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Autonomicity and Self-Management in IMS architecture

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Foreword

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

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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Executive summary

The purpose of the present document is to provide a Framework that serves to guide innovators and implementers of autonomics algorithms (including Artificial Intelligence algorithms) for what are called Autonomic Functions (AFs) instantiated into the IMS architecture and its associated management and control architecture in implementing the prescribed DEs and other GANA enablers for autonomics in IMS. The Autonomics Functions are software components called ETSI GANA Decision-making Elements (DEs) defined in the ETSI standard ETSI TS 103 195-2 [i.5].

Such prescribed GANA autonomics in IMS is meant to enable IMS functions to self-manage and at the same time be dynamically and adaptively policy-controlled by upper Artificial Intelligence-Driven Platform called GANA Knowledge Plane Platform - thanks to the introduction of Decision-making Elements (DEs) and associated control loops at the Network, Node and Function-level of the GANA reference model into the IMS network architecture and associated management and control architecture.

The Framework brings various benefits to stakeholders as described in the present document, stakeholders such as the following:

- Innovators for IMS autonomics DE algorithms, Autonomics Software Suppliers, and IMS Solutions Vendors/Suppliers.
- Communications Service Providers (CSPs) or Network Operators that deploy IMS.
- Researchers researching Autonomic Algorithms for Autonomic Service Management & Control for IMS.

Introduction

This clause introduces the Value of Autonomics in IMS in Evolving & Future Networks is described, as industry moves to Knowledge Planes (KPs) Driven Networking Era.

The following points provide a summarized view of the value of Autonomics in IMS in Evolving & Future Networks:

1) Autonomics is about Self-configuration, Self-diagnosis, Self-protection, Self-optimization, self-awareness, and other Self-* features in the management and control operations of a component (e.g. IMS Function) and the System as a whole (e.g. IMS Platform), using Control-Loops over (re)-configurable Managed Entities (MEs) and parameters of the Component/System.

2) The ETSI GANA Framework prescribes Design and Operational Principles for Autonomic Management & Control (AMC) Software Components (called GANA Decision-making Elements (DEs) that can be instantiated and implemented in Network Elements/Functions (NEs/NFs) and/or in the Management and Control realm of the associated Network Architecture.

3) Examples of Use Cases for Autonomic Management & Control of IMS Functions using GANA Knowledge Plane (KP) Platforms (defined in the clause that follows this present one and in ETSI TS 103 195-2 [i.5] in more detail) and/or by Autonomic Functions introduced and embedded within an IMS Function:

   - IMS Network Function (NF) Auto-Configuration and Adaptive Re-Configuration in detected or predicted situations or contexts.
   - Energy Saving.
   - Signalling Optimization.
   - QoS Optimization, e.g. Latency Optimization with respect processing time at NF, E2E latency, and service delivery to Users.

4) Autonomics in IMS plays an important role in the ETSI GANA based Autonomic & Cognitive Management of 5G Slices & E2E Orchestration - GANA KP Platforms should collaborate in Slice (re)-creation and Assurance based on various Situations and KPIs computed by the KPs. Operations Support System (OSS)/Business Support Systems (BSS), Management and Network Orchestration (MANO), Software-Defined Network (SDN) Controllers, etc., may be used in Slice Creation and KPs takeover the Assurance by adaptively re-programming OSS/BSS, MANO, SDN Controllers in adapting to situations by fixing problems in Slices.

5) The value of GANA autonomics introduced at a higher-level outside of an IMS function is as follows:

   - The present document introduces IP Multimedia Application Layer GANA Knowledge Plane (KP), IMS GANA Knowledge Plane (KP), and Transport Layer GANA Knowledge Plane (KP), and each is responsible for dynamic management and control of the Functions of its corresponding layer it is responsible for by using GANA DEs and DE Algorithms (which include Artificial Intelligence (AI) Algorithms) to dynamically (re)-orchestrate or (re)-configure as driven by Human Operator inputs such as service SLAs and other kinds of configuration data and situations that require the KP to compute a plan of actions to apply to the Functions of the layer in order to enforce a change in the configuration or operation of the Functions.

