

Huawei ADN & TM Forum AN Vision: An Evaluation

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EXECUTIVE SUMMARY

This article evaluates the goals, philosophy, and implementation path of the Huawei Autonomous Driving Network product plan vision against industry criteria as established in the TM Forum Autonomous Networks vision, as articulated in its AN2.0 release from October 2020.

This paper builds on the foundation laid in a previous ACG Research paper¹ that describes the TM Forum AN vision, articulates a set of current challenges to implementing the vision, and presents possible responses to the challenges. In this paper, I evaluate the Huawei ADN against the TM Forum AN vision in three areas: goals, architecture, and implementation approach. I also introduce a new set of requirements from the need for the ADN/AN to be the underpinning of a larger Intelligent Composable Fabric for enterprise digital transformation across communications, distributed computing and storage infrastructure, generic technology packages, cross-industry enterprise digital enablement applications, and industry-specific software applications.

Overall, ACG Research finds that the TM Forum AN and the Huawei ADN visions are in sync in goals and philosophy. Both are focused on describing the actions of a network that would be under the direct control of users and operators but would be able to configure and maintain itself and the services that utilize it, without any human intervention, becoming a true network platform (also called Network as a Service). However, as a vendor that intends to deliver the vision over time, Huawei is more specific in articulating its architecture and implementation approach.

The Huawei ADN differentiates itself by its vision of ubiquitous artificial intelligence at all levels of the architecture, including the equipment itself, and its extremely strong domain focus that calls for a set of domain controllers from the dominant vendor in a set of nested autonomous domains under the control of a cross-domain orchestration layer (or layers), an architecture that ACG Research believes will predominate. Of course, both the Huawei ADN Solution and the TM Forum AN vision will evolve as the industry gains more experience in implementing the next generation of highly-automated fixed and mobile networks.

¹ Mortensen, Mark H, Autonomous Networks: Now is the Time. ACG Research, December 2020. <https://www.acgcc.com/reports/autonomous-networks-now-is-the-time/>

Background

The concept of a network that configures and maintains itself under the direct control of a customer has been around for over twenty-five years. Such networks are called by many names, Network as a Service (NaaS), Zero-Touch Networks, and Autonomous Networks (AN). However, it is only in the last five years that software technology and communications standards have evolved to the point that such network operations are realizable. This is the third article in a series discussing this vision and how it is being implemented in stages by vendors and communications service providers (CSPs).

This is the third article in a series on autonomous networks and their implementation.

In the first article² I described the market needs, asked the question of why this vision (which has been around for many years) is now ripe for realization, and discussed some of the challenges ahead of the industry as we strive toward autonomous networks.

In the second article,³ Liliane Offredo-Zreik, my colleague, highlighted how autonomous networks can support the evolving Healthcare 4.0 and Manufacturing 4.0 initiatives.

In this paper, I look at one particular vendor's vision of the autonomous network, Huawei's Automatic Driving Networks and compare and contrast it with the TM Forum Autonomous Networks vision.

The TM Forum Autonomous Networks Industry Vision

The TM Forum, an industry forum that has driven some of the best standards in CSPs' network operations and Business Support Systems (BSS) and Operations Support Systems (BSS/OSS), has articulated a vision and a set of driving use cases for Autonomous Networks.⁴ Main contributors to this vision were BT, China Mobile, Ericsson, Huawei, Orange, Telstra, and the TM Forum itself.

The AN is an operations vision for networks of the future, provided either as a service or as a platform to enterprises and CSPs as defined by the TM Forum, delivering the Zero X experience, Figure 1.

² Mortensen, Mark H, Autonomous Networks: Now is the Time. ACG Research, December 2020. <https://www.acgcc.com/reports/autonomous-networks-now-is-the-time/>.

³ Offredo-Zreik, Autonomous Networks Power Industry 4.0. ACG Research, January 2021. <https://www.acgcc.com/reports/autonomous-networks-power-industry-40/>

⁴ See TM Forum white-paper, Autonomous Networks: Empowering digital transformation for the telecoms industry (Rel. 1), May 2019 (AN1.0) and TM Forum white-paper, Autonomous Networks: Empowering digital transformation for smart societies and industries, Release 2, October 2020.

