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Autonomicity and Self-Management in the Backhaul
and Core network parts of the 3GPP Architecture

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
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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) in the 3GPP Core and Backhaul network architectures. To this effect, it covers the instantiation of the reference model for Autonomic Networking, Cognition and Self-Management, called GANA (Generic Autonomic Networking Architecture), onto the architecture defined in ETSI TS 123 401 [i.2] and ETSI TS 123 402 [i.35]. It superimposes GANA Decision Elements (DEs) into node/device architectures and the overall 3GPP 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. It develops recommendations on the basic behaviours of the GANA Functional Blocks (FBs) in the above context. 3GPP specifications on policy control (ETSI TS 123 203 [i.3]) and network management (TS 123 32x series) are taken into account into the working reference architecture. It also involves the backhaul network and associated interactions between the different entities for an optimization with an end-to-end perspective.

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] ETSI TS 123 002 (V12.5.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Network architecture (3GPP TS 23.002 version 12.5.0 Release 12)".

[i.2] ETSI TS 123 401 (V13.6.1): "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401 version 13.6.1 Release 13)".

[i.3] ETSI TS 123 203 (V13.8.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Policy and charging control architecture (3GPP TS 23.203 version 13.8.0 Release 13)".

[i.4] ETSI TS 132 501 (V13.0.0): "Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Self-configuration of network elements; Concepts and requirements (3GPP TS 32.501 version 13.0.0 Release 13)".

[i.5] ETSI TS 132 541 (V13.0.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Self-Organizing Networks (SON); Self-healing concepts and requirements (3GPP TS 32.541 version 13.0.0 Release 13)".

[i.6] ETSI NTECH AFI White Paper (draft): "The GANA (Generic Autonomic Networking Architecture) Reference Model for Autonomic Networking, Cognitive Networking and Self-Management of Networks and Services".

[i.7] ETSI Draft DTR/NTECH-AFI-0018-GANA-Mesh: "Network Technologies (NTECH);Autonomic network engineering for the self-managing Future Internet (AFI); Autonomicity and Self-Management in Wireless Ad-hoc/Mesh Networks".

[i.8] 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.9] NGMN Alliance (2008): "NGMN Recommendation on SON and O&M Requirements".

NOTE: Available at https://www.ngmn.org/uploads/media/NGMN_Recommendation_on_SON_and_O_M_Requirements.pdf.

[i.10] Andrea Fabrizi: "NFV self-adaptive networks; Integrate your control plane with analytics", HP Viewpoint paper, July 2015.

NOTE: Available at https://www.hpe.com/h20195/V2/getpdf.aspx/4AA4-6147ENW.pdf.

[i.11] Ranganai Chaparadza, Tayeb Ben Meriem, John Strassner, Steven Wright and Joel Halpern: "Industry Harmonization for Unified Standards on Autonomic Management & Control of Networks and Services, SDN, NFV, E2E Orchestration, and Software-oriented enablers for 5G", Report from the Joint SDOs/Fora Workshop hosted by TMForum during TMForum Live 2015 Event Nice, France (June 4th, 2015).

[i.12] NGMN Alliance: "RAN Evolution Project, Backhaul and Fronthaul Evolution", 31 March 2015.

NOTE: Available at http://docplayer.net/10579127-Ran-evolution-project-backhaul-and-fronthaul-evolution.html.

[i.13] ETSI TS 129 274 (V13.6.0): "Universal Mobile Telecommunications System (UMTS); LTE; 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3 (3GPP TS 29.274 version 13.6.0 Release 13)".

[i.14] ETSI TS 129 281 (V13.2.0): "Universal Mobile Telecommunications System (UMTS); LTE; General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U) (3GPP TS 29.281 version 13.2.0 Release 13)".

[i.15] ETSI TS 129 272 (V13.6.0): "Universal Mobile Telecommunications System (UMTS); LTE; Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol (3GPP TS 29.272 version 13.6.0 Release 13)".

[i.16] ETSI TS 129 061 (V13.4.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN) (3GPP TS 29.061 version 13.4.0 Release 13)".

[i.17] ETSI TS 129 212 (V13.6.0): "Universal Mobile Telecommunications System (UMTS); LTE; Policy and Charging Control (PCC); Reference points (3GPP TS 29.212 version 13.6.0 Release 13)".

[i.18] ETSI TS 132 251 (V13.5.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Packet Switched (PS) domain charging (3GPP TS 32.251 version 13.5.0 Release 13)".

[i.19] IETF RFC 4006: "Diameter Credit-Control Application".

