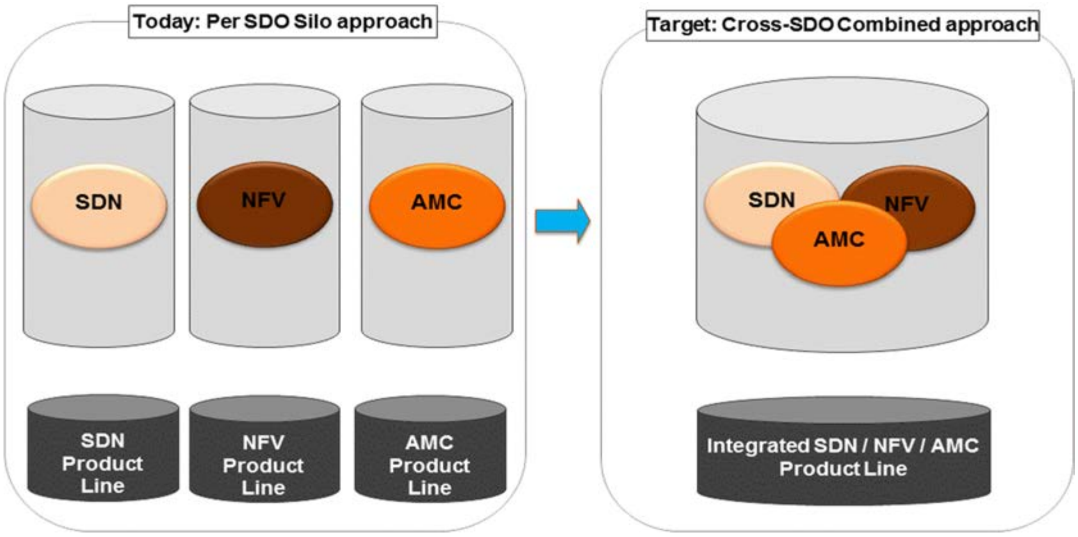

Figure 2: Harmonisation of Autonomic Management & Control (AMC), NFV (Virtualisation) and SDN

Events and activities that support the coming together of several SDOs and their collaboration on certain cutting-edge topics have proven to be a very successful format and a very effective instrument.

An Operator (or Communication Service Provider (CSP)) typically has its business goals tied to Key Performance Indicators (KPIs) and Service Level Agreements (SLAs) that reflect OPEX and operational efficiency, resource efficiency, effectiveness of resource utilization to maximize fairness, profitability, and other KPIs, and other factors. Whether it is a software-defined management approach as in SDNs, or a virtualization approach as in NFV, or an automation and autonomics approach as in AMC, those technology paradigms serve the purpose of CSP business objectives via:

- Increasing efficiency (including operational efficiency and expenditures OPEX) by reducing manual operations and effort and automating certain processes.
- Optimizing resource management and utilization to achieve an improved Quality of Service (QoS), Quality of Experience (QoE), and other resource-dependent metrics as efficiency, fairness and stability.
- AMC also enables cognitive behavioural modelling and flexible workflow support to back the business models of the CSP.

4.4 Revenue Generation using a combination of AMC, SDN, NFV, E2E Service Orchestration and Big-Data Analytics in Network Provider Environments

Stakeholders, especially CSPs, can generate revenue by applying technological paradigms such as AMC, SDN, NFV, end to end service Orchestration and Big Data Analytics.

When applying AMC as well End-to-End Service Orchestration, CSPs are able to build complex workflow with component DEs that reflect the use-cases comprising the business case relevant at the time. The ability to model the behaviour of business scenarios and to run the workflow reflecting that is a major USP (Unique Selling Point) that allows operators to monetize on their investments and services. The cognition and programmability aspects of AMC and E2E Orchestration are key in supporting this feature.

SDN and NFV also support revenue generation for CSPs via supporting partial process automation, resource virtualization, and scaling of resources and functionalities in a very efficient way.

