TM FORUM FUTURE ARCHITECTURE STRATEGY DISCUSSION PAPER

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1. Drivers of change

New technologies such as software-defined networking (SDN) and network function virtualization (NFV), combined with a move to 'cloud-native' computing, are changing the fundamental infrastructures of communications service providers (CSPs). At the same time, CSPs increasingly are looking beyond connectivity to compensate for the commoditization of basic service revenues. New business models and growth opportunities are emerging, not just at the communications infrastructure level but also at the business applications level. These factors create new demands for architectural agility.

Customers' demands and aspirations have also changed. Today's B2B and B2C customers expect services to be delivered on demand – in minutes, rather than days and weeks. Customers also expect a digital, self-service support model for services covering the full lifecycle from ordering, through live operation to cancellation. Real-time, online service management, including trouble management and remediation and billing, is a basic requirement and is becoming more complex, especially as CSPs embrace increasingly sophisticated, partner-based services and business models.

All of this requires a dramatically more agile architecture for service provider IT systems. This agility is needed not only in the network infrastructure, but also in operational and business support systems (OSS/BSS).

As a consequence, there will be extra complexity. For example, in a traditional network inventory is relatively static, but in an SDN and NFV infrastructure, virtual machines providing communications services can be provisioned in seconds anywhere in the infrastructure, meaning that a particular customer's instance can only be identified by a real-time inventory management solution that is constantly updated. **Without more agile IT systems, the value of SDN and NFV cannot be realized.**

Automation is required

The need for closed-loop automation to deal with real-time provisioning, service management and orchestration in this new, highly dynamic infrastructure becomes key. Such complex, real-time infrastructures require that optimization and remediation decisions are made in real time as well.

In short, automation alone is not enough: intelligent automation of complex decision making at super-human speeds is required. For this, we must add artificial intelligence (AI) to control and operate the communications networks of the future.

TM Forum is well positioned to help CSPs develop and manage these intelligent networks. We have been at the heart of OSS/BSS standardization and innovation for

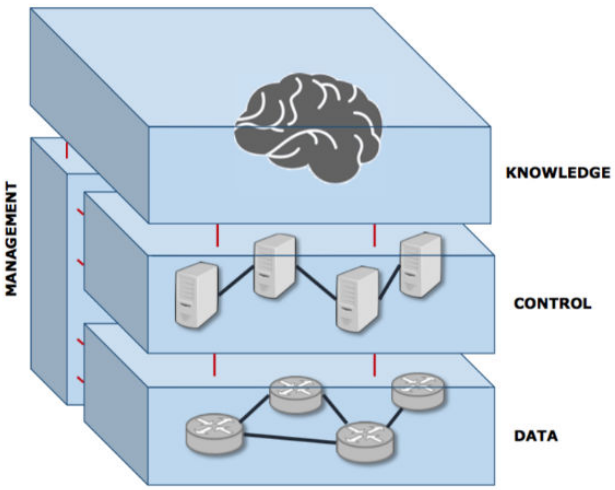
more than 25 years. The Forum's Frameworx suite of standards-based tools and best practices, which provide the blueprint for effective business operations, have become the common language for operators around the world. Using these tools, we are helping CSPs move toward zero-touch orchestration, operations and management.

2. Knowledge-defined networks

David Clark, a Senior Research Scientist at the MIT Computer Science and Artificial Intelligence Laboratory, and others have proposed a "Knowledge Plane for the Internet," a new construct that relies on machine learning and cognitive techniques to operate the network.

One of the biggest challenges when applying machine learning for network operation and control is that networks are inherently distributed systems, where each node (for example, switch, router, etc.) has only a partial view and partial control over the complete system. Learning from nodes that can only view and act over a small portion of the system is difficult and complex, particularly if the end goal is to exercise control beyond the local domain.

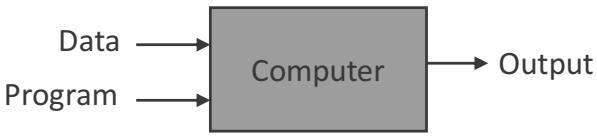
The emerging trend towards logical centralization of control (via SDN) will ease the complexity of learning in an inherently distributed environment.

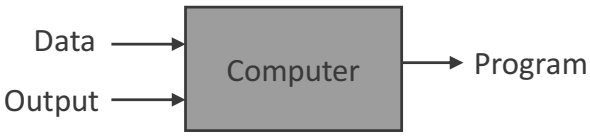


TM Forum's strategy is to work with our members to realize the Knowledge Plane for the network in the context of an underlying SDN infrastructure.