[i.20] ETSI TS 132 295 (V13.0.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Charging Data Record (CDR) transfer (3GPP TS 32.295 version 13.0.0 Release 13)".

[i.21] ETSI TS 129 219 (V13.3.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Policy and charging control: Spending limit reporting over Sy reference point (3GPP TS 29.219 version 13.3.0 Release 13)".

[i.22] ETSI TS 132 102 (V13.0.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Architecture (3GPP TS 32.102 version 13.0.0 Release 13)".

[i.23] 3GPP TR 23.705 (V13.0.0) (12-2014): "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on system enhancements for user plane congestion management (Release 13)".

[i.24] 4G Americas white paper: "Self-Optimizing Networks: The Benefits of SON in LTE", October 2013.

NOTE: Available at http://www.4gamericas.org/files/7714/0759/1264/Self-Optimizing_Networks-Benefits_of_SON_in_LTE_10.7.13.pdf.

[i.25] ETSI TS 132 426 (V13.0.0): "LTE; Telecommunication management; Performance Management (PM); Performance measurements Evolved Packet Core (EPC) network (3GPP TS 32.426 version 13.0.0 Release 13)".

[i.26] 3GPP TR 23.857 (V11.0.0) (12-2012): "Technical Specification Group Core Network and Terminals; Study of Evolved Packet Core (EPC) nodes restoration (Release 11)".

[i.27] ETSI TS 129 211 (V6.4.0): "Universal Mobile Telecommunications System (UMTS); Rx Interface and Rx/Gx signalling flows (3GPP TS 29.211 version 6.4.0 Release 6)".

[i.28] ETSI TS 132 299 (V13.5.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Diameter charging applications (3GPP TS 32.299 version 13.5.0 Release 13)".

[i.29] ETSI TS 129 214 (V13.6.0): "Universal Mobile Telecommunications System (UMTS); LTE; Policy and charging control over Rx reference point (3GPP TS 29.214 version 13.6.0 Release 13)".

[i.30] ETSI TS 132 101 (V13.0.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Principles and high level requirements (3GPP TS 32.101 version 13.0.0 Release 13)".

[i.31] IETF Draft: "IP based Generic Control Protocol (IGCP): draft-chaparadza-intarea-igcp-00.txt".

NOTE: Available at https://tools.ietf.org/html/draft-chaparadza-intarea-igcp-00.

[i.32] NGMN Alliance: "Recommended Practices for Multi-vendor SON Deployment", Deliverable D2, 28 January 2014.

NOTE: Available at https://www.ngmn.org/uploads/media/P-Small_Cells_WS2_Multivendor_Recommended_Practices_v1_0.pdf

[i.33] ETSI TS 103 371: " Network Technologies (NTECH); Autonomic network engineering for the self-managing Future Internet (AFI); Proofs of Concept Framework".

[i.34] 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.35] ETSI TS 123 402 (V13.6.0): "Universal Mobile Telecommunications System (UMTS); LTE; Architecture enhancements for non-3GPP accesses (3GPP TS 23.402 version 13.6.0 Release 13)".

[i.36] ETSI TS 129 215: "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Policy and Charging Control (PCC) over S9 reference point; Stage 3 (3GPP TS 29.215)".

[i.37] ETSI TS 123 228: "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia Subsystem (IMS); Stage 2 (3GPP TS 23.228)".

[i.38] ETSI ES 283 035: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Network Attachment Sub-System (NASS); e2 interface based on the DIAMETER protocoll".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Autonomic Behaviour (AB): process which understands how desired Managed Entity (ME) behaviours are learned, influenced or changed, and how, in turn, these affect other elements, groups and network [i.34]

NOTE: In the GANA model, an autonomic behaviour is any behaviour of a DE that is observable on its interfaces. Autonomic function (AF) desired element's behaviour in order to learn, influence, or changed on how it turns its effect on other elements or groups of element or network.

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, namely: auto-discovery of information and entities, Self-configuration (auto-configuration), Self-diagnosing, Self-repair (Self-healing), Self-optimization, and other self-* properties

NOTE 1: 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 2: 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.34].

Complex Event Processing (CEP): data processing discipline which correlates data from multiple sources to identify patterns of events

context aware: capability of a component or system to be aware of its execution environment, the objectives it is supposed to meet and possibly the consequences of not delivering on the objectives, and be able to react to changes in the environment

Decision Making Element (DME): functional entity designed and assigned to autonomically manage and control its assigned Managed Entities (MEs) by dynamically (re)-configuring the MEs and their configurable and controllable parameters in a closed-control loop fashion.