Big Data Analytics with massive and wide outreach to data parameters allows CSPs to increase their levels of awareness (especially when it comes to dynamics metric and parameter values and certain context information) and to monetize on the large scale and variety of data they have access to. No stakeholder has more access to such a wide range of data as a CSP. Guaranteeing the confidentiality and sovereignty of data is essential for sharing this data and enabling data-driven services and use-cases. Telco Data Space [i.7] provides a data governance framework for sovereign, secure and scalable exchange of data within a "trusted ecosystem" involving stakeholders across the commercial, social, and industry verticals dimensions. A Data Space allow data providers remain in control of shared data while collaborating securely. A set of business scenarios and opportunities can then be leveraged by CSPs, allowing them to monetize after unleashing the potential of sovereign data sharing [i.7].

In general, CSP monetization and revenue generation are supported by all the technology trends and paradigms. The amount of revenue and effectiveness of monetization an Operator can achieve depend on the quality of the fit of those paradigms to the business model under question.

4.5 Enablers for Live Cycle Management and Operationalization of Autonomics in Network Architectures Management and Control Planes

In the process of the instantiation of DEs onto target implementation-oriented architectures specified by SDOs, such as the Broadband Forum (BBF) reference architecture or 3GPP reference architecture, the DEs that will be instantiated in particular NEs (nodes) could be chosen on the basis of a criterion. This could be the managed networking resources a NE supports and its point of attachment as well as its role in the network topology. Once this decision has been made the DE behaviours and behaviours of the other DEs and Generic Autonomic Network Architecture Functional Blocks (GANA FB) specified in ETSI TS 103 195-2 [i.8], based on analysing various use case scenarios and requirements ETSI TS 103 194 [i.11] for autonomics and self-management in the particular target reference architecture. This also leads to further elaboration of the generic behaviours of the instantiated GANA FBs and their characteristic information exchange on the instantiated reference points (also the protocols used to exchange information and messages are then nailed down). The fundamental DE behaviours that need to be standardized versus those behaviours (e.g. customized DE algorithms) that may not be standardized need to be discussed and agreed in the standardization process. Characteristic information exchanged over the GANA reference points and the protocols used to convey it become more concrete and detailed during the phase of GANA instantiations and autonomics use cases requirements analysis in the target implementation-oriented architecture ETSI TS 103 194 [i.11]. ETSI GS AFI 002 [i.3] and specified in ETSI TS 103 195-2 [i.8] presents a table on GANA FBs and associated reference points (rfps) and generic characteristic information exchanged through those rfps. The table should be used as a basis for further elaboration required during GANA instantiation and implementation.

5 Business Models of GANA

5.1 The Business Value of the GANA Knowledge Plane

As described in ETSI TS 103 195-2 [i.8], the GANA Knowledge Plane should fulfil the combined role of Network Analytics Driven Service Orchestration and Network Analytics Driven Closed-Loop (Autonomic) Service Assurance:

- Network Analytics Driven Service Orchestration should be performed by the Knowledge Plane DEs in response to network or resource capacity demands and resilience targets/objectives. This has the overall business effect of guaranteeing and improving Quality of Experience (QoE) for users of the network and reducing churn for network operators as further elaborated in the points below.

- Network Analytics Driven Closed-Loop (Autonomic) Service Assurance should be performed by the Knowledge Plane DEs with the target of improving customer experience. Autonomic (Closed-Loop) Service Assurance involves the Knowledge Plane as an Analytics Platform equipped with engines (DEs) that collects and analyses data from various data sources such as traditional Service Assurance Platforms (e.g. Performance management systems), network service functions/nodes, SDN Controllers, etc., and detect any service degradations and SLA violations. The Analytics Platform then closes the loop by communicating monitor results to Orchestrators and triggering remediation and corrective operations via a combination of Service Orchestrators, SDN Controllers, and Service Functions/Nodes such as CPE (Customer Premises Equipment), Access Node, Boarder Network Gateway in Broadband Forum (BBF) architectures, and other types of service function nodes of other types of architectures. The Knowledge Plane DEs should be able to communicate to a Service Orchestrator Results obtained from Monitoring a Service such as SLA violations and generate Recommendations (actionable insights) which could be defined proactively with predictions or reactively with statistics on how the problems can be solved (humans could make use of the generated Recommendations, e.g. making use of the Recommendations to perform the actions if the Knowledge Plane DEs are configured to operate in an "Open-Loop" Mode). At the same time in a "Closed-Loop" mode, the DEs should go further on their own accord to trigger operations on the Service Orchestrators (which include orchestrator types like the NFV Orchestrator) in a "Closed-Loop" (autonomic) service assurance goal based on what the DEs determine to trigger on an orchestrator or any other management and control system such as an SDN controller, so as to realize Self "Configuration Healing Optimization Protection" (CHOP) of the Service(s)-thanks to autonomics of the Knowledge Plane operations. While Service Assurance should now evolve towards "Closed-Loop" (Autonomic) Service Assurance, rather that the Service Assurance Function computing Recommendations as actionable insights and operate in a an open loop as discussed in ETSI INT PoC White Paper 1 [i.9], the GANA Knowledge Plane is meant to be an implementation of a Service Assurance Function that is *autonomic* in its operation, acting in a Closed-Loop fashion that drives Self-* behaviours (performed on the Managed Entities (MEs) of the network) such as *Self-Healing, Self-Organizing, Self-Optimizing, Self-Protection, Self-Repair, etc. and exhibiting Self-Awareness.*