The autonomous networks are composed of the network resources⁵ themselves and the controlling⁶ ICT software, computing, and storage resources. Together, they provide a network that can be configured by stating a service intent to the system, which is instantiated automatically into the network fabric by database entries or explicit network resource allocation and configuration (especially important in providing network slices of shared resources or allocated network resources to the service). On an ongoing basis, the autonomous networks automatically configure themselves for optimally serving the current set of services according to their individual service level agreements. The networks provide nearly instantaneous (zero wait) actions without any human intervention (zero touch) and uses a combination of proactive and self-healing techniques to work flawlessly (zero trouble).

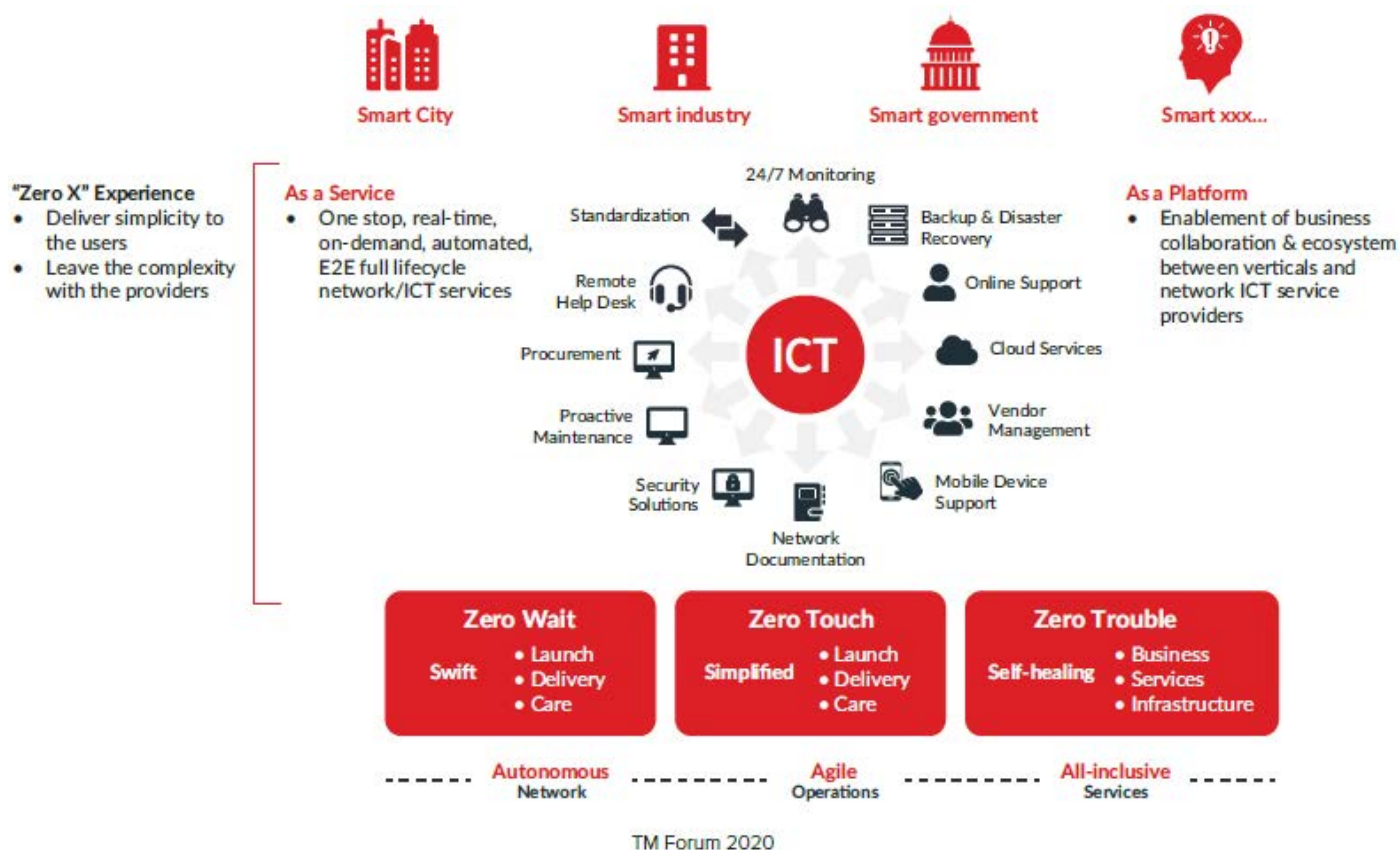


Figure 1. Autonomous Networks Vision (Source: TM Forum, 2020)

⁵ The network resources are a combination of physical and virtual network elements, many of which are disaggregating both in horizontal (multiple elements in the communications path) and vertical (disaggregating the hardware from the controlling software) dimensions.

