ETSI GS NGP 002 V1.1.1 (2017-05)

Next Generation Protocols (NGP); Self-Organizing Control and Management Planes

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Next Generation Protocols (NGP).

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1 Scope

The scope of the present document is to specify the self-organizing control and management planes for the Next Generation Protocols (NGP), Industry Specific Group (ISG).

2 References

2.1 Normative 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.

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The following referenced documents are necessary for the application of the present document.

[1] IETF RFC 7575: "Autonomic Networking: Definitions and Design Goals".

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.

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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 GS AFI 002 (V1.1.1): "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.2] IETF draft-ietf-anima-reference-model: "Reference Model for Autonomic Networking", April 2016.

[i.3] IETF draft-pritikin-anima-bootstrapping-keyinfra: "Bootstrapping Key Infrastructures", October 2016.

[i.4] IETF draft-ietf-anima-grasp: "Generic Autonomic Signaling Protocol (GRASP)", December 2016.

[i.5] ETSI TR 121 905: "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Vocabulary for 3GPP Specifications (3GPP TR 21.905)".

[i.6] ETSI TS 132 501: "Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Self-configuration of network elements; Concepts and requirements (3GPP TS 32.501)".

[i.7] ETSI GS NGP 006: "Next Generation Protocol (NGP); Intelligence-defined Network".

[i.8] NTECH(17)000013: "Requirements for Protocols and APIs for Enabling GANA based Autonomics, Cognitive Networking and Self-Management of Networks and Services in Evolving and Future Networks".

[i.9] IETF RFC 4192: "Procedures for Renumbering an IPv6 Network without a Flag Day".

3 Definitions and abbreviations

3.1 Definitions

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

NOTE: Some definitions are inherited from IETF RFC 7575 [1].

autonomic node: network node that supports a set of basic Self-organizing functions

NOTE: E.g. the ASAs for basic connectivity as described in clause 9.1.

autonomic domain: set of autonomic nodes compose a domain within which the autonomic node could create stable connectivity with each other and share the same intent

autonomic service agent: agent implemented on an autonomic node that implements an autonomic function, either in part (in the case of a distributed function) or whole (IETF RFC 7575 [1])

intent: abstract, high-level policy used to operate the network

NOTE: Its scope is an autonomic domain (IETF RFC 7575 [1])

network-wide knowledge: valuable information extracted from the data in various nodes or some network-level policies/information input from the administrators

self-X Network: network supports a set of "Self-" features such as Self-Configuration, Self-Orchestration, etc. (as described in clause 6) to form a self-organizing control and management plane

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TR 121 905 [i.5] and the following apply:

NOTE: Should apply to scenarios that include mobile network architectures.

ACO	Automatic Cluster Optimization
ACP	Autonomic Control Plane
AFI	Autonomic Future Internet
AI	Artificial Intelligence
AN	Autonomic Network
ANI	Autonomic Networking Infrastructure
API	Application Programming Interface
ASA	Autonomic Service Agent
ASG	Aggregation Site Gateway
BRSKI	Bootstrapping Remote Secure Key Infrastructures
BSS	Business Support System
CA	Certificate Authority
CSG	Cell Site Gateway
DE	Decision Element
DHCP	Dynamic Host Configuration Protocol
ECMP	Equal-cost Multi-path Routing
FCAPS	Fault, Configuration, Accounting, Performance, Security
GANA	Generic Autonomic Networking Architecture
GRASP	Generic Autonomic Signalling Protocol
IETF	Internet Engineering Task Force
IGP	Interior Gateway Protocol
IP	Internet Protocol
IPRAN	IP-based Radio Access Network
IRP	Integration Reference Point

ISG	Industry Specific Group
ISIS	Intermediate System to Intermediate System
ISP	Internet Service Provider
MPLS	Multi-Protocol Label Switching
ND	Neighbour Discovery
NGP	Next Generation Protocols
NMS	Network Management System
OAM	Operations, Administration, and Maintenance
OSPF	Open Shortest Path First
OSS	Operation Support System
PW	Pseudo-Wire
RQ	Requirement
RSG	Radio Service Gateway
SDN	Software Defined Network
SLAAC	Stateless Address Autoconfiguration
SMN	Self-Managed Network
SON	Self-Organizing Networks
SXN	Self-X Network
TE	Traffic Engineering
ULA	Unique Local Address
VPN	Virtual Private Network