Machine learning needs data. In fact, you can say data is the 'currency' of machine learning. This requires moving from today's process-based architecture to a data-driven architecture.

The figure below contrasts traditional programming with machine learning.

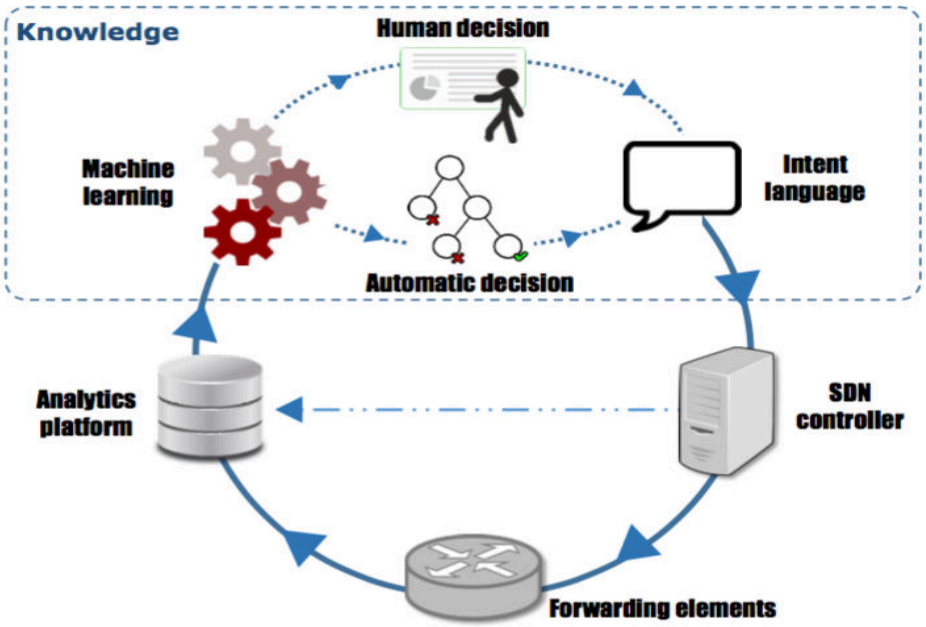




In programming, a human writes a computer program and provides the data, which the computer processes to create the output. In machine learning, humans provide the data along with the desired output, rules and constraints, and the computer writes the program to deliver this.

What is a KDN?

A *knowledge-defined network* (KDN) operates by means of a control loop to provide automation, recommendation, optimization, validation and estimation.



CSPs are beginning to use AI and machine learning in three key areas:

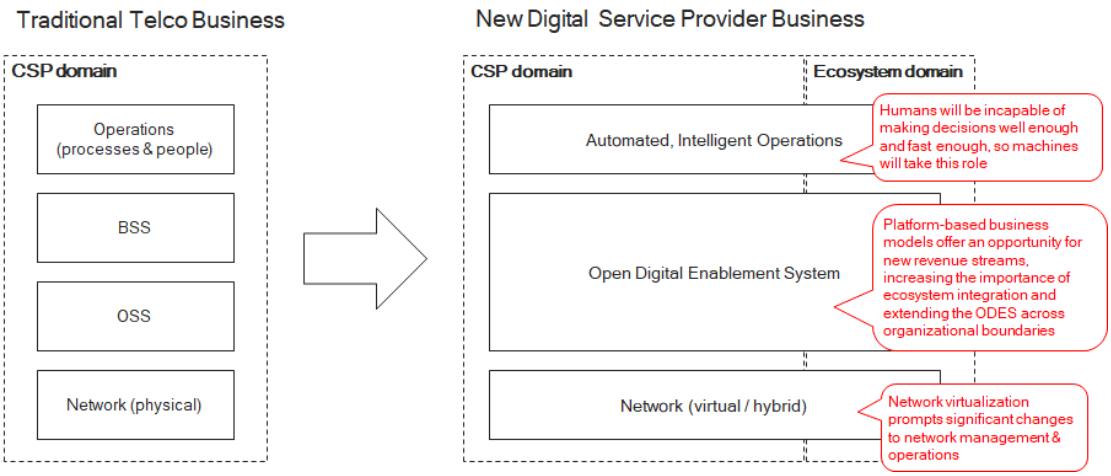
1. Customer experience management
2. Service management and optimization
3. Network management and optimisation

For example, operators are using virtual agents and chatbots to improve customer experience. As the internet of everything takes shape, network and service management must be zero-touch, because it isn't feasible to support the volume and velocity of changes that must happen in a software-defined network made up of millions of nodes running thousands of applications.