⁶ In the past, instead of saying controlling software, I would have written supporting software, those BSS and OSS that support the operations of the network. In the modern software defined network (SDN) approach, the view is that the software controls the network, becoming more of an operational whole.

The basic architecture of the AN is shown in Figure 2. A series of interlocking closed-loop processes provide a hierarchical operational framework based on a concept of autonomous domains.⁷ At the bottom are the network resources themselves, divided into separate resource domains, which work automatically and autonomously under the control of what ACG Research calls **domain controllers**.⁸ Cross-domain control is done at a higher level (dubbed **cross-domain orchestrators**) and operates across domains for engineering, provisioning, assurance, and security. Services operations also include most of the functions that are currently in OSSs today.

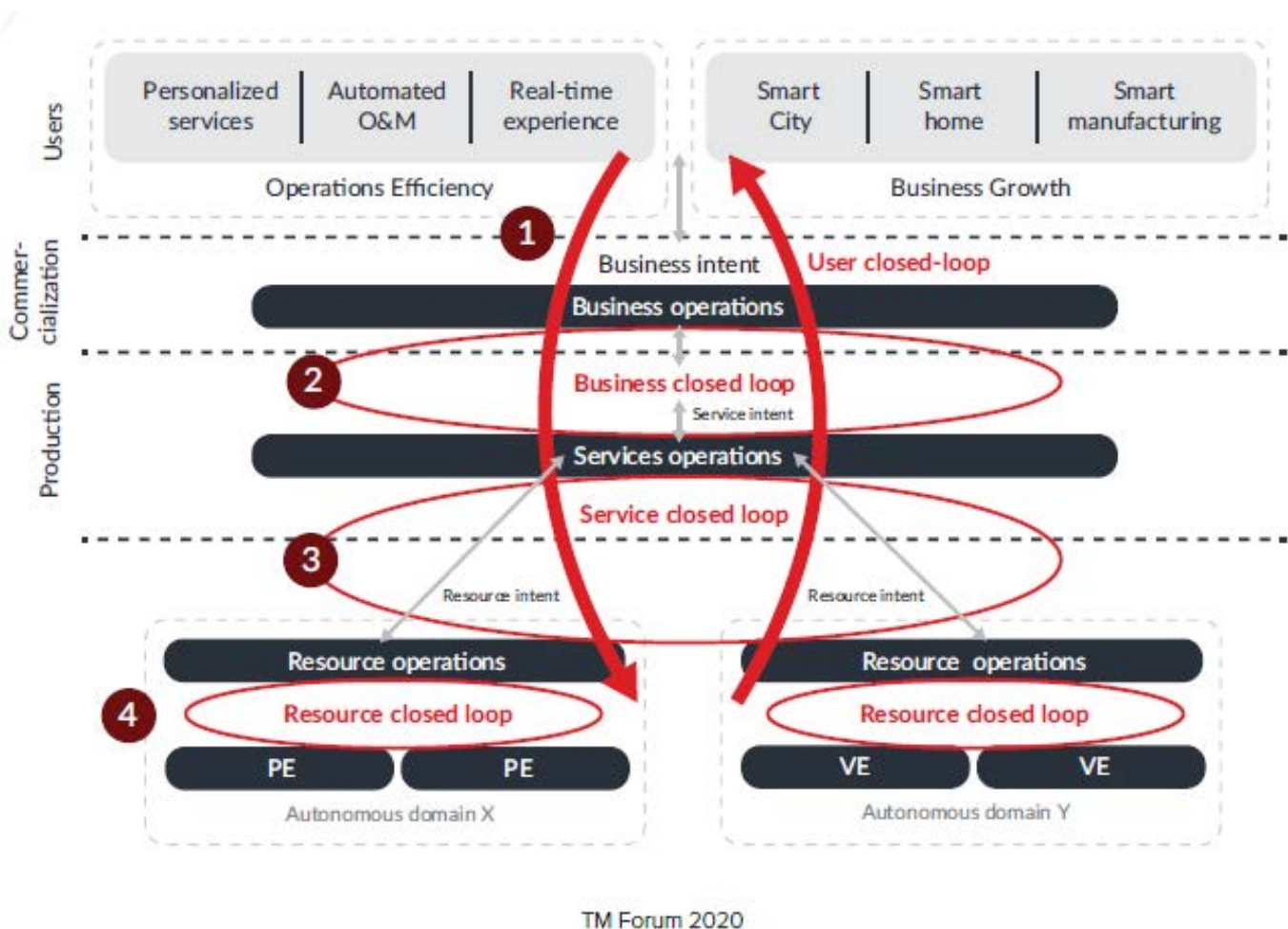


Figure 2. AN Framework (Source: TM Forum, 2020)

⁷ The AN and other whitepapers are silent on the question of what the set of domains will be, considering it to be an implementation detail that will depend strongly upon the desires of a particular CSP. ACG Research has researched the question and provided a set of domains that appear to match the needs of most CSPs. Contact the mmortensen@acgcc.com for further information. Huawei also has its defined set of domains, as will be discussed later in this paper.

⁸ In ACG Research's view, these domains may not operate completely autonomously and may be stacked into sub-domains. Some suboptimization within a domain may be necessary to provide globally-optimized network configurations but at the cost of significantly more complex higher-layer computations and interactions between the domain controllers and the higher-level cross domain orchestrators.