4 Overview

The ISG Next Generation Protocols (NGP) aims to review the future landscape of Internet Protocols, identify and document future requirements and trigger follow up activities to drive a vision of a considerably more efficient Internet that is far more attentive to user demand and more responsive whether towards humans, machines or things.

A measure of the success of NGP would be to remove historic sub-optimized IP protocol stacks and allow all next generation networks to inter-work in a way that accelerates a post-2020 connected world unencumbered by past developments.

The NGP ISG is foreseen as having a transitional nature that is a vehicle for the 5G community and other related communications markets to first gather their thoughts together and prepare the case for the Internet community's engagement in a complementary and synchronized modernization effort.

Therefore NGP ISG aims to stimulate closer cooperation over standardization efforts for generational changes in communications and networking technology.

The present document introduces the NGP, ISG view on how the network could get self-managed, through interaction between devices based on a set of new protocols. One important principle is taking an incremental approach that the Self-X Networks (SXN) should co-exist and interact with current network.

The present document presents the vision of Self-Managed Networks in clause 6. The vision is separated into several goals, which are mainly inherited from the classic FCAPS model. In clause 7, the present document discusses a couple of important principles of designing the SXN.

Then, according to clause 6 and clause 7, the architecture of SXN is introduced in clause 8. The architecture is angled from a node perspective; and the node is called Autonomic Node (AN). The essential component in an AN is the Autonomic Service Agent (ASA), which could be considered as applications running in network devices to fulfil specific network management functions/tasks without human intervene. There could be various kinds of ASAs to fulfil different functions/tasks; some ASAs, which are considered as basic and common functions in a network, are introduced in clause 9.

There are also two use cases of the proposed architecture introduced in clause 10. At last, a summary of future protocol requirements are documented in clause 11.

5 Background

5.1 Motivation of Self-Management and Control

The success of the Internet has made IP-based networks bigger and more complex. The scale of networks is quickly increasing; the numbers of network devices are also quickly increasing. With the increasing of new features and functionalities, network devices has been becoming more and more complicated and new network services have been continuing emerging. Network controlling is becoming more multidimensional, beyond the routing reachability. Diversified network management requirements are growing while the granularity of network management is required to be finer and more precise. The controlled and managed objectives in the network have complicated relationships, which have not yet been considered. The cooperation and interference among devices are complicated.

In the current IP based network systems, only routing functions may be considered as autonomic. Even that requires manual provisioning of peer neighbours, route policies and other attributes to achieve the desired effect. It results in a rigid network traffic management. Although several network management tools can automate repeatable work through scripts, the overall network operations, control and management functions still require human intelligence and experts with in-depth knowledge of all aspects.

Currently, the network controlling and management are mostly through the device parameters, which rely on the decision and implement of network administrator. With the growing network infrastructures, network changes are more frequent and impact vast geographies. A network administrator needs to modify configurations as often and in timely manner. However, manual verification and validation processes are usually slow, painstaking and still error prone. It is reported that most network problems (above 95 %) are caused by human's mis-configurations. The network administrator is both the key and the bottleneck, even the source of problem.

All of the abovementioned situations are extremely demanding for dynamic management that needs to response to a large amount of information. Human based management are not able to meet the requirements any more. A more flexible, extensible and self-managing system is urgently needed. A completely automatic solution for network control and management could simplify human management, avoid human errors, and reduce the cost of network maintenance.