- Offer insights that help the Operator to create and launch new types of services that could be offered to customers based on the Recommendations that the Analytics performed by DEs in the Knowledge Plane can produce with respect to the types of services (e.g. connectivity services) that can be provisioned over the capacity deduced to be available without compromising QoE (Quality of Experience) of end users currently served by the network. The Recommendations should be based on converged and aggregate analytics that are collectively correlated by the various DEs in the Knowledge Plane over historical usage trends of the E2E network capacity and other information such as performance trending data, etc.

5.2 The Stakeholders to whom the GANA Model Addressed: A Perspective on Business Models and Opportunities Enabled by the GANA

The following two categories determine the actors or players the GANA model is addressing:

a) Suppliers (vendors) of GANA Functional Blocks (FBs)

The suppliers can be further categorized as follows, bearing in mind that DE algorithms, just as in the case with SON algorithms, may not be standardized as they should provide means for DE vendor differentiation:

- Independent developers of software components and algorithms for autonomics from the research community (research institutes, universities, etc.).

- ISVs (Independent Software Vendors) e.g. OSS (Operations and Support Systems) vendors.

- Traditional network equipment vendors.

- Network operators mostly with software development capabilities may develop some DEs on their own and load them into nodes (provided this can be supported by the host platform or operating systems) and/or in the Knowledge Plane.

- Data owners/suppliers: Data is required to train and develop DEs, and data owners are now essential actors to develop DEs.

- cloud infrastructure suppliers which provide capabilities to train Artificial Intelligence (AI) Models and design DEs.
- Data scientists: develop algorithms to train AI Model used within cognition DEs.
- Data experts: define features, clean and pre-process datasets which are used by data scientists to train AI models with unbiased datasets.

b) Provider of assets required by the developers of GANA Functional Blocks (FBs)

Perspectives on such assets are as follows:

- GANA presents a framework to design Autonomic Functions (AFs) required at various GANA levels of abstraction for self-management functionality. The section on the implementation guide for ETSI TR 103 195-3 [i.10] and [i.4] discuss the subject of how to implement, step-by-step, autonomics at various levels of abstractions defined by the GANA model. The GANA specification and other assets described in the part on the implementation guide constitute useful input required by developers, while interacting with ETSI AFI WG on implementation guidance and helping close gaps in the autonomics standards and the frameworks.
- Data is required to develop DEs. Data providers will be key actors to develop DEs.

Table 1 describes in more detail the actors/players and the roles attached to each actor. Indeed, each actor needs to know its related roles, rights, duties and responsibilities.

Table 1: Description of the roles attached to each Player/Actor in implementing GANA Model