Above the service operations are the business operations, the realm of BSS today. They provide the customer care, ecosystem enablement, rating and billing, and other business functions.

The Huawei Autonomous Driving Network Solution

Huawei has articulated its product vision of the autonomous network of the future, labeling it the *Autonomous Driving Network Solution*.⁹

The Huawei ADN was the evolution of the work from Huawei's future networks lab, initiated in 2012. It is built upon the Huawei visions of its all-cloud strategy (SoftCOM, 2013), network function virtualization (NFV) solutions (2012), SDN controller (2015), All Cloud Strategy (2016), AI Powered Autonomous Network (2018), and the *Telecom ADN Communications Intelligence White-Paper* (2019). The solution was released in 2020 and has served as Huawei's blueprint for its contributions to the TM Forum AN project as well as many other standards projects.

The ADN Solution is based on four major components, with ubiquitously embedded AI, that support both network provisioning and assurance functions, as shown in Figure 3.

1. A simplified network infrastructure with an embedded AI inference unit for real-time, service-aware local management,
2. A network management and control unit for provisioning and assurance functions that exceeds the scope of the individual network elements,
3. An intelligent operations and maintenance platform, provided as a cloud-based service, for automating network provisioning and assurance,
4. A cloud-based network AI unit for the training, coordination, and management of the distributed AI intelligence.

Autonomous networks are built on a philosophy of single-domain autonomy with multidomain orchestration.

⁹ Huawei, ADN Solution White-Paper (Automatic Driving Network), Huawei, 2020. <https://carrier.huawei.com/~media/CNBGV2/download/adn/Autonomous-Driving-Network-whitepaper-en1.pdf>

