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TECHNICAL REPORT

**Network Technologies (NTECH);
Autonomic network engineering for
the self-managing Future Internet (AFI);
Autonomicity and Self-Management in
the Broadband Forum (BBF) Architectures**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Network Technologies (NTECH).

Modal verbs terminology

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1 Scope

The present document aims at providing recommendations for the introduction of autonomics (management and control intelligence) into the fixed broadband access and aggregation networks specified in the Broadband Forum (BBF) Architecture specifications. To this effect, it covers the instantiation of the reference model for Autonomic Networking, Cognition and Self-Management, called GANA (Generic Autonomic Networking Architecture) [i.1], starting from the reference architecture defined in BBF TR 101 [i.6], and considering also BBF TR 178 [i.7] and BBF TR 317 [i.28] reports. It superimposes GANA Decision Elements (DEs) into nodes/devices and the overall BBF network architecture, so that the DEs and their associated control-loops can be further designed to perform autonomic management and control of the specific resources (Managed Entities) in the target architecture.

Based on this, the present document identifies the requirements for autonomic behaviours (Autonomics Functions/DEs) across the fixed broadband access and aggregation network segments of the BBF reference architecture and provides recommendations on where and how the GANA Functional Blocks (including DEs) should be instantiated. It further extends these recommendations to the virtualized manifestation of these segments considering their virtualized evolution in conjunction with SDN and NFV technologies. Finally, it also provides recommendations on the interworking and coordination between autonomic functions among GANA-BBF and GANA-3GPP (Core Network) domains, as well as recommendations on the Interworking and coordination between virtualized GANA-BBF and virtualized GANA-3GPP (Core Network) domains.

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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NOTE: This GS is now undergoing a transformation to an ETSI TS 103 195-2 [i.30] that has been published by ETSI in 2018: http://www.etsi.org/deliver/etsi_ts/103100_103199/10319502/01.01.01_60/ts_10319502v010101p.pdf.

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3 Definition of terms and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 195-2 [i.30] and the following apply:

access network: network that encompasses the elements of the broadband network from the NID at the customer premises to a Broadband Network Gateway

NOTE: This network typically includes one or more types of Access Node and can include an Ethernet aggregation function.

Access Node (AN): network node located in the access network, which can implement one or more access technologies based on copper, fibre or wireless

aggregation network: network segment that stretches from the Access Nodes to the Broadband Network Gateway(s)

NOTE: In the context of the present document the aggregation network is considered to be Ethernet based, providing standard Ethernet interfaces at the edges, for connecting the Access Nodes and Broadband Network Gateway(s), and some transport for Ethernet frames (e.g. Ethernet over SONET, MPLS, RPR, etc.) at the core.

autonomic networking: networking paradigm that enables network devices or elements (physical or virtual) and the overall network architecture and its management and control architecture to exhibit the so-called self-managing properties

NOTE 1: Autonomic networking includes: auto-discovery of information and entities, Self-configuration (auto-configuration), Self-diagnosing, Self-repair (Self-healing), Self-optimization, and other self-* properties.

NOTE 2: Autonomic Networking can also be interpreted as a discipline involving the design of systems (e.g. network nodes) that are self-managing at the individual system levels and together as a larger system that forms a communication network of systems.

NOTE 3: The term "autonomic" comes from the autonomic nervous system (a closed control loop structure), which controls many organs and muscles in the human body. Usually, human are unaware of its workings because it functions in an involuntary, reflexive manner - for example, human do not notice when their heart beats faster or their blood vessels change size in response to temperature, posture, food intake, stressful experiences and other changes to which human are exposed. And their autonomic nervous system is always working [i.4].

autonomically: by virtue of employing a control-loop (including feedback control-loop(s))

