# Intent-based Networking: Report on Joint NMRG-NoF Demo Session

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## Overview

The *IRTF Network Management Research Group* (NMRG) and the organizing committee of the *10th International Conference on Network of the Future* (NoF 2019) organized a joint demo session focused on *Intent-based Networking* (IBN). The demo session was part of the 56th NMRG meeting, held on October 3-4, 2019 in Rome, Italy and co-located with NoF 2019.

The demo session was intended to provide a venue for researchers and practitioners from academia and industry actively involved in the field of IBN to discuss their work, share their experience, and stimulate collaboration, with an emphasis on prototypes, practical implementations and work-in-progress activities aimed at designing and developing IBN enablers and solutions. The event also aimed at consolidating the IBN community and promoting research and (pre-)standardization opportunities by contributing to the IBN roadmap currently being defined by the NMRG. The program and all materials presented during the meeting are publicly available at [1].

The main feature of IBN systems is their ability to use high-level, human-friendly abstractions to define and declare service and network operation objectives (the "what") without actually specifying in detail the set of operations (the "how") needed to reach them. An IBN system provides the functionality required to manage the whole intent lifecycle covering two main phases: *Fulfilment* and *Assurance*. The Fulfilment phase encompasses means to express, parse, interpret, validate and operationalize intents towards low-level policies, while the Assurance phase encompasses means to measure, evaluate, verify, recommend and report on the actuation of the intents.

## Day 1 (October 3rd, 2019)

After a short introduction on the NMRG IBN activities and an overview of the meeting program and objectives, given by the NMRG Chairs, Laurent Ciavaglia and Jérôme François, the first session included a tutorial presentation on *Intent-based Network Programmability* presented by Walter Cerroni [2]. The tutorial was centered on the main concepts behind IBN as a driver for declarative network programmability, offering a historical perspective on the first attempts to standardize an intent-based northbound interface, and mentioning some notable industrial initiatives and academic research approaches.

The second session was focused on the IBN activities carried out within the research group, starting with a presentation of the IBN roadmap [3] by the NMRG Chairs and continuing with technical presentations

of two Internet Drafts (I-Ds) currently under development. The first I-D *Intent-based Networking: Concepts and Overview* was presented by Laurent Ciavaglia [4] and covered the main concepts and principles characterizing an intent-based system, and a description of the proposed intent lifecycle. The discussion triggered interesting observations on the implications of the guiding principles, and clarifications needed on the lifecycle. The second I-D titled *Intent Classification* was presented by Olga Havel [5]. This work tries to develop a taxonomy of intents based on various classification criteria such as user types, application domains, granularity, abstraction levels or else time. A concrete outcome of the discussion is a proposal to create a *Mapping table* representing, for each of the demos, the specific criteria value.

# Day 2 (October 4th, 2019)

The second day of the workshop was dedicated to demonstrations and practical work achieved with the aim to identify how much the presented approaches fulfill the functionality of an IBN system and the potential interactions that can be developed in the near future.

The first demonstration was entitled *Intent-Based 5G IoT Application Network Slice Deployment* by Fred Aklamanu, Sabine Randriamasy, and Eric Renault [6a][6b]. After a short review of the state of the art especially on languages (4th generation and transformational languages), which are an essential element in the intent pipeline to interpret their contents, the presenter, Fred Aklamanu, introduced an IBN system for network slice automation. Once a slice is defined with different attributes such as performance, time and space constraints, the system automatically maps the intent to a pre-existing network slice template, checks the feasibility to deploy an instance of the template in regard to the specified intent parameters and, if successful, finally deploys it. Since the system relies on pre-existing templates, it can be qualified better as intent *mapping* rather than intent *translation*; such distinction was judged useful in the discussion and later allowed to refine the naming of the lifecycle functionality as presented in the *Overall IBN tools view* [7]. In addition, the intrinsic nature of predefined templates simplifies the processing pipeline since no validation is necessary in that case.

The second demonstration was entitled *Self-Generated Intent-Based System* by Mehdi Bezahaf, Marco Perez Hernandez, Lawrence Bardwell, Eleanor Davies, Matthew Broadbent, Daniel King, and David Hutchison [8a][8b]. The presenter, Mehdi Bezahaf, first gave his vision of the intent lifecycle management, starting from an intent expressed in (a restricted) natural language and so requiring Natural Language Processing (NLP) techniques to handle and satisfy it in a particular context with QoS and reliability constraints. A parallel was made with the Reference Model of Open Distributed Processing (RM-ODP) to derive the enterprise view (the intent) down to the engineering one, which defines the practical operations to set up for realizing the intent. In the proposed approach, metrics are collected from the control and data planes, and then analyzed to generate knowledge such as detected patterns that can then be reused to inject new “recommended” intents to ensure a better QoS. The work of *Self-Generated Intent-Based System* builds on the reflections and in particular on one outcome of the NMRG interim meeting held in Montreal in July 2019: *Intents can be represented in multiple views depending on the audience (user, operator, NOC engineer, etc.)*. The focus of the demo was on guaranteeing

high-performance connectivity, i.e. *host-to-host connectivity* intent. Therefore, an anomaly detection module was able to detect a saturated link and generate automatically an intent for rerouting traffic using the ONOS SDN controller.