NOTE 1: Decision Making Elements (DMEs) [i.15] referred in short as Decision Elements (DEs) fulfil the role of Autonomic Manager Elements.

NOTE 2: In GANA a DE is assigned (by design) to very specific MEs that it is designed to autonomically manage and control (ETSI GS AFI 002 [i.8] provides more details on the notion of ownership of MEs by specific DEs required in a network element architecture and the overall network architecture).

Managed Entities (Mes): physical or logical resource that can be managed by an Autonomic Manager Element (i.e. a Decision Element) in terms of its orchestration, configuration and re-configuration through parameter settings [i.34]

NOTE: MEs and their associated configurable parameters are assigned to be managed and controlled by a concrete DE such that an ME parameter is mapped to one DE. Mes can be protocols, whole protocol stacks, and mechanisms, meaning that they can be fundamental functional and manageable entities at the bottom of the management hierarchy (at the fundamental resources layer in a network element or node) such as individual protocols or stacks, OSI layer 7 or TCP/IP application layer applications and other types of resources or managed mechanisms hosted in a network element (NE) or in the network in general, whereby an ME exposes a management interface through which it can be managed. Mes can also be composite Mes such as whole Nes themselves (i.e. Mes that embed sub-Mes).

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

overlay: logical network that runs on top of another network

NOTE: For example, peer-to-peer networks are overlay networks on the Internet. They use their own addressing system for determining how files are distributed and accessed, which provides a layer on top of the Internet's IP addressing.

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-healing: capability of a component or system to detect and recover from problems (manifestations of faults, errors, failures, and other forms of degradation) and continue to function smoothly

self-monitoring: capability of a component or system to observe its internal state, for example by monitoring quality-of-service metrics such as reliability, precision, rapidity, or throughput

self-optimization: capability of a component or system to detect suboptimal behaviours and optimize itself to improve its execution

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 Symbols

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

Gx	Reference point between PCEF and PCRF
Gy	Reference point between OCS and PCEF
Gyn	Reference point between OCS and TDF
Gz	Reference point between OFCS and PCEF
Gzn	Reference point between OFCS and TDF
Itf-N	Interface between the Network (Element Manager or NEs with an embedded EM) and the Network Manager
Itf-P2P	Interface between peer Domain Managers

Np	Reference point between RCAF and PCRF
Rx	Reference point between PCRF and AF
S3	Reference point between MME and SGSN
S4	Reference point between S-GW and SGSN
S5	Reference point between S-GW and P GW
S6a	Reference point between MME and HSS
S6d	Reference point between SGSN and HSS
S11	Reference point between MME and S-GW
Sd	Reference point between TDF and PCRF
Sgi	Reference point between PDN GW and packet data networks
Sp	Reference point between SPR and PCRF
Sy	Reference point between OCS and PCRF

3.3 Abbreviations

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

3GPP	3rd Generation Partnership Project
AC_DE	Auto-Configuration Decision Element
AF	Autonomic Function
AFI	Autonomic network engineering for the self-managing Future Internet
AMC	Autonomic Management and Control
AN	Access Network
ANDSF	Access Network Discovery and Selection Function
ANIMA	Autonomic Networking Integrated Model and Approach
AP	Access Point
APN	Access Point Name
BG	Border Gateway
BGP	Border Gateway Protocol
BH	BackHaul
CAPEX	Capital Expenditures
CEP	Complex Event Processing
CMIP	Common Management Information Protocol
CN	Core Network
CN-EMS	Core Network-Element Management System
CN-NMS	Core Network-Network Management System
COPS	Common Open Policy Service
CORBA	Common Object Request Broker Architecture
CORBA IIOP	Common Object Request Broker Architecture Internet Inter-ORB Protocol
CPU	Central Processing Unit
CSON	Centralized SON
C-SON	Centralized Self-Organizing Network
DE	Decision-making-Element
DHCP	Dynamic Host Configuration Protocol
DL	DownLink
DPI	Deep Packet Inspection
e2e	end-to-end
EIR	Equipment Identity Register
EM	Element Manager
EMS	Element Management System
EPC	Evolved Packet Core
EPC-KP	Evolved Packet Core-Knowledge Plane
EPS	Evolved Packet System
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FB	Functional Block
FM_DE	Fault Management Decision Element
GANA	Generic Autonomic Network Architecture
GERAN	GSM EDGE RAN
GMLC	Gateway Mobile Location Centre
GPRS	General Packet Radio service
GRASP	GeneRic Autonomic Signalling Protocol

