Landscape of Autonomics for Network Management

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Outline

• Introduction
• Academic Research
  ○ Hype Cycle
• Standardization @ IETF
  ○ Autonomic Networking @ NMRG
  ○ UCAN BoF
  ○ ANIMA WG
• Outlook
Introduction

- Minimum set of properties of an Autonomic System (AS)
  - Automatic, i.e. it can "self-control its internal functions and operations"
  - Adaptive, i.e. it can change its "configuration, state and functions"
  - Aware, i.e. it can "monitor its operational context"
- Different set of definitions for an AS
  - E.g., self-CHOP, MAPE-K, OODA
- Application to the complete network lifecycle (e.g. installation, commissioning, operating) → Autonomic Networking (AN)
Introduction

(Maintenance Loop) +---------------------------------+ Actual vs. desired state evaluation and decision making +---------------------------------+ Autonomic manager

V

Data gathering

V

New configuration (Adjustment Loop)

<^>

Managed resource

Figure 1: Simple sketch of an autonomic networking control loop

Levels of autonomy

Manual

Managed
- Centralized tools and manual operations
- Event correlation and decision assistance

Predictive

Adaptive
- Contextual behavior and analysis, ad-hoc action plan

Business-driven networking

Basic

Level 1
Level 2
Level 3
Level 4
Level 5
Introduction

- Autonomic Networking (AN) → focus of several research projects over the last decade
  - AN Architecture (ANA), Generic ANA (GANA), etc
- AN usually addressed by the Network Management Community (IM, NOMS, CNSM), and other events/communities (ICAC, ICAS…)(TCAC,
- Link with MAS, Bio-inspired…
- Link with Mobile networking (SONs), Ad-hoc networks

"Of course, some of the network management work of the 1980s and 1990s could be retrospectively termed autonomic networking, as some of the self-* issues were addressed; however, in practice, the term is a twenty-first-century one." [2]
Academic Research

- First mentions → circa 2005, 2006
- Several antecedentes
  - Artificial Intelligence in NM (90s)
  - Self-Organisation Networks, Declarative Policies, etc
- Papers
Another timeline

- Cybernetics
- Self-organization
- IBM Autonomic Computing
- A Knowledge Plane for the Internet

...a defining initiative
Academic Research

- A lot of momentum → circa 2007-2009
- Papers
- Projects
Research scope

AN research span the whole ICT spectrum
• IT and network, infrastructures and services, fixed and wireless, access to core...

AN research investigates
• Evolutive and clean-slate architectures, models, functions, processes...
Research projects

Many research projects and initiatives...
Academic Research

- Decrease in interest → *circa* 2011-2013
- Possible reasons?
  - Other technology gaining momentum? →
    - SDN, NFV...
  - New terms?
    - Cognitive, Intelligence-driven...
  - Lack of successful deployment cases?
- Standardization
  - ETSI GANA, IETF ANIMA...
Overview of AN standardization

● The need for standards is simple
  ○ The problem and challenges are too big to be solved by individual initiatives
  ○ Solutions will emerge from collaborative work and partnerships
  ○ But global scale adoption will require interoperable systems

● The key question is: What needs to be standardized?
  ○ at least, the communication interfaces between functional blocks and devices
  ○ Resource models
  ○ Service interfaces
  ○ Common and consistent management principles and language
  ○ Context- and goal-oriented management
Overview of AN standardization

AN standards landscape

- Different SDOs, time, scope, importance and degrees of success...

“A Holistic”

Autonomic Communications Forum (ACF)

Mobile networks

ITU-T Future Networks Focus Group, Rec. Y.3001

SON Functions 3GPP Release 11

AFI-002 GS ETSI AFI ISG

NGMN NGCOR

IRTF NMRG AN workshop series

“IP” networks

RFC7575 RFC7576
Standardization @ IETF

- First efforts
  - Autonomics for Network Management @ NMRG
- Related efforts in different IETF WG and IRTF RG
  - SUPA, HOMENET, SDNRG, NFVRG, I2RS...
- UCAN BoF (IETF 90) → ANIMA WG
- NMLRG (proposed), IDN (BoF?)
Autonomic Networking @ NMRG

• 32nd NMRG Meeting (Vancouver, November 2013) - Autonomics for Network Management (Part I)
  ○ Definition of autonomic networking terms
  ○ Autonomic networking frameworks and architectures
  ○ Network configuration negotiation problem statement
  ○ Peer-to-peer detection of service level agreement violations
  ○ Bootstrapping trust on a homenet

