

Landscape of Autonomics for Network Management

Jéferson Nobre
Laurent Ciavaglia
Lisandro Granville

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

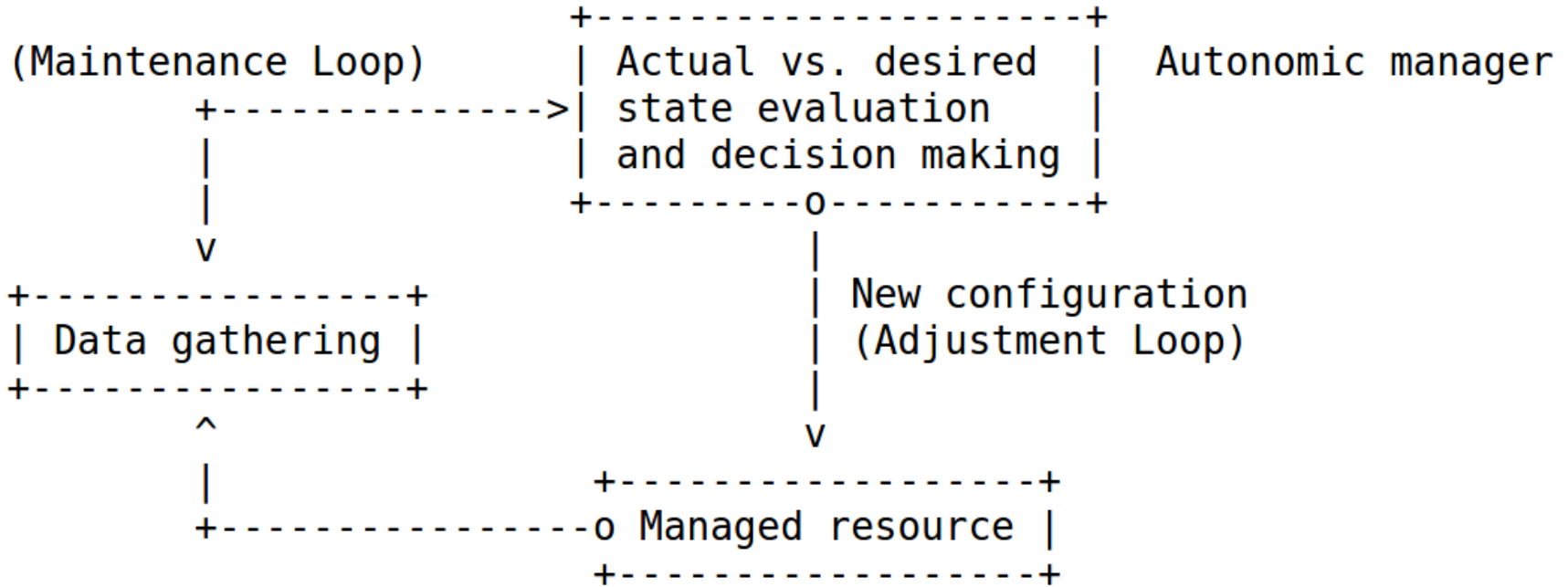
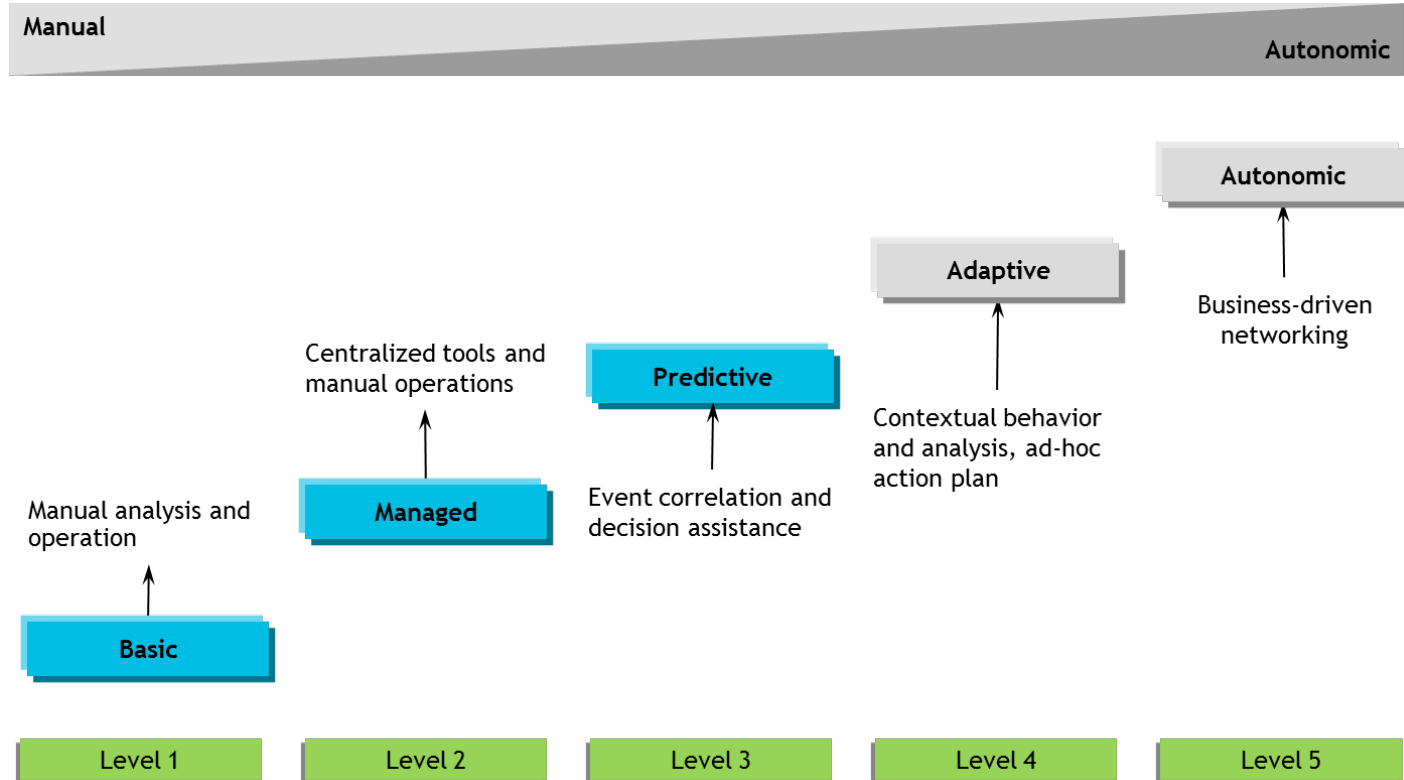