Broadband Network Gateway (BNG): access point to the provider's IP network for wireline broadband services

non-aggregated scenario: scenario of 3GPP architecture without the aggregation of other types of networks, e.g. previous generations of mobile networks

self-advertising: capability of a component or system to advertise its self-model, capability description model, or some information signalling message (such as an Ipv6 router advertisement message) to the network in order to enable other entities to discover it and be able to communicate with it, or to enable other entities to know whatever is being advertised

self-awareness: capability of a component or system to "know itself" and be aware of its state and its behaviours. Knowledge about "self" is described by a "self-model"

self-configuration: capability of a component or system to configure and reconfigure itself under varying and unpredictable conditions

self-descriptive: capability of a component or system to provide a description of its self-model, capabilities and internal state

self-organizing function: function that includes processes which require minimum manual intervention

self-protecting: capability of a component or system to be capable of detecting and protecting its resources from both internal and external attack and maintaining overall system security and integrity

self-regulation: capability of a component or system to regulate its internal parameters so as to assure a quality-of-service metric such as reliability, precision, rapidity, or throughput

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAA	Access, Authentication and Authorization
ACL	Access Control List
ACS	Access Control System
AF	Autonomic Function
AI	Artificial Intelligence
AMC	Autonomic Management & Control
AN	Access Node
ANEC	Access Node Externalized Control
ANLC	Access Node Localized Control
API	Application Programming Interface
APN	Access Point Name
ARP	Address Resolution Protocol
ASSIA	Adaptive Spectrum and Signal Alignment
BAA	Broadband Access Abstraction
BBF	BroadBand Forum
BNG	Broadband Network Gateway
BPCF	Broadband Policy Control Function
BRG	Bridged Residential Gateway
BS	Base Station
BSS	Business Support System
CEP	Complex Event Processing
CPE	Customer Premises Equipment
DBA	Dynamic Bandwidth Allocation
DE	Decision Element
DHCP	Dynamic Host Configuration Protocol
DMCF	Domain Management Coordination Function
DSL	Digital Subscriber Line
EM	Element Management
EMS	Element Management System
EPC	Evolved Packet Core
ERPS	Ethernet Ring Protection Switching
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FANS	Fixed Access Network Sharing
FB	Functional Blocks
FCAPS	Fault, Configuration, Accounting, Performance, Security
FI-WARE	European Commission funded project (called FI-WARE) under the Commission's R&D Framework Program FP7
FMC	Fixed Mobile Convergence
GANA	Generic Autonomic Network Architecture
GRE	Generic Routing Encapsulation
GW	GateWay
HD-TV	High Definition Television
IBM	International Business Machines (Corporation)
IETF	Internet Engineering Task Force
IFOM	IP Flow Mobility
IGMP	Internet Group Management Protocol
IMS	IP Multimedia Subsystem

IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
IPFIX	Internet Protocol Flow Information eXport
IPoE	Internet Protocol over Ethernet
IPTV	Internet Protocol Television
IPv6	Internet Protocol version 6
KP	Knowledge Plane
LACP	Link Aggregation Control Protocol
LAN	Local Area Network
LCP	Link Control Protocol
LDAP	Leightweight Directory Access Protocol
LSL	Logical Subscriber Link
LSO	MEF Lifecycle Service Orchestration
MAC	Medium Access Control
MANO	Management and Orchestration
MBTS	Model Based Translation Service
MCO	Management Control Orchestration (MCO)
ME	Managed Entity
MEF	Metro Ethernet Forum
MME	Mobility Management Entity
MPLS	Multi-Protocol Label Switching
MTU	Maximum Transmission Unit
MUX	Multiplexer
NA	Not Applicable
NB	Node-B
NE	Network Element
NERG	Network Enhanced Residential Gateway
NFV	Network Function Virtualisation
NFVI	Network Functions Virtualisation Infrastructure
NFVO	Network Functions Virtualisation Orchestrator
NM	Network Management
NPS	Net Promoter Score
NSWO	Non-Seamless WLAN Offload
OAM	Operations, Administration and Management
ONIX	Overlay Network for Information eXchange
OPEX	OPeration EXpenditure
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
OSS	Operation and Support System
OTT	Over The Top
PADI	PPPoE Active Discovery Initiation
PADO	PPPoE Active Discovery Offer
PADR	PPPoE Active Discovery Request
PADS	PPPoE Active Discovery Session-confirmation
PADT	PPPoE Active Discovery Terminate
PCRF	Policy and Charging Rules Function
PDN	Packet Data Network
PNF	Physical Network Function
PON	Passive Optical Network
PPP	Point of Presence Protocol
PPPoE	Point-to-Point Protocol over Ethernet
QoE	Quality of Experience
QoS	Quality of Service
RADIUS	Remote Authentication Dial-In User Service
RCA	Root Cause Analysis
RFC	Request For Comments
RG	Residential Gateway
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
SDAN	Software Defined Access Network
SDN	Software Defined Networks
SLA	Service Level Agreement