GS	Group Specifications
GTP	GPRS Tunnelling Protocol
GTP-C	GPRS Tunnelling Protocol control plane
GTP-U	GTP user plane
GW	GateWay
HLR	Home Location Register
HSS	Home Subscriber Server
HW	HardWare
IDE	Incident Dissemination Engine
IETF	Internet Engineering Task Force
IGCP	ICMPv6 based Generic Control Protocol
IIOP	Internet Inter-Object request broker Protocol
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IP-CAN	IP Connectivity Access Network
KP	Knowledge Plane
KPI	Key Performance Indicator
LBI	Linked Bearer ID
LS	Liaison Statement
LTE	Long Term Evolution
LTE-A	LTE-Advanced
MBTS	Model-Based-Translation Service
ME	Managed Entity
MIB	Management Information Base
MM	Mobility Management
MME	Mobility Management Entity
MNO	Mobile Network Operator
MPLS	Multi-Protocol Label Switching
ND	Neighbour Discovery
NE	Network Element
NFV	Network Function Virtualisation
NGMN	Next Generation Mobile Networks
NM	Network Manager
NMS	Network Management System
OAM	Operation Administration and Maintenance
OCS	Online Charging System
OFCS	Offline Charging System
ONIX	Overlay Network system of information servers for Information eXchange
OPEX	Operational Expenditures
OSI	Open Systems Interconnection (model)
OSPF	Open Shortest Path First
OSS	Operation Support Systems
P Router	Provider Router
PCC	Policy and Charging Control
PCEF	Policy and Charging Enforcement Function
PCRF	Policy and Charging Rules Function
PDN	Packet Data Network
PDN-GW	Packet Data Network-GateWay
PDP	Policy Decision Point
PE	Provider Edge
PEP	Policy Enforcement Point
PGW	Packet GateWay
P-GW	Packet Data Network Gateway
PS	Packet Switched
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RCAF	RAN Congestion Awareness Function
REST	Representational State Transfer
RFC	Request For Comments
Rfp	Reference point
RNC	Radio Network Controller

RPL	Routing Protocol for Low-Power and Lossy Networks
RRC	Radio Resource Control
S1-AP	S1 Application Protocol
SC	Self-Configuration
SCTP	Stream Control Transmission Protocol
SDN	Software Defined Networking
SGSN	Serving GPRS Support Node
SGW	Service GateWay
S-GW	Serving Gateway
SH	Self-Healing
SNMP	Simple Network Management Protocol
SO	Self-Optimization
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SON	Self Organizing Network
SPR	Subscription Profile Repository
STF	Specialized Task Force
SW	SoftWare
TC	Technical Committee
TcoSH	Trigger Condition of Self-Healing
TCP	Transmission Control Protocol
TDF	Traffic Detection Function
TSG-SA	Technical Specification Group-System Aspects
UDC	User Data Convergence
UDP	User Datagram Protocol
UDR	User Data Repository
UE	User Equipment
UL	UpLink
UMTS	Universal Mobile Telecommunications System
UTRAN	Universal Terrestrial Radio Access Network
WG	Working Group
WLAN	Wireless Local Area Network
WS	Web Services

4 Background

4.1 Introduction

Autonomic management and control (AMC) of Network & Services 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 Use Cases and Requirements for AMC in various architectures, the Generic Autonomic Network Architecture (GANA) reference model, and instantiations of the GANA model onto various implementation-oriented reference architectures that enable developers to innovate and implement algorithms for the autonomics enabling GANA Functional Blocks (FBs). The TC is now progressing in producing technical reports on instantiation of the GANA Reference Model onto existing network architectures and emerging ones to embed Self-management capabilities.

The objective of the present document is to produce specifications for the instantiation of the GANA model onto the mobile backhaul and the Evolved Packet Core (EPC) deployed as per 3GPP Architecture specifications. Depending on the specific implementation of the EPC components by the various operators, the present document can be used in order to enable the mapping of GANA reference model functions onto the EPC components, thus enabling autonomic functions (AF) to be introduced in the EPC modules.

The work has been divided into several tasks which are reflected in the following clauses. The first task consisted in extracting from 3GPP specifications the 3GPP reference architecture that has been a basis for GANA instantiation in the report. This is documented in clause 5. In a second step, a mapping of the GANA model to the 3GPP architecture was defined for a basic scenario with the 3GPP EPC and the mobile backhaul networks as standalone networks. This is reported in clause 6. The final task consisted in considering autonomic behaviours across multiple segments. This is presented in clause 7.