Figure 1: Simple sketch of an autonomic networking control loop

Levels of autonomy



Introduction

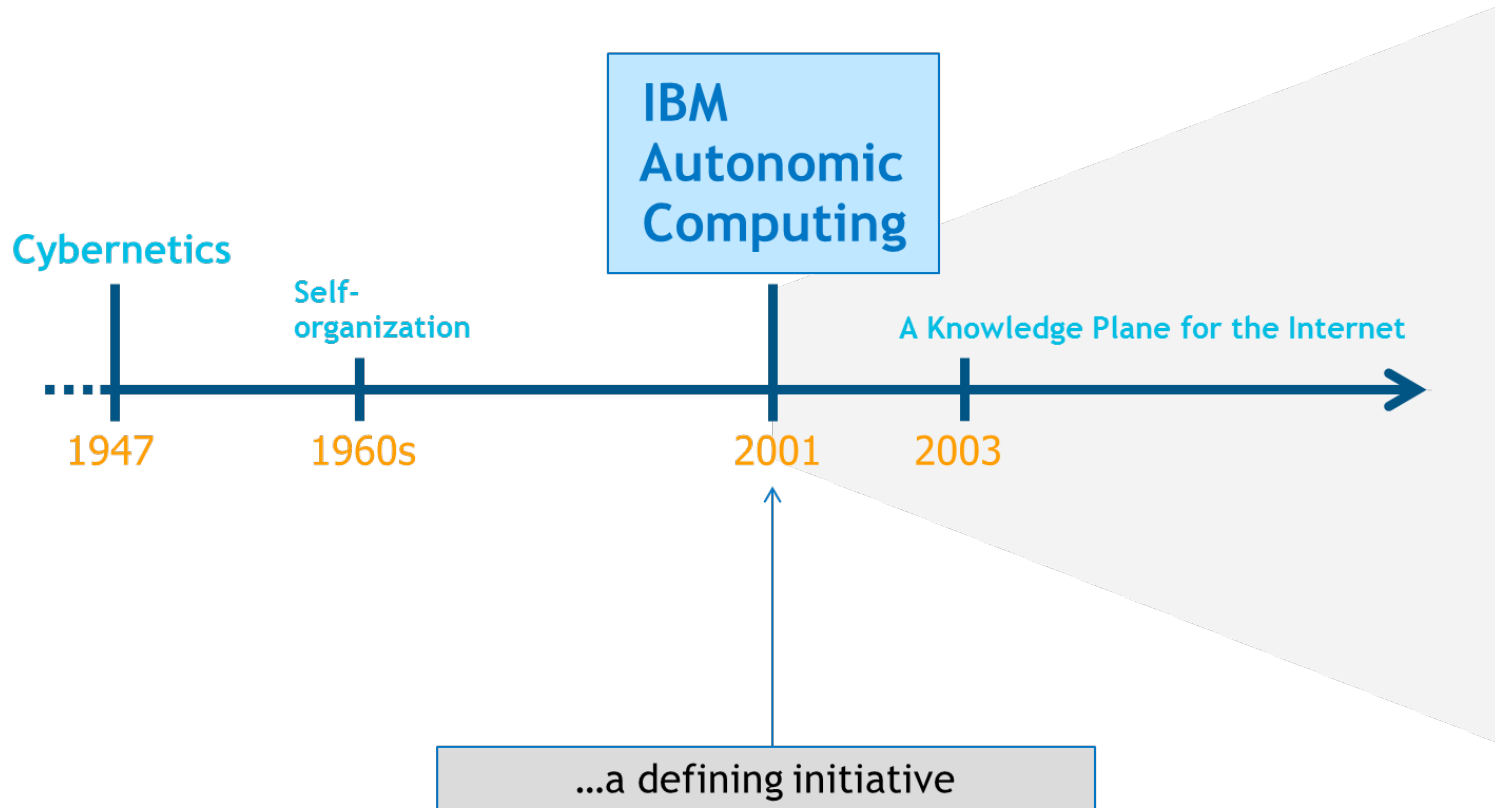
- Autonomic Networking (AN) → focus of several research projects over the last decade
 - AN Architecture (ANA), Generic ANA (GANA), etc
- AN usually addressed by the Network Management Community (IM, NOMS, CNSM), and other events/communities (ICAC, ICAS...)(TCAC,
- Link with MAS, Bio-inspired...
- Link 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
 - Strassner, J.(2004) Autonomic networking - theory and practice. IM 2005 (NOMS 2004?)
 - Mortier, R., & Kiciman, E. (2006). Autonomic network management: some pragmatic considerations. ACM SIGCOMM INM
 - Agoulmine, N. et al (2006). Challenges for autonomic network management. IEEE MACE