Actor 1	Suppliers (vendors) of the GANA Functional Blocks (FBs) (software components/modules/libraries, protocols and DE algorithms for autonomics). The Functional Blocks (FBs) defined by the GANA (such as the GANA Knowledge Plan FBs), their associated reference points and characteristic information exchange, and the GANA abstraction DE levels for autonomic components in general (particularly GANA Level-2 up to GANA Level-4 DEs), all determine the types of suppliers for the FBs. The roles described in this table provide a characterization of the types of suppliers of various GANA FB software components/modules/libraries, protocols and DE algorithms for autonomics.
Role 1	GANA Knowledge Plan component suppliers (for GANA FB and network-level DEs) and associated algorithms and protocols.
Who should fulfil this role?	This role could be fulfilled by ISVs (Independent Software Vendors), e.g. OSS vendors, or traditional networking equipment vendors. Even network operators who may have software development capabilities may develop some DEs on their own.
Role 2	Suppliers of GANA Level-2 and Level-3 Decision Elements/Engines (DEs) and their associated algorithms.
Who should fulfil this role?	Could be fulfilled by traditional networking equipment vendors and/or even ISVs. GANA defines an autonomic networking node/device internal reference point along with the structure of a GANA node and visualization of placeholders for control-loops (ETSI TS 103 195-2 [i.8]). Such an NE internal reference point could apply in some open networking boxes (i.e. some vendors provide an NE or device-internal interface for control-software agents to be loadable into the device). This would enable either the traditional network equipment vendor or the network operator to load DEs from a third party (e.g. Independent Software Vendor (ISV)) to empower the device (physical or virtual) with third party developed DEs and algorithms. Also, with the advent of "White Box Networking", ISVs may develop these types of DEs (level 2 and possibly level 3 as well) and associated algorithms that drive the DEs' control loops. More details are included in the section "GANA and White Box Networking". Even network operators who may have software development capabilities may develop such DEs on their own and load them into nodes (provided this can be supported by the host platform or operating systems).
Role 3	Suppliers of GANA Level-1 autonomics (DEs and algorithms).
Who should fulfil this role?	This supplier role could be fulfilled mainly by traditional networking equipment vendors who often provide the protocol stacks that run in the equipment anyway. However, such suppliers should be more fucus on levels 2 to 4.

Role 4	Providers of Independent DE Algorithms for any of the four GANA levels of abstraction of self-management functionality. This applies especially to GANA levels 2 to 4, as the protocol level (level 1) may not easily allow modifying some of the existing protocols to embed intelligence and control loops. But though this may be possible in certain newly developed protocols, the issue of control-loops in protocols leading potentially to undesired emergent behaviour (as discussed earlier) needs to be considered.
Who should fulfil this role?	This role could be fulfilled by algorithm developers for autonomics from the research sector (research institutes, universities, etc.) as new actors entering this autonomics market such as data scientist. As discussed in ETSI TS 103 195-2 [i.8] and earlier, algorithms for autonomics (DE algorithms) may not be standardized- as DE algorithms provide for DE vendor differentiation. However, innovation in autonomics algorithms require the collaboration of industry (traditional network equipment vendors and ISVs) with research organizations (institutes and universities) who are expected to continue advancing the research on developing better algorithms for autonomics (even in the long term). This means research organizations equipped with experimental facilities and expertise on autonomics have the potential to be providers of autonomics algorithms to vendors (e.g. in some partnerships) who can then incorporate the algorithms in their DE software components. However, the data owner will be a key value actor as he will provide the data for these suppliers.
Actor 2	Provider of Assets required by the developers of GANA Functional Blocks (FBs) (software components/modules/libraries, protocols and DE algorithms for autonomics).
Role 1	Provider of the GANA Implementation Guide.
Who should fulfil this role?	ETSI AFI Working Group.
Role 2	Provider of autonomics-enabled implementation-oriented architectures.
Who should fulfil this role?	The following players fulfil this role: ETSI AFI Working Group. Any other SDO (e.g. in ITU, IEEE™, etc.) that performs the instantiation of GANA on their reference architecture to create an autonomics-enabled implementation-oriented reference architecture. ETSI AFI WG is performing work on instantiating the GANA onto various reference architectures and producing various autonomics-enabled reference architectures that are required by developers, e.g. autonomics-enabled Broadband Forum (BBF) ETSI TR 103 473 [i.12] reference architecture; autonomics-enabled of 5G Slices NGMN references architecture ETSI TR 103 747 [i.15], in 3GPP references architectures [i.13] and IP Multimedia Subsystem reference architectures ETSI TR 103 627 [i.16] references architectures; autonomics-enabled 3GPP reference architecture; autonomics-enabled wireless ad-hoc/mesh sensor network architectures ETSI TR 103 495 [i.14] which are developed with the outcome of PoCs [i.6]. What developers can obtain from such GANA instantiation cases are details on what types of DEs and associated control-loops should be implemented in the GANA Knowledge Plane and in specific NEs, as well as the mapping of DEs to specific MEs they should autonomically manage and control.