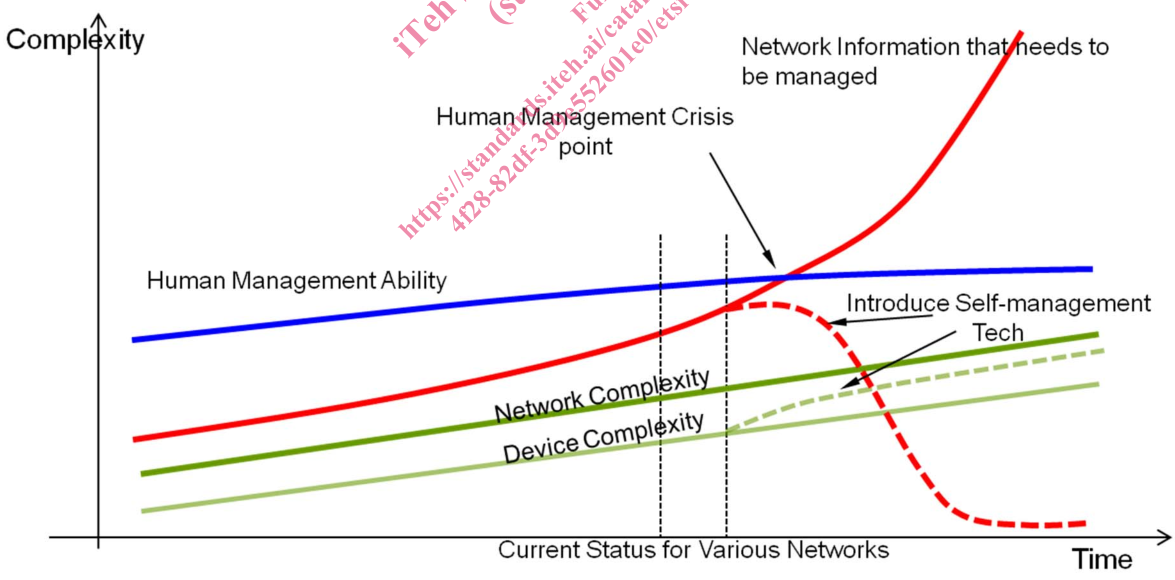

Figure 1: Trend of Network Complexity and Impact of Introducing Self-managing Technologies

5.2 Evolution History of Network Control and Management

IP networking was initially designed with similar properties in mind. An IP network should be distributed and redundant to withstand outages in any part of the network. Routing protocols such as OSPF and ISIS exhibit properties of self-management and can thus be considered autonomic in the definition of the present document.

However, as IP networking evolved, the ever-increasing intelligence of network elements was often not put into protocols to follow this paradigm, but was put into external north-to-south configuration systems. This configuration made network elements dependent on some process that manages them, either a human or a network management system, which is still human based with some enhanced tools.

While the network scale keeps increasing, the complexity becomes a bigger issue. There are two diverted opinions regarding to evolving directions:

a) Centralized control and management systems are introduced to ease the management of a large number of devices and largely reduce the inconsistency/conflicts among devices However, centralization does not mean more intelligence; rather, it only stands for the aggregation of information and the management is still essentially relying on the intelligence of the administrators. The network complexity will increase beyond the handling capability of human.

b) Distributed Intelligence should extend to other network aspects beyond the reachability. DHCP and ND are also moving towards this direction, but these two protocols are only deployed in the edge network where the end devices communicate with the network directly. This evolving direction emphasis more on sensing and communication in the horizontal level among the network devices, and it can only deal with very limited management tasks.

In a nutshell, to achieve a more self-managing network without increasing human burden, neither only aggregating information and control centrally, nor simply increasing horizontal communication is enough. The essential thing is that each of the network devices needs to be enhanced with more intelligence.

5.3 Relationship with Existing Work

1) 3GPP SON

3GPP has a set of technologies called "Self-Organizing Network (SON)". In one aspect, 3GPP SON focusing on specific 3GPP systems while the SXN in the present document is more generic; in another aspect, current 3GPP SON is mostly regarding to wireless interface self-optimization while the SXN could be the candidate architecture and technical approaches for the 3GPP SON of the fixed network part.