- Each of the KPs may perform the following, in respect of the Functions of the Layer the KP is responsible for in a standalone manner and/or in collaboration with other KPs that provide it some data/information (e.g. KPIs) of relevance to the operations:
  - Automated service orchestration and provisioning (via Management and Control Systems such as OSS/BSS, SDN Controllers, MANO, etc.).
  - Automatic service resilience and close-loop service adaptation to various challenges detected or predicted in the network such as faults/errors/failures and/or security-threats/attacks/risks and/or performance degradations of various service impacting entities.
  - Autonomic Functions Orchestrations based on resilience and survivability scenarios.
  - End to End Service Level Agreements (E2E SLAs) fulfilment and Assurance by the collaboration of the KP Platforms.
  - Security-Driven Autonomic Service Adaptation.

NOTE 1: Node (NE/NF) level Autonomics (Low-Level Autonomics) by GANA DEs introduced to operate within an IMS Function, e.g. Self-configuration case for an IMS Function such as the HSS with associated Managed Entities (MEs) is illustrated in the present document.

NOTE 2: Higher-Level Autonomics is to be realized by higher level hierarchical GANA DEs of what are called GANA Knowledge Plane (KP) Platform(s), and the present document also provides a framework for implementing GANA KP Level autonomics in the IMS architecture.

In the present document, the **Benefits the Framework for GANA Autonomics in IMS Architectures brings to Key Stakeholders** is described.

The Framework for GANA Autonomics in IMS Architectures presented by the present document brings the following benefit to the key stakeholders indicated:

1) **Benefits to Innovators for IMS autonomics DE algorithms, Autonomics Software Suppliers, and IMS Solutions Vendors/Suppliers:**

   - ETSI Framework on GANA Instantiation onto IMS offers Innovators and Autonomics Software Suppliers guidance on how to implement GANA DEs with associated Analytics and AI Algorithms for Autonomics in IMS in Evolving and Future Networks as Industry Moves to Knowledge Planes (KPs) Driven Networking Era.
   - Federation of Knowledge Planes (KPs) Platforms is required to manage E2E services as IMS is in overlay over every IP capable networks (fixed or mobile networks) and it is always interconnected with Circuit Switched networks and Legacy mobile signalling Networks.

2) **Benefits to CSPs (Communications Service Providers) or Network Operators that deploy IMS:**

   - ETSI GANA DEs instantiated into an IMS Function make the IMS function to exhibit some self-management intelligence pertaining to self-configuration, resilience, self-protecting and self-defending from attacks/risks, self-optimizing its operations, and other self-* features that can be introduced directly into an IMS Function as discussed later in the present document.
   - From OPEX reduction for IMS operations and Innovation opportunities this intelligence implemented in individual IMS functions using DE algorithms for autonomics enables CSPs to benefit from various Business and Operational Scenarios that could be envisaged. While the complementary GANA Knowledge Plane (KP) Platform(s) in IMS environment for Higher-Level Autonomics by higher level hierarchical GANA DEs offer even more benefits when combined with the DEs implemented in IMS Functions in terms of OPEX reduction in operations of IMS and Network Automation based on AI-Driven Orchestration and dynamic adaptation of IMS Services.
   - A GANA KP Platform for IMS Layer (IMS_KP) is used for self-management and control of IMS Network functions using advanced AI Algorithms and Analytics by the KP's DEs.

- GANA DEs' Control-loops can be implemented on any IMS NF for autonomic operations such as autonomic security management (self-protection and self-defense), Self-Configuration (Auto-configuration), Autonomic QoS/QoE Management, Autonomic Fault-Management, as DEs dynamically (re)-configure their associated Managed Entities (as prescribed by the ETSI Framework presented in the present document).

3) Benefits to Researchers researching Autonomic Algorithms for Autonomic Service Management & Control for IMS:

- Researchers can now bring Research Results on Autonomics Algorithms for Dynamic IMS Services to implementing autonomic IMS products according to the ETSI Framework for implementing Autonomics in IMS presented by the present document.