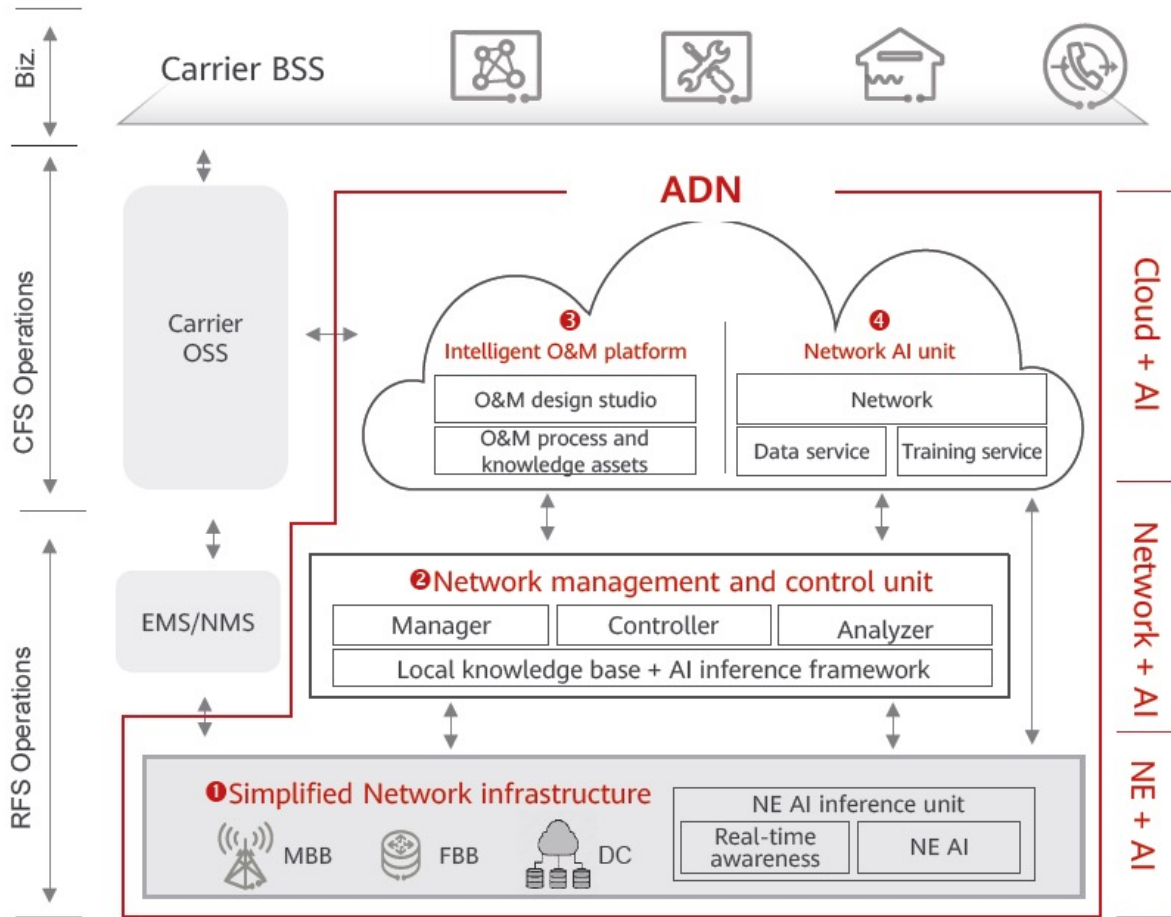


Figure 3. Huawei ADN Network Solution (Source: Huawei, 2020)

Simplified Network Infrastructure

The Huawei ADN posits an agile network architecture that supports network convergence, resource pooling for centralized functions, and cloud-based architectures to simplify operations and maintenance. It includes new simplified protocol stacks to ease service configuration and optimize the maintenance processes. It foresees lighter-weight devices as high-density integrated blades that simplify planning and construction.

However, it also includes greater intelligence in the network itself, including built-in AI inference capabilities to create real-time awareness of the network and service status and the ability of the management systems of the network and the underlying cloud resources to closely coordinate their activities to provide optimized zero-touch and zero-trouble service.

For fixed broadband networks, the Huawei ADN Vision foresees all-optical access and aggregation networks for better resource utilization and a simplified transport network for fixed network services for internal and enterprise uses that has fewer layers.

For mobile broadband networks, simplified wireless sites with ubiquitous blades for supporting 2G through 5G services with improvements in both power consumption and frequency utilization. Simplified services introduction through integrated slicing and multiedge computing (MEC) platforms.

A simplified core network would support a converged fixed/wireless network architecture that will be self-aware of connection services and promised service level agreements as well as having fewer layers to make automated network design, implementation, and service assurance faster and simpler.

Network Management and Control Unit

Huawei breaks the network into two super-domains, with a network management and control unit for each, called the iMaster NCE for fixed broadband networks and the iMaster MAE for mobile networks. Both of these provide domain control functionality (provisioning and assurance) for individual subdomains (via specialized submodules) and cross-domain orchestration across the entire super-domains. The iMaster products are composed of refactored functions from existing EMSs integrated into the iMaster product as well as new components with extensive AI capabilities.

