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Operational Opportunities and Challenges of SDN/NFV Programmable Infrastructure

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Operational Opportunities and Challenges of SDN/NFV Programmable Infrastructure

1 Introduction

The development of technologies, including network function virtualization and Software-Defined Networking (SDN), builds on previous concepts such as active networks and programmable networks to increase the level of programmability within the infrastructure (communication, computation, storage, etc.).

This document will identify operational issues and opportunities associated with increasing programmability of the infrastructure. For example, this includes OSS/BSS impacts, reliability/fault detection, and administration, as well as maintenance issues over the network element, and service life cycles of IP-infrastructure-based network elements. The FG will also identify likely changes in operational procedures and staffing skill sets required to support increasing programmability.

The need for greater programmability is a common thread inherent in recent technology concepts such as SDN; Network Function Virtualization (NFV); evolution in device capabilities (e.g., due to Moore's Law); evolution in service concepts [e.g., Service Oriented Architectures (SOA) and cloud service delivery models (e.g., IaaS, PaaS)]; and evolving market expectations. This leads to the top down consideration of the range of impacts as the industry pivots towards supporting various forms of programmability. This pivot is an industry transition that is potentially more significant than previous technology transitions (such as that from circuit to packet technologies) because of the impacts on operational and service aspects.

In considering this transition between the traditional device centric, service-siloed infrastructure (A in Figure 1) and the emerging programmable infrastructures (B in Figure 1), there may exist more than one path from A to B based on the situation of that particular infrastructure operator. The goal is to identify use cases that articulate the vision of programmable infrastructure (with a particular emphasis on customer visible capabilities), motivate further work in the problem space, and help the industry understand the range of challenges and opportunities from the programmability pivot.

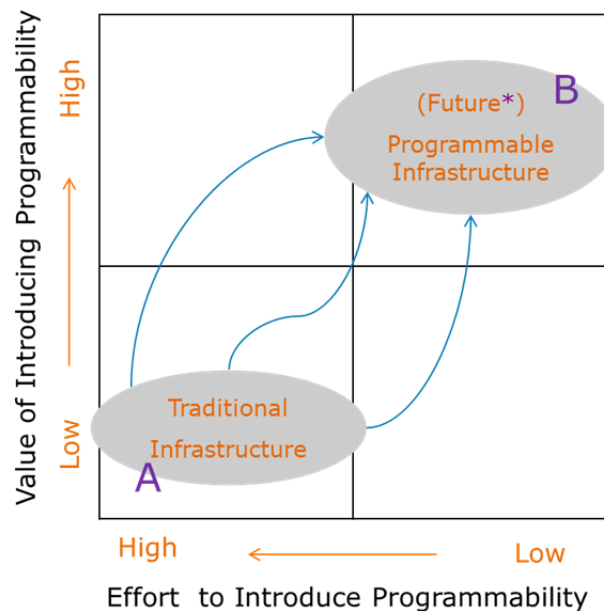


Figure 1: Value vs Effort of Introducing Programmability

2 Scope

The approach has been to conduct a top-down analysis of various programmability use cases leading to developing requirements for the following:

- Business Process Changes
- Information exchange between components
- Performance needs of components
- Personnel Staffing

Use cases and areas of standards gaps were identified as time permitted. There was *no plan for the development of technical solutions, protocols, and data models*. This document was completed in 6 months, ending in October 2013.

3 Programmability

Programs are generally considered as being comprised of algorithms operating on data structures¹. There are various data structures associated with network infrastructures. For example, a given network element may implement data structures associated with:

- The protocols that the NE supports on its interfaces.
- The management information bases (MIBs) used to administer the NE (e.g., CLEI codes).
- Internal data structures used by software within the NE to perform the functions required of the NE.

An Operations Support System (OSS) may implement data structures associated with:

- The management information bases (MIBs) used to administer the NEs.
- The connectivity arrangements.
- Location of devices and facilities (e.g., CLLI codes).

A Business Support System (BSS) may implement data structures associated with:

- the subscribers/consumers of the network services (e.g., accounting records)
- business processes (e.g., work flow sequences).

Computer programming is the process of designing, writing, testing, debugging, and maintaining the source code of computer programs. Whatever the approach to development of software, the final program may be evaluated for various properties, including reliability, robustness, usability (ergonomics), portability, maintainability, and efficiency/performance. Programming languages can be used to create programs to execute algorithms or control the state of a machine. In the case of programmability of network infrastructure, the program may control the state of the network infrastructure, or be used to transform the data being transported through the network.

Programming paradigms are fundamental styles of computer programming, including imperative declarative, functional, and object-oriented paradigms. *Imperative programming* is a paradigm that

¹ See, Wirth, Niklaus (1976). *Algorithms + Data Structures = Programs (in English)*. Prentice-Hall. ISBN 978-0-13-022418-7