 - Balasubramaniam, S. et al (2006). Towards integrating principles of molecular biology for autonomic network management. HP OVUA

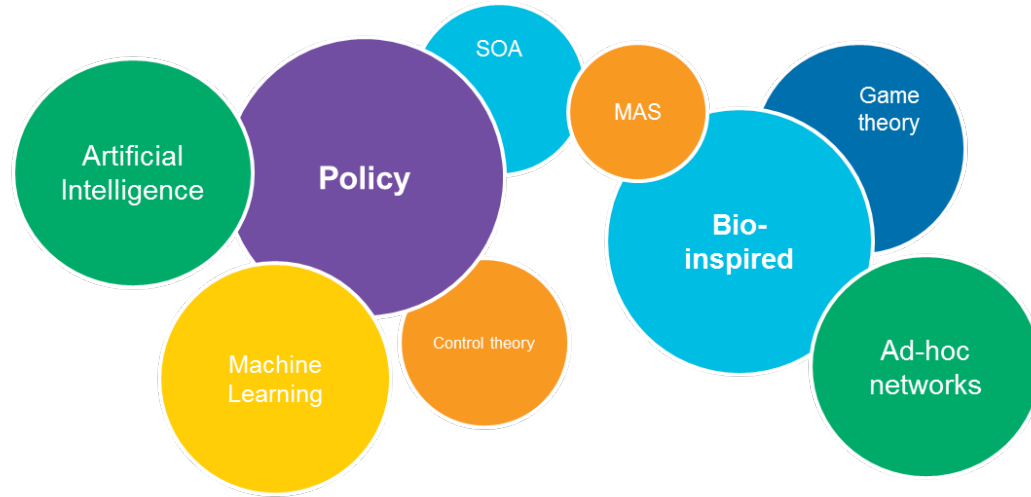
Another timeline



Academic Research

- A lot of momentum → *circa* 2007-2009
- Papers
 - Pavlou, G. (Ed.) (2007). Key Research Challenges in Network Management. IEEE communications magazine
 - Samaan, N., & Karmouch, A. (2009). Towards autonomic network management: an analysis of current and future research directions. IEEE Communications Surveys & Tutorials
 - Agoulmine, N. (Ed.). (2010). Autonomic network management principles: from concepts to applications. Academic Press
- Projects
 - Charalambides, M., Pavlou, G. (2009). Management of the Internet and Complex Services European 6h Framework Network of Excellence. Deliverable D9.5 Autonomic Management: Challenges and Solutions