5.3 Business Governance - Profiles and Policies

The enabling notion of autonomic network governance requires as input goals and requirements defined by the human operator and customers. The network operate with respect to the operator business rules and the operator should trust the autonomic network behaviour to provides services requested by customers as depicted in Figure 3.

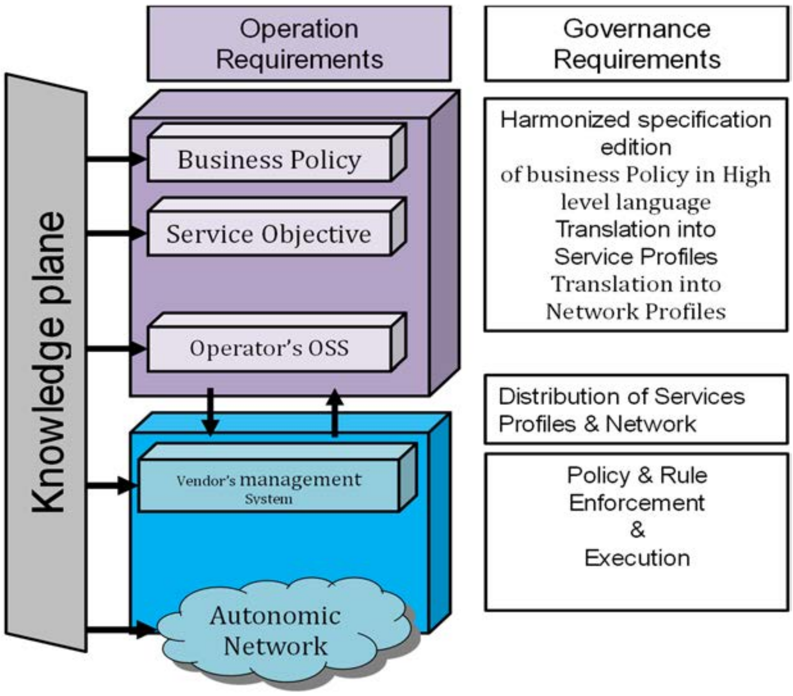

Figure 3: GANA governance model

As well DE might be used for different optimization process for different objectives and goals. A data workflow processed by DEs need to be govern according to business goals at different Intelligent management process layers and between them enhanced with Artificial Intelligence (AI).

Table 2

Intelligence Management process layer	"AI" used in DEs?
Business	Control and manage AI for proactive and predictive customer experience management, reduce churn, identify dynamically the best Service Level Agreement (SLA) according to customers behaviour or partners offers (VNF, service, infrastructure marketplace), maximize user satisfaction, (Robot with Natural Language Processing in customer care centre), anticipate customer service needs, minimize fraud.
Service	AI helps to create, build, design services governed by business requirements, such as optimize services for an end-to-end service lifecycle management, identify a chain of functions required to deploy a service, test the service (federated test bed test, service interoperability test), orchestrate and self-managed the functions required for a service.
Network	AI helps to self-manage each network domain (access, backhaul, core, service networks). Slow control loops with advanced AI might be used to adapt a network behaviour according to E2E service objectives e.g. continuously learn the AI model that need to be used within fast control loop to self-manage a function.
Network Function (Network element with AI which self-managed entity)	AI helps to self-manage a Network function (plug and play: i.e. self-configured, self-secured, self-healed, self-X) and governed by network objectives. Fast control loops with simple AI might be used to adapt a network function according to E2E service objectives for example a model learned by network might be inferred and transferred within a network function.
Protocol	AI should be avoided at lower level such as protocol level, as it is difficult to manage, control and update.

It requires then a new organization to manage and governed Data and DEs workflow such as data access stored in Data Lake, datahub, data warehouse, data base and managed entities (ONIX). As well data scientist and domain expert that need to cooperate to build design and manage the journey of DEs. The business objective will be used to instantiated and orchestrated a DE workflow to reach objectives required by customers (Telco Data space [i.7]).

History

Document history		
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