SNMP	Simple Network Management Protocol
SON	Self Organizing Networks
SP	Service Provider
SPML	Service Provisioning Markup Language
STP	Spanning Tree Protocol
TCP	Transfer Control Protocol
TCP/IP	Transfer Control Protocol/Internet Protocol
TV	Television
UE	User Equipment
VC	Virtual Circuit
VIM	Virtual Infrastructure Manager
VLAN	Virtual Local Area Network
VNF	Virtual Network Function
VNFM	Virtual Network Function Manager
VNO	Virtual Network Operator
VP	Virtual Path
WAN	Wide Area Network
WI-FI	IEEE 802.11 family of standards
WLAN	Wireless Local Area Network
WT	BBF Working Text
XML	eXtensible Markup Language
YANG	Yet Another Next Generation

4 Background and Introduction to the ETSI GANA Reference Model

4.1 Background

Autonomic Networking & Services Management is intended to help operators and enterprises in reducing OPEX and handling the increasing complexity of network Management. The ETSI AFI WG of TC NTECH produces specifications for the Autonomic Networking & Services Management, namely the Generic Autonomic Network Architecture (GANA) Architectural Reference Model for Autonomic Networking, Cognitive Networking and Self-Management; and its instantiations onto various reference network architectures and their associated management and control architectures to enable the implementation of autonomics, cognition and self-management in the architectures. The TC is now progressing in producing technical reports on instantiation of the GANA Reference Model onto existing reference network architectures and emerging ones to embed self-management capabilities in those reference network architectures and their associated management and control architectures. In GANA empowered autonomic and self-managed networks, self-management capabilities are realized by special autonomic management and control software components (called Decision Elements (DEs) in GANA) that implement cognitive algorithms and dynamically orchestrate and configure resources and parameters of the network to achieve self-configuration, self-diagnosis, self-healing, self-optimization, self-protection, and other self-* features.

Though the GANA model was validated in testbeds, a key step towards adoption of autonomics by the industry is to instantiate it onto a set of representative well-known reference architectures in order to enable launching pilot projects on concrete use cases. This is because many network architectures being deployed today do not intrinsically exhibit autonomicity and self-management capabilities, and industry needs to understand the implication of evolving them towards this technology.

The objective of the present document is to develop a Technical Report on the instantiation of the GANA model on the BBF Architecture specifications. More specifically, it is required to perform a mapping on fixed broadband access, aggregation network architectures and the convergence and integration of GANA with SDN/NFV.

The work has been divided into several tasks which are reflected in the following clauses. The first task consisted in defining the BBF reference architecture to be addressed. This is reported in clause 5. In a second step, a mapping of the GANA model onto the BBF architecture was defined for the key components of the architecture. This is reported in clause 6. The final task consists in considering SDN/NFV convergence with GANA Functional Blocks in the same architecture consisting of GANA autonomics enabled network architecture and its associated management and control architecture. This will be reported in clause 7.