NOTE 3: The various Stakeholders are encouraged to join the ongoing work in ETSI TC INT AFI WG on Autonomics in IMS, or join the Open 5G PoC Program for a Joint Demos on Autonomic IMS in 5G: ETSI *5G PoC on 5G Network Slices Creation, Autonomic & Cognitive Management & E2E Orchestration - with Closed-Loop (Autonomic) Service Assurance:* https://intwiki.etsi.org/index.php?title=Accepted_PoC_proposals.

1 Scope

The present document provides a Framework of an ***Autonomicity-enabled IP Multimedia Subsystem (IMS) Architecture***. It focuses on the standardized IP Multimedia Subsystem reference architecture.

The present document describes:

- A high level GANA Autonomicity-enabled 3GPP IMS architecture, based on the instantiation of GANA Functional Blocks (FBs) for autonomics and their Reference Points (Rfps) that serve as enablers for autonomic management and control operations in IMS architecture and its associated management and control architecture. The GANA FBs include Decision-making Elements (DEs) and other types of GANA functional entities described in the present document.
- Autonomicity-enabled IMS functions like Media Gateway Control Function (MGCF), Media Gateway Function (MGF), Application Server (AS) and end to end Network Management, thanks to the instantiation of the GANA autonomics enablers onto the IMS functions and the overall IMS architecture.
- An analysis of significant GANA Decision-making Elements (DEs) for implementing Hierarchical Control-Loops for closed-loop management and control of network resources, parameters and services, and Reference Points associated with GANA Functional Blocks (FBs) that should be considered in introducing autonomics in IMS service orchestration, management and control, based on deployment scenarios.
- How to achieve E2E Closed-Loop (Autonomic) IMS Services Assurance and Security Assurance by Federated GANA Knowledge Plane (KP) Platforms.

The present document provides the recommendations that innovators and implementers of autonomics algorithms (including Artificial Intelligence algorithms) for the GANA DEs instantiated into the IMS architecture and its associated management and control architecture should follow in implementing the prescribed DEs and other GANA enablers for autonomics in IMS. Such prescribed GANA autonomics is meant to enable IMS functions to self-manage and at the same time be dynamically and adaptively policy-controlled by upper Artificial Intelligence-Driven Platform called GANA Knowledge Plane Platform - thanks to the introduction of Decision Elements (DEs) and associated control loops at the Network, Node and Function-level of the GANA reference model into the IMS network architecture and associated management and control architecture.

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.

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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.5] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 103 195-2 [i.5] and the following apply:

2G	Second generation of mobile technologies
3G	Third generation of mobile technologies
4G	Fourth generation of mobile technologies
5G	Fifth generation of mobile technologies
xDSL	different variations of Digital Subscriber Line

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 195-2 [i.5] and the following apply:

3GPP	3rd Generation Partnership Project
5GC	5G Core network
AF	Autonomic Function
AFI	Autonomic network engineering for the self-managing Future Internet
AGW	Access GateWay
AI	Artificial Intelligence
AMC	Autonomic Management and Control
AN	Access Network
API	Application Protocol Interface
AS	Application Server
AS-SCC	Application Server - Service Centralization and Continuity
BBF	BroadBand Forum
BCF	Border Control Function
BGCF	Breakout Gateway Control Function
BNG	Border Network Gateway
BSS	Business Support Systems
CEP	Complex Event Processing
CN	Core Network
CPE	Customer Premises Equipment
CS	Circuit Switch
CS_KP	Circuit Switch Knowledge Plane
CSCF	Call Session Control Function
C-SON	Centralized SON
CSP	Communications Service Providers
CSS	Call Stability Score
DE	Decision-making Element
DevOps	Development and Operations
D-SON	Decentralized SON
E2E	End to End