• 33rd NMRG Meeting (London, March 2014) - Autonomics for Network Management (Part II)
  ○ Definition of autonomic networking terms (continuation)
  ○ Proactive self-healing mechanisms for IP networks
  ○ Gap analysis for autonomous networking
Autonomic Networking @ NMRG

- 34th NMRG Meeting (Toronto, July 2014) - Autonomics for Network Management (Part III)
  - Definition of autonomic networking terms (continuation)
  - Gap analysis for autonomous networking (continuation)
  - Lessons learned on using autonomics for network management
  - Real world experiences on using autonomic principles in network management

- 35th NMRG Meeting (Rio de Janeiro, November 2014)
  - 2 presentations on AN
  - Autonomic Networking Definitions Revisited
  - Autonomic Networking Use Case for Distributed Detection of SLA Violations
Autonomic Networking @ NMRG

- Focus on the definition of autonomic networking terms
- Internet-Drafts and RFC
  - Set of design goals and non-goals for AN [irtf-nmrg-autonomic-network-definitions] → RFC 7575
  - Standardization → open question and deployment limited to specific mechanisms [irtf-nmrg-an-gap-analysis] → RFC 7576
UCAN BoF

- Important outcome of the NMRG work
- Good popularity of the BoF (IETF 90)
- UCAN docs
  - Background
  - Use Cases
  - Solution space

Now RFC 8316!
ANIMA WG

- Definition → “a system of autonomic functions that carry out the intentions of the network operator without the need for detailed low-level management of individual devices”
- Goal → “complete solution for full autonomic networking is an ambitious goal” → the specification of a min set of reusable infrastructure components to support autonomic interactions and use cases
- Focus → professionally-managed networks
ANIMA WG

• Development of protocol specifications (or extensions)
  ○ Discovery for autonomic nodes
    ▪ GRASP [draft-ietf-anima-grasp-15]
  ○ Negotiation for autonomic nodes
    ▪ GRASP [draft-ietf-anima-grasp-15]
  ○ Bootstrapping a trust infrastructure
    ▪ BRSKI [draft-ietf-anima-bootstrapping-keyinfra-09]
  ○ Separated Autonomic Control Plane
    ▪ ACP [draft-ietf-anima-autonomic-control-plane-13]
ANIMA WG

- Limited initial set of work items → avoid "boiling the ocean"
- Additional ("unchartered") docs
  - E.g., (Policy) Intent, Use Cases, Autonomic Service Agents (ASAs)
  - Encouraged as individual submissions or NMRG submissions
AN @ NMRG post ANIMA

- Some unchartered work remains in ANIMA → waiting for new phases/recharter
  - E.g., coordination, intent format and distribution, etc
- Internet-Drafts and RFC
  - AN Use Case for Distributed Detection of SLA Violations [draft-irtf-nmrg-autonomic-sla-violation-detection] → RFC EDITOR
  - Autonomic Networking Definitions Revisited [draft-pentikousis-nmrg-andr] → inactive
Outlook

- Deployment of new network technologies → typically a time-consuming and labour-intensive task
- A way forward → AN in NMRG in the context of programmable networks and through a more comprehensive manner
- Lots of earlier research of AN, but little deployment
- NMRG work on AN so far as aimed primarily on node-level aspects
- AN research (and future standards) → highly-virtualized and programmable infrastructures
Outlook

Reasons for lack of wide-scale deployment

- Maturity
- Trust
- Monolithic, top-down approach (full architecture, constrained function model/specifications)
- Lack or real problem to solve
- Lack of real gain (functional, performance)
- Lack of operator buy-in / involvement
- Lack of real operational relevance
Outlook

- Fully programmable network elements and functions interesting for AN
- SDN and NFV principles $\rightarrow$ wider audience of researchers and practitioners
  - E.g., lots of interest on SDNRG (defunct) and NFVRG
    - Desirable: programmability communities to think in terms of control, management, and operational planes (e.g., RFC 7426)
- New projects on 5G $\rightarrow$ intersection of AN and virtualization
Outlook

- AN definitions, goals and gap analysis within the context of IETF → more consideration
- NMRG possible a home for the discussion (?)
- Machine Learning (ML)
  - NMLRG (defunct) <> AN
  - AN formulations seem to precede current ML development → room for investigations
- Intents
  - Controversial topic
  - Currently out of scope of ANIMA (IETF?)
Outlook

Areas of application: 5G, IoT, Smart X (factory, city, health...)
New use cases
Focus on gaps, different/complementary approach
Better link with real-world operations (engage with other communities (NANOG, RIPE, operators councils, open source...)
Validate and deliver on theory and practice (PoCs, tools...)
Thank you.

Questions?