2) AFI GANA

The AFI (Autonomic network engineering for the self-managing Future Internet) is an ETSI ISG that dedicated for autonomic networking. AFI had launched the GANA (Generic Autonomic Network Architecture) reference model for autonomic networking, cognitive networking and self-management in 2013 (the latest version, ETSI GS AFI 002 [i.1]).

GANA is a very generic and comprehensive model, of which the main objective is "to define, iteratively, a generic, conceptual architectural reference model intended to serve as guideline for the design of the future generation networks exhibiting autonomic characteristics or capabilities", as stated in the GANA document. The SXN essentially keeps consistent with some important concepts in GANA. For example, the Autonomic Node defined in clause 8 is essentially the same with Network Element in GANA; the ASAs described in clause 9 could be considered as specific instances of the GANA Decision Element; the Network-wide Knowledge in clause 8 is a simple instance of Knowledge Plane defined in GANA.

So, in general, the SXN is consistent with the GANA model, and there is no conflict. However, the SXN concepts and technologies are not as generic as GANA; rather, they aim at defining specific components that much more closed to implementation based on current network.

3) IETF Anima

Anima (Autonomic Networking Integrated Model and Approach) is an IETF working group aims at developing protocols/mechanisms that could be directly implemented and integrated into current networks to improve the autonomics. Anima's approach is to identify some very basic and common technical components that could be re-used among different scenarios. These components are called ANI (Autonomic Network Infrastructure). Currently, there are three technologies defined as ANI, as the following.

- GRASP (GeneRic Autonomic Signalling Protocol):

  GRASP is the protocol used between autonomic nodes to cooperate to fulfil management tasks. It provides generic and basic communication schemes such as Discovery, Negotiation, Synchronization and Flood. GRASP is a realization of the Discovery Agent and Information Distribution Agent in clause 9.

- ACP (Autonomic Control Plane):

  ACP enables a secure and stable management channel between autonomic nodes without any manual configuration. ACP is one realization fits into Autonomic Reliable Connectivity Agent in clause 9.

- BRSKI (Bootstrapping Remote Secure Key Infrastructures):

  BRSKI allows new devices joining the Autonomic Domain by authentication of the device certificate; and also makes the new devices assigned with Autonomic Domain certificates for secure communication afterwards. It is a realization of Secure Bootstrap Agent in clause 9.

Overall, Anima provides specific IP-based realization of some functions specified in the present document; but the present document has a more general scope and not binding to IP protocols. The present document only considers Anima as an instance/reference of realizing corresponding self-managing functions.

6 Vision of Self-X Networks

6.1 Overview

This clause describes the high-level goals that are expected to be achieved by the SXN.

According to ISO FCAPS model, network management contains Fault Management, Configuration Management, Accounting Management, Performance Management and Security Management. This classic model is also a very suitable reference for setting up the high-level goals of the SON.

However, this clause excludes the Accounting from the FCAPS; and narrows down the Performance Management and Security Management to Self Optimization and Self Defense. Apart from FCAPS, this clause includes Self Service Orchestration into the scope.

6.2 Self Configuration

Self-configuration means that all the Autonomic Nodes are configured autonomically and dynamically. "Autonomically" means the configuration is done by the node and the network without human intervene; while "dynamically" means the configurations are not static rules but rather generated according to the node and the networks' features and conditions.

The configurations mainly contain two parts:

1) Initial configuration: when a node newly joins in the Self-Managed Network, it needs to get the basic connectivity configurations such as addressing, routing, etc. (clause 9.1 introduces ASAs for this purpose).

2) Service configuration: when the SXN wants to enable a service (e.g. MPLS VPN), it needs to make configurations on a certain of nodes. (clause 9.3 introduces ASAs for this purpose).

Self-configuration could be considered as a very basic yet very important feature in SXN. Since the network can simply begin to run after the Self-configuration.

6.3 Self Service Orchestration

When deploying a service, in a perspective of an Autonomic Node, there could be two approaches:

1) The nodes receive specific configurations which have been sorted out by a central management server or controller, according to the service request. This is also the traditional manner in service orchestration.