The invited presentation, *Multi-layer IBN in NFV ecosystem: Functional Architecture and Practical Experience*, co-authored by Barbara Martini (presenter) and Molka Gharbaoui [9], described three different uses of intents in the context of NFV: service chain, virtual link and SDN-capable slice deployment. From an intent detailing what services to be deployed in the chain, the source, the destination and latency constraint, the IBN system is able to find and allocate necessary resources while ensuring the forwarding with SDN. The second case is then focused on providing intra- and inter-POP connectivity. In the last demonstrated proof of concept, the objective was to give to the user the ability to express an intent and be capable of programming network flows within it using SDN protocols. In a nutshell, the user requests a set of virtual applications and a SDN-enabled network to interconnect them. During the discussion, a notable question that arose was related to the correct monitoring of intent realization. Indeed, while we are used to monitor network performance and match it to an expected level of QoS for example, it is important to assess how well an intent is fulfilled and the necessary means to evaluate the quality of the intent actuation.

The last demonstration was showcased by Davide Borsatti and was titled *Intent-based Service Function Chaining on ETSI NFV Platforms* by Davide Borsatti, Walter Cerroni, Gianluca Davoli, and Franco Callegati [10a][10b]. The aim of the presentation was to demonstrate the use of intents to deploy Service Function Chaining (SFC) on top of an ETSI NFV environment. First, the definition of a general service-level intent format was given, which allows to specify a generic service chain in terms of "blocks" composing the service itself. Each block includes a number of properties obtained as the result of an abstraction process determining what a service chain must achieve, i.e. an ordered sequence of service components, possibly managed, to be selectively applied to the forward and reverse path of traffic flows. Then, it was shown how the specified intent can be mapped into network service descriptors suitable to deploy the requested service chain on top of an NFV Management and Orchestration (MANO) system. Since the service components are selected from a set of predefined blocks offered in a catalog, this approach should also be rather classified as intent *mapping* than intent *translation*. The proposed intent-based SFC specification was demonstrated on a remote experimental test bed based on commonly available open-source software platforms, such as Open Source MANO and OpenStack. An interesting discussion took place on the conceptual difference between the proposed SFC intent and the standard NFV service graph descriptors, leading to the conclusion that the intent is supposed to increase the level of abstraction and be much simpler than the descriptors.

To conclude the session of the second day dedicated to the demonstrations, the participants engaged in an exercise consisting in mapping the context and functionality of the demonstrations on a so-called *Overall IBN tools view* [11]. This view is based on the initial intent lifecycle diagram proposed in the I-D *Intent-based Networking: Concepts and Overview*, as depicted in Figure 1. The exercise was done for each demo and helped to better understand the demo content, boundaries and technical choices made by the developers. The synthetic analysis of the different mappings allowed a comparison between the demos, outlining commonalities and differences, and reinforcing some of the first patterns identified at

the individual demo level; thus providing useful evolution inputs for a revised and enhanced intent lifecycle. Concrete examples of such an output are the distinction now made between intent *translation* and intent *mapping*, or proposal for new missing functionality or steps. Finally, the exercise also proved to be useful to identify potential links between demos, opening the door to future collaborations and more comprehensive solutions.