The iMaster NCE supports the IP, optical, fixed access network, IP and optical synergy, data center networks, campus networks, SD-WAN, computer infrastructure, and WAN subdomains as well as cross-domain orchestration and simulations of proposed changes to ensure proper capacity after changes to network resources or services. iMaster NCE NetEcco is an application for data center energy savings.

The iMaster MAE supports the radio access network, core mobile network, and MEC subdomains with full functionality. The iMaster MAE-CN is a configuration of the iMaster MAE for managing the core network, including edge and core data center resources. It integrates all of the functions of EMSs, MANO, NSMF, NSSMF, MEAO, and MEPM. The iMaster MAE-M is another configuration that supports the RANs, automating the operations of the radio sites. It has intelligence to automatically and dynamically configure the RAN parameters for optimal service quality.

Intelligent OA&M Platform

iMaster AUTIN is an intelligent operations and maintenance platform, implemented as a cloud service for ADNs. It provides design services for carrier engineers and partners as well as automated assurance processes. It is being built as a centralized system that can use the best contributions to the process library to optimize operations. It incorporates semi-manual operations and is rapidly evolving with more than 900 automated apps.

Network AI Unit

The distributed AI functions in all parts of the network and the control systems bring problems. How do you bring together all the data and best-practice machine-learned intelligence, optimize it, and distribute it to the various AI systems? The iMaster NAIE is designed to solve that problem. Also provided as a cloud service by Huawei, it simplifies AI model development, improvement, and management

Evaluating The Huawei ADN Match To The TM Forum An Vision

The Huawei Autonomous Driving Network is Huawei's vision of the future. As one of the driving members of the TM Forum's Autonomous Networks vision, it is not surprising that the two are in accordance with each other. However, the match goes deeper than that, being in near-perfect harmony. However, the Huawei ADN vision goes into much more implementation detail. It also provides a particular set of domains that matches the comprehensive Huawei product line that covers the entire gamut of functions needed by a CSP's network. The Huawei ADN also specifies the ubiquitous use of AI in all levels of network software and equipment.

ACG Research finds the ADN solution and the TM Forum AN vision in near perfect harmony

	TM Forum AN	Huawei ADN
Goals	Fully autonomous network operations based on available technology for a multivendor network.	Fully autonomous network operations based on Huawei ADN product set meeting intent-based networking standards northbound from both domain controllers and network orchestrators. Supports multivendors' mixed physical and virtual networks.
Architecture	<ul style="list-style-type: none"> Operational domain orientation with domain controllers for separate technology domains. Cross-domain orchestration. Northbound connectors to OSS systems. 	<ul style="list-style-type: none"> Strong operational and technology domain orientation. Single-domain and multidomain controllers for separate technology domains and desired operational boundaries. Strong multivendor support at orchestration & domain control levels for elements meeting standards. Northbound connectors to OSS systems.
Implementation Approach	Not addressed	<ul style="list-style-type: none"> Overall solution from Huawei, capable of controlling other vendors' equipment at orchestration levels. Evolution path from current Huawei EMS/NMS systems. Ubiquitous AI control & cooperative learning & AI management infrastructure.

Goals

The **TM Forum AN** seeks to meet CSPs' goals to reduce costs as operating expenditures have continued to outstrip revenue growth and meet the increasing customers' expectations that have been driven by better customer experience from web-scale companies than has been traditional in telecoms. It sees network automation as key to meeting both these goals as well as in being able to drive increased revenues in 5G and Industry 4.0. In fact, the stated goal of the AN vision is to "support a set of innovative business models and network services that enable the digitalization of vertical industries as well of the digital life of consumers through fully automated and intelligent business, ICT, and network operations." These provide the zero-wait, zero-touch, and zero-trouble characteristics of a network that is self-fulfilling, self-healing, and self-optimizing.

Huawei's ADN strategy involves a set of architectural and technology innovations by integrating multiple intelligent technologies such as SDN, NFV, cloud, big data, AI, and knowledge graphs. It sees a set of changes, powered by innovations:

- Move from manual operations to automatic execution in all aspects of operations, including configuration delivery, changes, and upgrades. It sees humans on the loop, monitoring the network behavior and making policy changes, not in the loop, doing the operations themselves.
- Transition from reactive maintenance driven by complaints to proactive maintenance before issues occur. By processing large volumes of historical data, constantly monitoring, and constantly updating the rules through machine learning, it envisions a move toward zero customer-affecting events.
- Move operations from manual decisions by people to machine-based decision making, with machine learning.
- Migrate from open-loop management to data-driven closed-loop autonomy, providing an assured service experience.