eMBB	enhanced Mobile Broadband
EMS	Element Management System
eNB	Enhanced Node B
EPC	Evolved Packet Core
FB	Functional Block
FCAPS	Fault, Configuration, Accounting, Performance and Security
FE	Functional Entity
FM	Fault Management system
FTTH	Fiber To The Home
GANA	Generic Autonomic Network Architecture
GS	Group Specification
HSS	Home Subscriber Service
I-CSCF	Interrogating Call Session Control Function
I-CSCF	Interrogating Call Session Control Function
IEEE	Institute of Electrical and Electronics Engineers
IM	IP Multimedia
IMS	IP Multimedia Subsystem
IMS_KP	IMS Knowledge Plane
INT	core network and Interoperability Testing
IoT	Internet of Things
IP	Internet Protocol
IP-CAN	IP-Connectivity Access Networks
IPFIX	IP Flow Information eXport
IPM_KP	IP Multimedia networks Knowledge Plane
IT	Information Technology
KP	Knowledge Plane
KPI	Key Performance Indicator
LMS_KP	Legacy Mobile Signalling network Knowledge Plane
LTE	Long Term Evolution
M2M	Machine to Machine
MANO	Management and Network Orchestration
MBTS	Model Based Translation Services
ME	Managed Entity
MGCF	Media Gateway Control Function
MGF	Media Gateway Function
MGW	Media GateWay
MIB	Management Information Base
ML	Machine Learning
MMC	Man-Machine Communication
mMTC	massive Machine-Type Communications
MO	Management Object
MRFC	Multimedia Resource Control Function
MRFP	Multimedia Resources Function Processor
NAT	Network Address Translation
NE	Network Element
NF	Network Function
NFV	Network Functions Virtualisation
NFVO	Network Functions Virtualization Orchestrator
NGMN	Next Generation Mobile Networks
NMS	Network Management System
OAM	Operating and Maintenance
ODA	Open Digital Architecture
ONAP	Open Network Automation Platform

NOTE: Available at https://www.onap.org/.

ONIX	Overlay Network for Information eXchange
OOB	Out-Of-Band
OPEX	OPeration EXpenditure
OSS	Operation Support System
OTT	Over The Top
PCEF	Policy Control Enforcement Function

PCRF	Policy Control Resource Function
P-CSCF	Proxy Call Session Control Function
PDP	Packet Data Protocol
P-I-S-CSCF	Proxy- Interrogating- Serving- Call Session Control Function
PLMN	Public Land Mobile Network
PM	Performance Management system
PNF	Physical Network Function
PoC	Proof of Concept
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Services
RAN	Radio Access Network
RCA	Root Cause Analysis
RCS	Rich Communication Services
Rfp	Reference point
RTP	Real Time Transport Protocol
S-CSCF	Serving Call Session Control Function
S-CSCF	Serving Call Session Control Function
SDN	Software-Defined Network
SDO	Standards Development Organization
SEC	Security
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLF	Subscription Locator Function
SNMP	Simple Network Management Protocol
SON	Self Organizing Network
SPAN	Switch Port Analyser (also called Port Mirroring)
STUN	Simple Traversal of User Datagram Protocol (UDP) Through Network Address Translators (NATs)
TAP	Test Access Point
TAS	Telephony Application Server
TC	Technical Committee
TISPAN	Telecommunications and Internet converged Services and Protocols for Advanced Networking
TMForum	TeleManagement Forum
UA	User Agent
UE	User Equipment
URLLC	Ultra-Reliable Low Latency Communications
VIM	Virtual Infrastructure Manager
vIMS	Virtual IMS
VNF	Virtual Network Function
VoLTE	Voice over LTE
VoWiFi	Voice over WiFi™
vTAP	Virtual TAP
WAN	Wide Area Network
WG	Working Group
xDSL	Digital Subscriber Line

4 About the ETSI GANA Reference Model for Autonomic Networking, Cognitive Networking and Self-Management of Networks and Services

4.1 Overview

ETSI TS 103 195-2 [i.5] defines the concept of Autonomic Manager element or "engine" (called a "Decision-making Element" (DE) in the GANA terminology) as a functional entity that drives a control-loop meant to configure and adapt (i.e. regulate) the behaviour or state of a Managed Entity (i.e. a resource) - usually multiple Managed Entities (MEs).