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...**

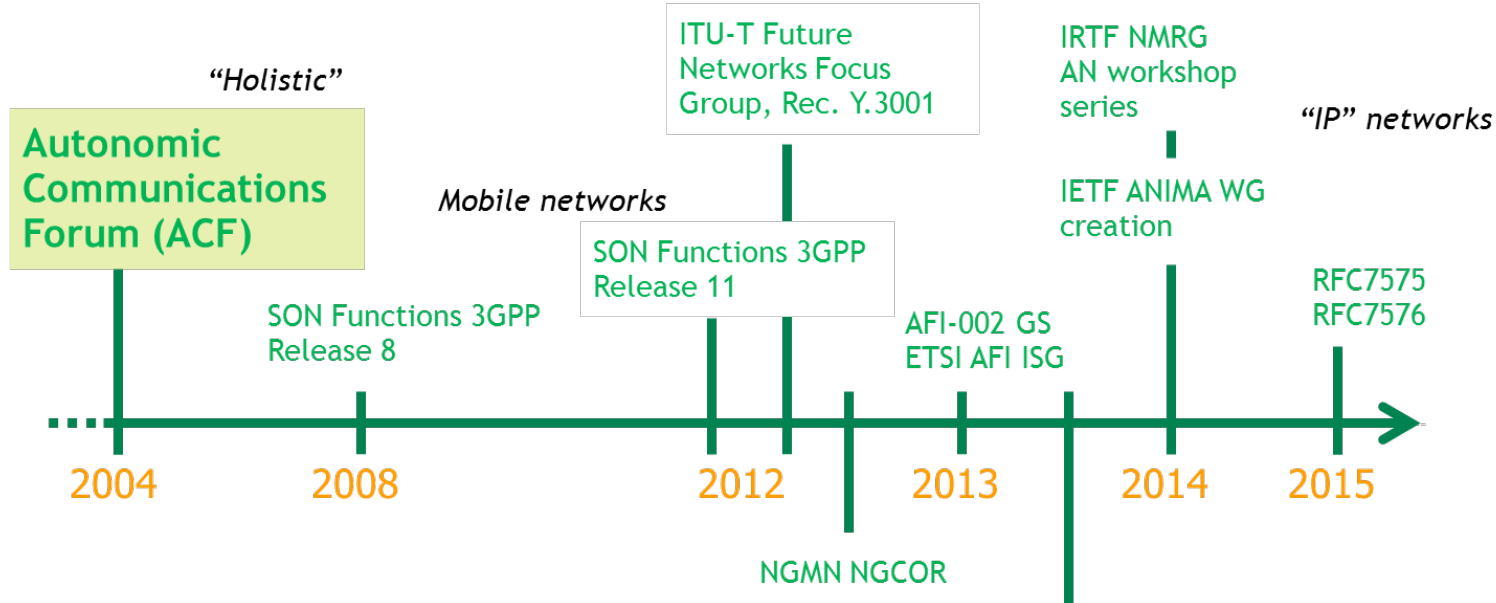
Overview of AN standardization

- 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...



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
 - <http://tools.ietf.org/html/draft-irtf-nmrg-an-gap-analysis>
 - <http://tools.ietf.org/html/draft-irtf-nmrg-autonomic-network-definitions>
 - Use Cases
 - <http://tools.ietf.org/html/draft-carpenter-nmrg-homenet-an-use-case>
 - <http://tools.ietf.org/html/draft-jiang-auto-addr-management>
 - <http://tools.ietf.org/html/draft-behringer-autonomic-bootstrap>
 - <http://tools.ietf.org/html/draft-irtf-nmrg-autonomic-sla-violation-detection>
 - <http://tools.ietf.org/html/draft-bogdanovic-nmrg-mobile-backhaul-use-case>
 - Solution space
 - <http://tools.ietf.org/html/draft-jiang-config-negotiation-ps>
 - <http://tools.ietf.org/html/draft-jiang-config-negotiation-protocol>
 - <http://tools.ietf.org/html/draft-pritikin-bootstrapping-keyinfrastructures>
 - <http://tools.ietf.org/html/draft-behringer-autonomic-control-plane>

→ 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 of 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 → 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 → 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?