MyTake on Goals

The goals of the TM Forum AN Vision and the Huawei ADN are in perfect harmony. This is not surprising since Huawei is a major partner in many of the TM Forum initiatives, including the AN Vision. As a vendor, Huawei has a strong orientation of being an overall solution supplier, integrating the network resources (both physical and virtual network elements) with the control software.

Architecture

The **TM Forum AN** architecture is domain-based with cross-domain orchestration. The functions supported include:

- resource provisioning for new, changed or decommissioned network (physical and virtual) resources,
- service provisioning for services (including sliced network resources),
- service assurance for equipment (virtual and physical) and services (including sliced resources).

The document is silent on the incorporation of security in the various domains or how overall resource, network, service, and end-user device security is handled.

The domains are autonomous in operation, with four levels of autonomous loops that incorporate the previously mentioned functions:

- Resource-level closed loop for physical elements and resource level for virtual elements: these have northbound resource intent interfaces.
- Service-level closed loop for multidomain operations: these have northbound service intent interfaces.
- Business-level closed loop for business operations: this has a northbound business-intent interface.

- User closed loop that interfaces to the user of the services, presenting a service fulfilment API to the user. This loop operates across the three layers.

The architecture implies that physical and virtual network elements be managed in an integrated fashion at the equipment, network, and service level but managed in separate domains at the resource level. It is silent on the issue of the architecture of the management of the virtual elements underlying compute and storage interfaces, as to whether these are in a separate resource domain, managed by its own domain management system or integrated into the virtual element domain management system.¹⁰

The **Huawei ADN** has a strong domain approach in its ADN implementation, with domain controllers dedicated to each technology super-domain (although they share many technical components with each other). Huawei domain controllers provide multivendor support, where needed, although the preferred Huawei architecture appears to be for other vendors' equipment to be controlled by their own domain controllers, which have northbound interfaces to a Huawei cross-domain orchestration system.

MyTake on Architecture

The Huawei approach of each vendors' equipment viewed as a separate domain with domain controllers from the vendor of the equipment will be the dominant architecture in the future. However, in two cases, that will not be true: disaggregated network elements and when there is a minority equipment vendor in the network. In the former, there will be a domain controller as a component of the disaggregated architecture that attempts to pull together the multivendor components into an operational whole. In the latter, the domain controller from the dominant vendor will provide adequate support of the minority vendor's equipment, its functionality depending upon the adherence of the equipment to standards and the degree to which interoperation has been required by the competitive marketplace.

Implementation Approach

The **TM Forum AN** does not specify the domains but suggests that examples include access, metro backbone, core, edge, customer networks as well as from the customers' perspective, SD-WAN, VoLTE, and CDN services. The TM Forum AN architecture implies that physical and virtual network elements be managed in separate domains at the resource level.

¹⁰ Compute and storage management offerings such as the VMWare Telco Cloud treat these resources as a separate domain that provides domain management for all cloud-native (containerized) or virtualized software resources. This includes all general-purpose software, management software, and resources for VNFs. The domain controllers for the resources presents intent-based interfaces to other domain controllers that need to create, modify or decommission any compute and storage resources.

The **Huawei ADN** has a strong domain approach in its ADN implementation, with domain controllers dedicated to each technology super-domain. The distributed AI in the architecture is managed as its own domain.

The ADN domains are nested with controllers for each domain:

- Fixed Broadband Networks Super Domain, iMaster NCE
 - NCE-Campus for private campus network and edge computing resources,
 - NCE-FAN for Wi-Fi/ONT and PON for the fixed access network,
 - NCE-IP for IP core,
 - NCE-T for optical transport networks and data center interconnect,
 - NCE-WAN for SD-WAN,
 - NCE-Fabric for managing the underlying cloud (compute and storage resource) fabric resources,
 - NetEco for AI based intelligent power and cooling management functions,
 - NCE (super) for private-line service automation, including both IP and optical networks.
 - Other network resource vendors' domain controllers for their (virtual and physical) network resources.
- Mobile Broadband Networks Super Domain, iMaster MAE
 - MAE-M for wireless network elements,
 - MAE-CN for core network elements,
 - Other network resource vendors' domain controllers for their (virtual and physical) network resources.
- AI Systems, iMaster NAIE intelligent engine
- Cross-domain service orchestration, iMaster AUTIN