TM Forum has been at the heart of BSS/OSS standardization and innovation for many years. The Frameworx suite of best practices and standards, which provide the blueprint for effective business operations, have become the common language for operators around the world. Key components of Frameworx include the Business Process Framework (eTOM), the Information Framework (SID) and the Application Framework (TAM).

With its vibrant collaboration community building on the Frameworx heritage, TM Forum is ideally placed to become a leader in the development of the KDN.

In recent years, TM Forum has been laying the foundations for the evolution of CSP OSS/BSS in response to the significant market and technology changes highlighted in the figure below:



These foundations include:

- Our work on Digital Platform Reference Architecture (DPRA) and Digital Services Reference Architecture (DSRA), as well as our Open APIs Program, to enable ecosystem-based business models
- Our Zero-touch Orchestration, Operations and Management (ZOOM) project, which is developing best practices to support the technology and business transformation brought about by the introduction of NFV and SDN
- Our work defining the OSS/BSS of the Future.

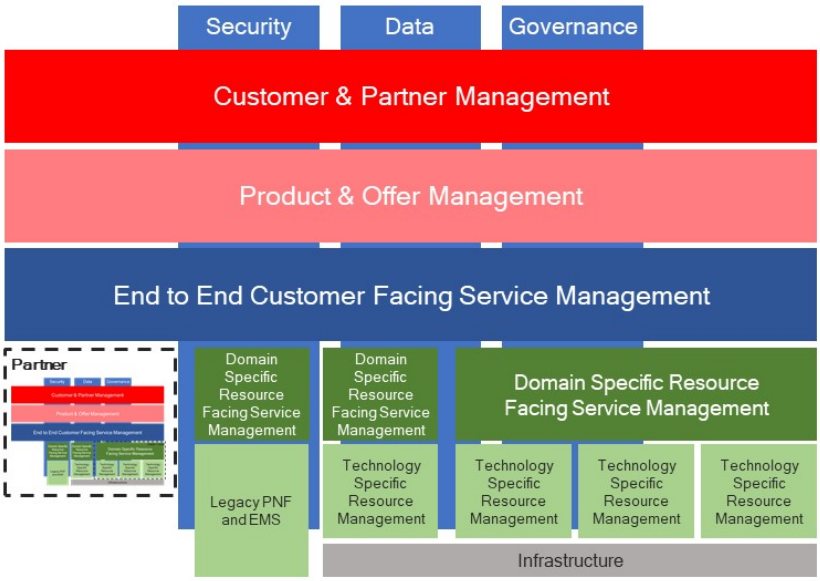
As part of the future OSS/BSS work, we have held recent workshops[1] with several of TM Forum's senior CSP members, who are now proposing a new architecture vision for service providers to replace traditional OSS and BSS. We will refer to this new system here as the Open Digital Architecture[2] (ODA).

[1] Participants and contributors to the CSP Workshops include AT&T (Jenny Huang & Martin Phelps); Bharti Airtel (Nathan Phipps); BT (Charles Gibbons & Colin Paterson); O2 (Gurjit Gill & Chris Hatton); Orange (Laurent Leboucher); Telefónica (Daniela Galigniana, David Holcombe & Andy Conway); Vodafone (Dr Lester Thomas & Atul Purohit).

[2] Working title

3. An evolutionary model: TM Forum Open Digital Architecture

The recent CSP workshops proposed the model below for the ODA – essentially a new operating system for service providers to replace traditional OSS and BSS:



This single architecture will deliver all the capabilities previously siloed in independent BSS and OSS. It removes the barriers between the two creating a loose coupling between the layers, which increases flexibility and lowers costs and helps CSPs deliver a truly digital customer experience end-to-end. This approach supports the requirements of future agile, real-time, service provider infrastructures based on SDN and NFV.

The architecture is data-centric, meaning a consistent and holistic data architecture runs end to end though the various layers of the stack. Having this holistic data architecture would not have been possible a few years ago due to the performance constraints of data base architectures at the time. However, with new technologies, like Hadoop clusters, solid state memory etc., this has now become viable.