The ETSI GANA Standardized Framework for Autonomic Management and Control (AMC) (ETSI TS 103 195-2 [i.5]) defines an Intelligent Management and Control Functional Block called GANA Knowledge Plane (KP) that is an integral part of AMC Systems that provides for the space to implement complex network analytics functions performed by interworking Modularized and specialized DEs. The GANA KP DEs run as software in the Knowledge Plane and drive self-* operations such as self-adaptation, self-optimization, self-monitoring objectives for the network and services by programmatically (re)-configuring Managed Entities (MEs) in the network infrastructure through various means possible: e.g. through the North-Bound Interfaces available at the OSS, Service Orchestrator, Domain Orchestrator, SDN controller, EMS/NMS, NFV Orchestrator, etc.

The GANA KP consists of multiple modularized DEs. In contrast to non-modularized management systems, each DE is expected to be a module (as atomic block, FB) and that it should address a very specific "management domain (scope of management aspects/problems)" such that it can run as a "micro service". Examples of autonomic manager elements (i.e. DEs) are: QoS-management-DE, Security-management-DE, Mobility-management-DE, Fault-management-DE, Resilience & Survivability-DE, Service & Application management-DE, Forwarding-management-DE, Routing-management-DE, Monitoring-management-DE, Generalized Control Plane management-DE. DE components of the GANA KP are "macro" autonomic managers (atomic and modular) that drive logically centralized network-wide with slow control loops that operate in "slower timescale" than similar control-loops introduced to run in Network Elements (NEs) and operating as "fast control-loops". Macro autonomic managers (GANA KP DEs) should be complemented by "micro" Autonomic Manager components (DEs injected into NEs) that can be introduced in the Network Elements (physical or virtualized) for driving local intelligence within individual network elements to realize "fast control-loops" in network elements. Macro autonomic managers (GANA KP DEs) policy-control the "micro" autonomic managers (GANA DEs in NEs - i.e. the so-called GANA Level-2 and Level-3 in ETSI TS 103 195-2 [i.5].

ETSI work on E2E autonomic networking involves introducing self-manageability (autonomics) properties (e.g. self-*configuration, self-diagnosis, self-repair, self-healing, self-protection, self-awareness, etc.) within network nodes/functions (NEs) themselves and also enabling distributed "in-network"* self-management within the data plane network architectures (and their embedment of "thin control planes"). This low level intelligence (autonomics) achievable by so-called "GANA DEs" that should be instantiated to drive fast control-loops within network nodes/elements (NEs) and to also drive horizontal self-adaptive collaborative "in-network" behaviour involving the collaboration of certain autonomic nodes is also called "Micro level" autonomics ("fast control loops"). The low-level autonomics should be complemented and policy-controlled (governed) by higher level autonomics ("slow control loops") (at "Macro level") achievable and driven by higher level "GANA **KP** DEs" responsible for network-wide and logically centralized autonomic management and control of networks and services. At "Macro level", the autonomics paradigm (control loops) is introduced outside of Network Elements (NEs), in the outer, logically centralized, management and control planes architectures of a particular target network. This "realm" for implementing the much more complex, cognitive and analytics algorithms (including Artificial Intelligence (AI) Algorithms) for autonomics that operate on network-wide views is called the GANA Knowledge Plane (GANA KP). The three key Functional Blocks of the GANA KP are summarized below:

- **GANA Network-Level DEs: Decision-making Elements (DEs)** whose scope of input is network wide in implementing "slower control-loops" that perform policy control of lower level GANA DEs (for fast control-loops) instantiated in Network nodes/Elements (NEs). GANA Network Level DEs operate in what is called the GANA Knowledge Plane (KP) and so are an integral part of a GANA KP. A GANA KP should be implemented to run as and operate as a Platform. The GANA Network Level DE are meant to be designed to operate the outer closed control loops on the basis of network wide views or state as input to the DEs' algorithms and logics for autonomic management and control (the "Macro-Level" autonomics). The GANA Network-Level-DEs (Knowledge Plane DEs) can designed to run as a "micro service".