MyTake on Implementation Approach

In the near term, the key question is what the list of domains will be and how to coordinate them with cross-domain orchestration, especially in a more disaggregated, multivendor architecture. The AN is silent on this, leaving this as a local implementation decision. The Huawei ADN, with its need to present a migration plan from current networks to the ADN, is more specific. The Huawei ADN super-domain, nested implementation concept provides a good map for current Huawei customers for the domains, especially those for whom Huawei is a major supplier of equipment in multiple domains. In the Huawei ADN architecture, the Huawei iMaster AUTIN provides the cross-domain orchestration required for overall CSP operations.

For the longer term, the major issue will be how to orchestrate the distributed control AIs, each of which desires to optimize within its own sphere of influence but needs to mute their own domain optimization to provide a more global optimization. Also, black swan behaviors that inevitably happen as emergent events in autonomous systems will have to be ring fenced. These are still problems that will need to be addressed in both the AN and ADN before fully autonomous operations can be completely implemented.

As industries seek to implement the Industry 4.0 vision, becoming composable enterprises, they must undergo a full digital transformation of their company processes and their IT computing, storage, and processing infrastructure. They also require a new vision of their communications infrastructure to provide the enabling rapidity, composability, and flexibility. ACG Research has envisioned the creation of an Intelligent Composable Fabric (ICF). This fabric brings together the communications, information, data processing and storage, operations technology, and process automation technologies that are needed to compose a digital platform for a wide range of enterprises as they undergo their digital transformations.

Key to providing this infrastructure is an integrated, highly flexible, exceptionally reliable, self-service, autonomously managed communications platform that can be deeply integrated with information processing and storage to meet the evolving needs of the enterprise. Networks that meet the goals of an AN or ADN would meet these basic criteria but may have requirements that look beyond into the integration into the other components of the ICF.

MyTake©

The AN and ADD concepts are just what is needed for the communications part of an ICF. However, networks that are part of the ICF will have additional requirements that relate to their tight integration into the rest of the IT/OT fabric. These are still a matter for research at ACG, but early indications include:

¹² See, for example, Future of Applications: Delivering the Composable Enterprise, Gartner, 11 February 2020.

¹³ Mortensen, Dr. Mark H. and Parker-Johnson, Paul, Enterprise Digital Enablement via an Intelligent Composable Fabric. Layer123 Conference, 2021.

- *Sophisticated simulation and sandbox capabilities before autonomous interactions are taken to ensure that overall ICF KPIs are preserved in highly sliced networks (another example of global versus local optimization),*
- *Detailed knowledge and, potentially, control of the resources used in the network to integrate with infrastructure as code control structures for the ICT portion of the ICF,*
- *Greater integration with the data center networking part of the fabric, especially around geographic distribution of resources and mitigation against accidental tangled hierarchies of resources, applications, and control software.*

Conclusion

In this paper we have examined the TM Forum Autonomous Network vision and the Huawei implementation of that vision in its Autonomous Driving Network. We found them to be compatible, with the Huawei ADN having more detail, since it is not only a vision, but also a roadmap for Huawei product evolution in the future as well as an overall architecture for its legacy and evolving network resources.

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About the Author:



Dr. Mark H Mortensen (mmortensen@acgcc.com, [@DrMarkHM](https://twitter.com/DrMarkHM)) is an acknowledged industry expert in communications software for the TMT sector, with over 40 years of experience in OSS and BSS specifications, software architecture, product marketing, and sales enablement. His work has spanned the gamut of technical work at Bell Labs, strategic product evolution at Telcordia, CMO positions at several software vendors, and as a research director at Analysys Mason. Most recently, Mark has focused on the technology and processes of digital transformation for Communications Service Providers and the growing automation and orchestration of network and business processes. He joined ACG Research in 2018 where he has been responsible for Communications Software research and consulting. He recently, with his colleague, Paul (PJ) Parker-Johnson launched a new syndicated research program, *Domain Control and Orchestration*, that characterizes the state of the industry, profiles vendor solutions, and tackles many of the network management issues described in this paper.

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