The KDN will be connected into this data architecture, as well as into other layers, so that AI-driven intents can be fed into the architecture in line with the closed-loop model described in the previous section.

'Framelets' as building blocks

The new architecture will be built from microservices with TM Forum-compliant APIs, enabling containerization. For the sake of clarity, we will use the working name '*Framelets*' to describe the subcomponents of the architecture.

Framelets are the Lego-like building blocks of the future ODA architecture. We need to keep these at a reasonable level of granularity: too many and we increase the complexity of assembly, but too few and we may not have enough flexibility.

Framelets will enable service providers to obtain architectural components from different vendors, which can then work together seamlessly, independent of which company supplies them.

An individual Framelet or a group of Framelets can be provided by an open source program (or not, as the case may be). However, having the Framelet boundaries in the architecture allows for choice in components with plug and play between them, irrespective of how they are produced.

This has several advantages: it allows for choice between components and for vendor differentiation, say in performance, resource utilization, etc. In the case of open source components or component groups, Framelets allow for projects to have a reasonable scope and not be forced to span the entire set of ODA requirements.

This approach also allows for straightforward addition of new components to the model and reuse of components throughout the ODA.

5 key principles

The ODA is based on the following principles:

1) **AI-capable and autonomous**
   - Simple automation is not enough given the need for superhuman speed/complexity of decision-making. Therefore, our aim will be for an event-driven model governed by a holistic knowledge-defined artificial intelligence.

2) **Data-centric (rather than process-centric)**
   - Enables dynamic end-to-end processes
   - Intent-based, driven by policy
   - Common data repository for all layers.

3) **Microservice-based, using Open APIs**
   - Built from TM Forum-compliant microservice definitions, enabled by TM Forum and other industry-agreed open API definitions, which enables containerization and supports the extension of capabilities across organizational boundaries within ecosystems
   - We will work with our members and relevant standards bodies to define the complete set of subcomponents at the right granularity (Framelets)
   - Vendors would build capabilities to TM Forum Framelet boundaries; however, they could combine several Framelets together in a single product (provided the product exposes all the Open APIs of the Framelet combination)
   - The granularity and appropriateness of any Framelet boundaries will be reviewed regularly with members: The measure of a good component will be its reuse.

4) **Real time**
   - All layers of the model work in real time; this is true for the customer/ecosystem-facing and resource-facing layers

- It is expected that most customer interaction with the model will be web-based, with all customer information such as usage, billing and partner/ecosystem settlement being updated in real time
- Resource interactions will also be in real time, meaning that inventory and reporting must also be in real time
- Design time and runtime capabilities will be integrated at all layers of the stack (there will be no need to 'stop the machine' when adding new products and services or even new network configurations), thereby enabling business development and operations workflows to be integrated together, and providing support for a DevOps (and NoOps) based approach
- There will need to be governance around the change management of ODA as the model develops with the right change policies applied to Framelet versioning.

5) Supports platform business models and cloud-native capabilities

- Allows for Framelets (actualization platform capabilities) to be exposed/resold by business platforms
- Allows for third-party Framelets to be integrated
- Supports integration with partner networks
- Allows for the exposure/resale of partner capabilities.

4. Next Steps

Our aim is to develop an industry-agreed ODA with an agreed set of Framelets using TM Forum Open APIs. This standardization will enable faster realization of CSPs' digital transformation programs, optimal deployment of virtualized networks and support for new business models, which will benefit all ecosystem stakeholders.

Specifically, TM Forum will:

- Continue development of the new model with our members to drive industry consensus for ODA and complement related efforts from other organizations
- Work on the next level decomposition of the architecture into Framelets with Open APIs
- Focus our Open API program on the Framelets defined within the model
- Align the model with TM Forum's DSRA and show how the Framelets fit into the DPRA/DSRA capabilities
- Further develop project workstreams and Catalysts around AI and the KDN concept.

References

Knowledge Defined Networks

Albert Mestres1, Alberto Rodriguez-Natal, Josep Carner, Pere Barlet-Ros, Eduard Alarcón,Marc Solé, Victor Muntés-Mulero, David Meyer, Sharon Barkai, Mike J Hibbett,Giovani Estrada, Khaldun Ma'ruf, Florin Coras, Vina Ermagan, Hugo Latapie, Chris Cassar,John Evans, Fabio Maino, Jean Walrand and Albert Cabellos

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