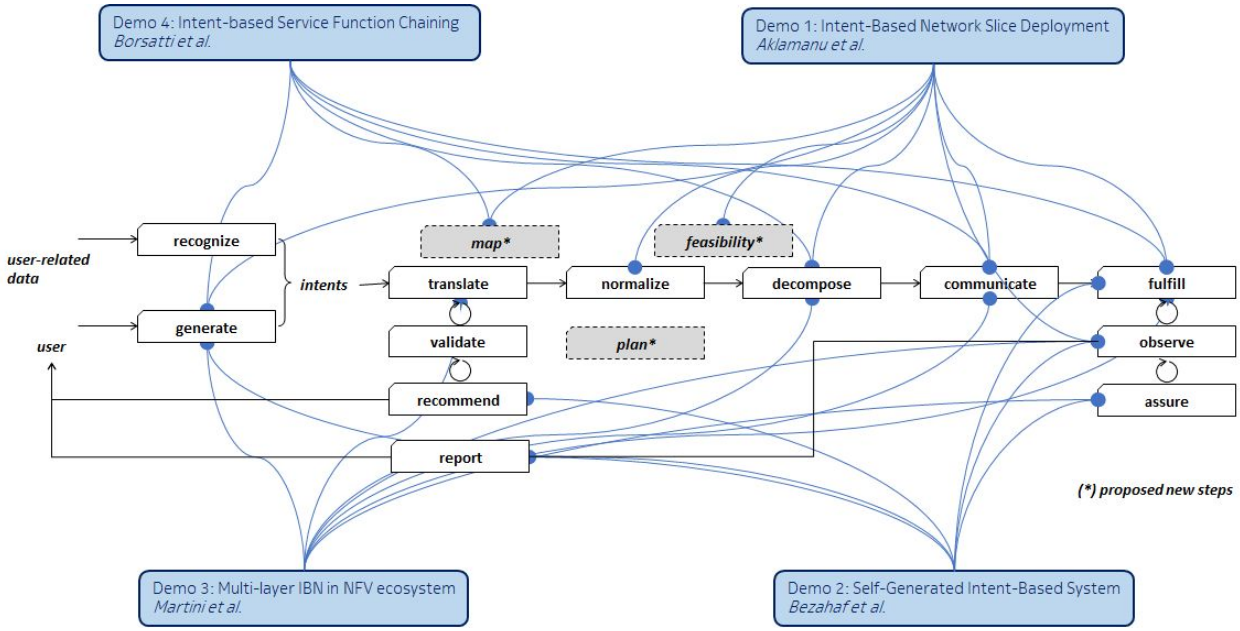


Figure 1: Mapping of the four demonstrations on the overall IBN tools view.

# Future directions

As described just above, the meeting interactions allowed to identify a set of actions for the continuation and development of an *IBN tools suite* beyond the *Overall IBN tools view* such as:

- Creation of a code repository including tools/demos description and installation/use guides.
- Definition of an *IBN tool data sheet* and commitment of the meeting participants to provide documented tool data sheets for their demos. Additional tools and proof of concepts have already been identified.
- Proposition of the *Mapping table* and population based on the available use cases and demos.
- Maintenance and updates to the *Overall IBN tools view*.
- Creation of an *IBN Resource Hub* to gather scientific publications, standards and industry documentation, and pointers to projects, events and useful resources on IBN.
- Follow-up interactions and further joint development or interconnection between tools presented at the meeting and new ones.

The NMRG is also planning to participate in the IETF 108 Hackathon to be held in July 2020 in Madrid on the topic of intent based networking, and to benefit from a European location to attract and engage

EU-based organizations, teams, participants from academia, industry and EU-funded projects in the field of IBN to take an active part in the hackathon. Of course, the participation is open to all!

The NMRG roadmap and challenges on IBN constitutes another direction. The NMRG is updating and redefining its objectives for the coming years, in particular regarding the IBN topic. This workshop aimed particularly at exposing our current vision to practical and experimental applications. As highlighted in the previous section, it allows us to refine the lifecycle promoted by a generic IBN system covering all necessary functional blocks. Agreeing on such a general framework is actually one of the essential work items of the NMRG IBN work plan. Indeed, another work item of NMRG is to provide techniques to realize one or more functional elements of the proposed lifecycle. In addition, we aim at establishing a common understanding of the IBN concepts and the related terminology. Through the different presentations, the global vision seems to converge but at the same time it was acknowledged that the terms used by the participants highly differs. Thus, agreeing on a common terminology in the community would help in strengthening the overall consistency of the research. Through the variety of the use cases, it also appears there cannot be a unique description of an intent, a unique type of granularity and a unique language fitting the various needs and constraints. However, the role of the NRMG will be also to document the different possibilities to model or express an intent, where they converge, where they diverge and how they could interoperate. Finally, NMRG also aims at supporting the practical implementation of IBN systems through different actions. On one hand, the organization of dedicated events, such as the joint demo session with NoF 2019 we currently report here, is very helpful to vet the theoretical concepts of an IBN system with a real deployment environment but also to allow the different authors to discuss the integration of multiple contributions for the near future. On the other hand, having some recurrent use cases help to refine our understanding and positions for other work items such as lifecycle management, elementary functional block, terminology, etc.

# Acknowledgements

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The NMRG Chairs would like to express their gratitude to Prof. Walter Cerroni for its proactivity and continuous support in the organization of the meeting.

# Links and References

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