ETSI TR 103 195-1 V1.1.1 (2023-09)

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

Reference
DTR/INT-002-1_AFI-0015-1-GS02

Keywords
autonomic networking, self-management

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Sous-Préfecture de Grasse (06) N° w061004871

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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.

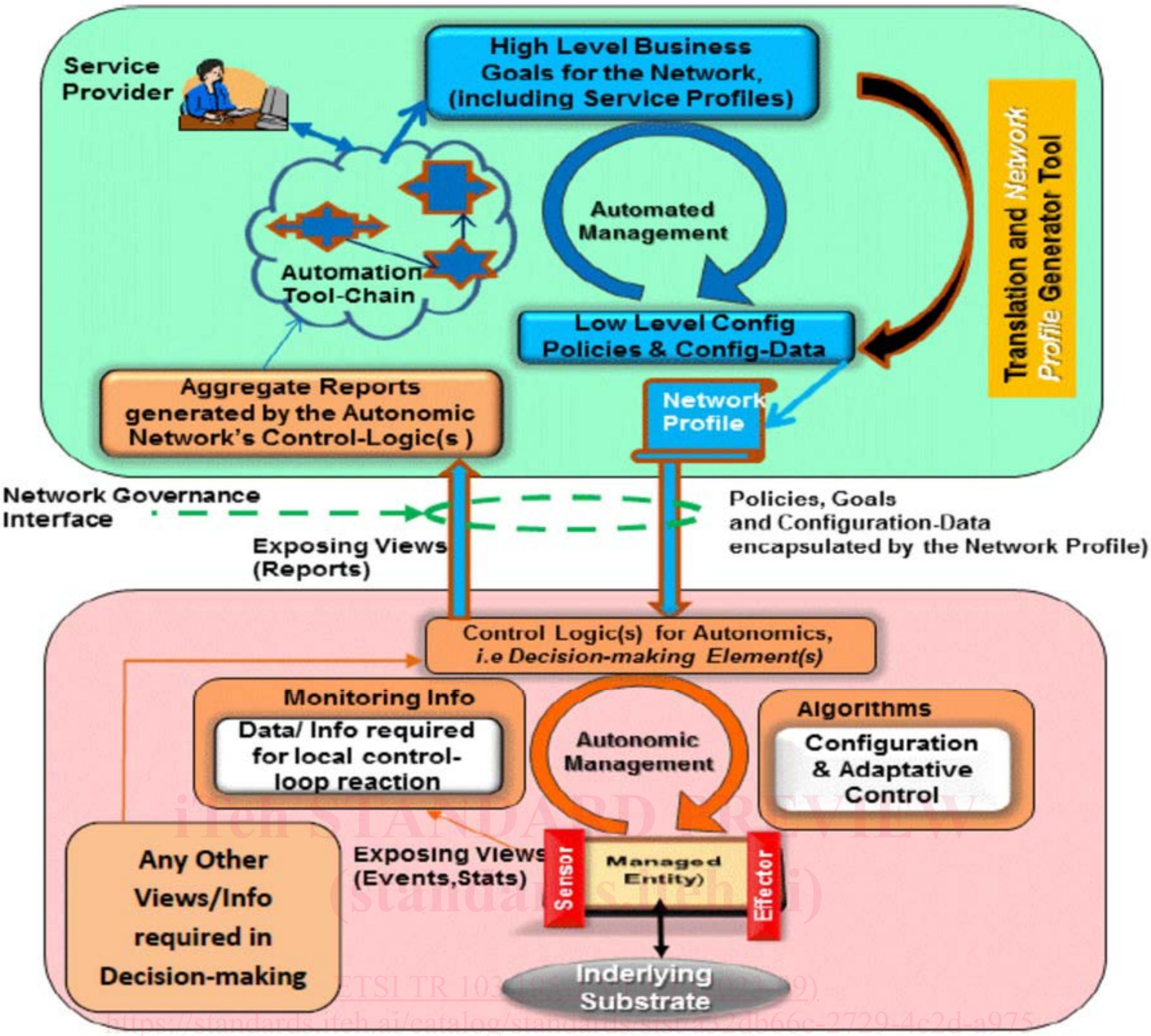

Figure 1: Automated Management vs Autonomic Management illustration (their interaction and complementarity)

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.