Huawei ADN Solution Approach to Implementing Autonomous Networks

Mark H Mortensen, Ph.D.

EXECUTIVE SUMMARY

This article evaluates the approach that Huawei is taking in its Autonomous Driving Network Solution product plan vision to meet the challenges of implementing a true autonomous network. ACG Research finds that the Huawei approach and current product offerings and plans well address the near-term issues as articulated in our previous reports. It also provides an excellent overall framework for the longer-term issues for implementing a fully autonomous network, driven by both practical concerns, a strong vision, and customer-driven product evolution plans.

Huawei distinguishes itself through:

- A strong bottoms-up autonomous domains operations philosophy, implemented as a set of layered network super-orchestrators, orchestrators, super-controllers, and controllers,
- A suite of orchestrators and controllers with standard interfaces, both northbound and southbound from each. Its integrated AI powered control structure can be implemented in toto for a full solution or decomposed to interface with autonomous domain controllers and equipment from other vendors,
- Practical evolution plans toward autonomous networks operations for CSPs that have already deployed Huawei EMS and NMS systems in their fixed and/or wireless networks,
- A plan to simplify the operations of the autonomous network through consolidation of the underlying domain structure control of its virtual and physical equipment, especially in the transport domain,
- A distributed AI inference framework, provided as software services, to train the ubiquitous AIs. This framework uses the CSPs own data and best current practice data from other CSPs as curated by Huawei,
- Strong professional services offerings to plan and speed the technical and organizational transition of a CSP's network operations toward autonomous networks,
- A continuing commitment to standards development and implementation to achieve the autonomous networks of the future.

Introduction

This paper builds on the foundation laid in a previous ACG Research papers that:

- Describe the TM Forum AN vision: Why the time has come to push AN implementation and articulates a set of current challenges to implementing the vision. [1]
- Show how the AN vision is an essential supporting communications infrastructure for Industry 4.0 implementation in several industries. [2]
- Evaluate the Huawei ADN against the TM Forum AN vision in three areas: goals, architecture, and implementation approach. [3]

In this paper, we update the set of challenges facing AN implementation and describe Huawei's approach to meeting these challenges in its ADN product plan.

The Huawei ADN and 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 (OSS), has articulated a vision and a set of driving use cases for autonomous networks.[4] Main contributors to this vision are BT, China Mobile, Ericsson, Huawei, Orange, Telstra, and the TM Forum itself.

Huawei, a major contributor to the TMForum AN vision, has articulated its product plans of the autonomous network of the future, dubbing it the *Autonomous Driving Network (ADN) Solution*.[5] The goal of the ADN is to proceed in incremental steps, guided by the AN vision toward operational intelligence and full automation, incorporating the best, current practices of multiple CSPs as Huawei moves to **zero-x experience**, nearly instantaneous (zero-wait) actions without any human intervention (zero-touch) by using a combination of proactive and self-healing techniques to provide flawless service (zero-trouble).

---

[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/

[2] Offredo-Zreik, *Autonomous Networks Power Industry 4.0*. ACG Research, January 2021. https://www.acgcc.com/reports/autonomous-networks-power-industry-40/.

[3] Mortensen, Mark H, Huawei AND & TM Forum AN Vision: An Evaluation. ACG Research, April 2021. https://acgcc.com/blogs/2021/05/03/huawei-adn-tm-forum-vision-evaluation/

[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.

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

The ADN Solution is based on four major components, with ubiquitously embedded AI, that support both network provisioning and assurance functions, Figure 1.

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 exceed 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.

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.

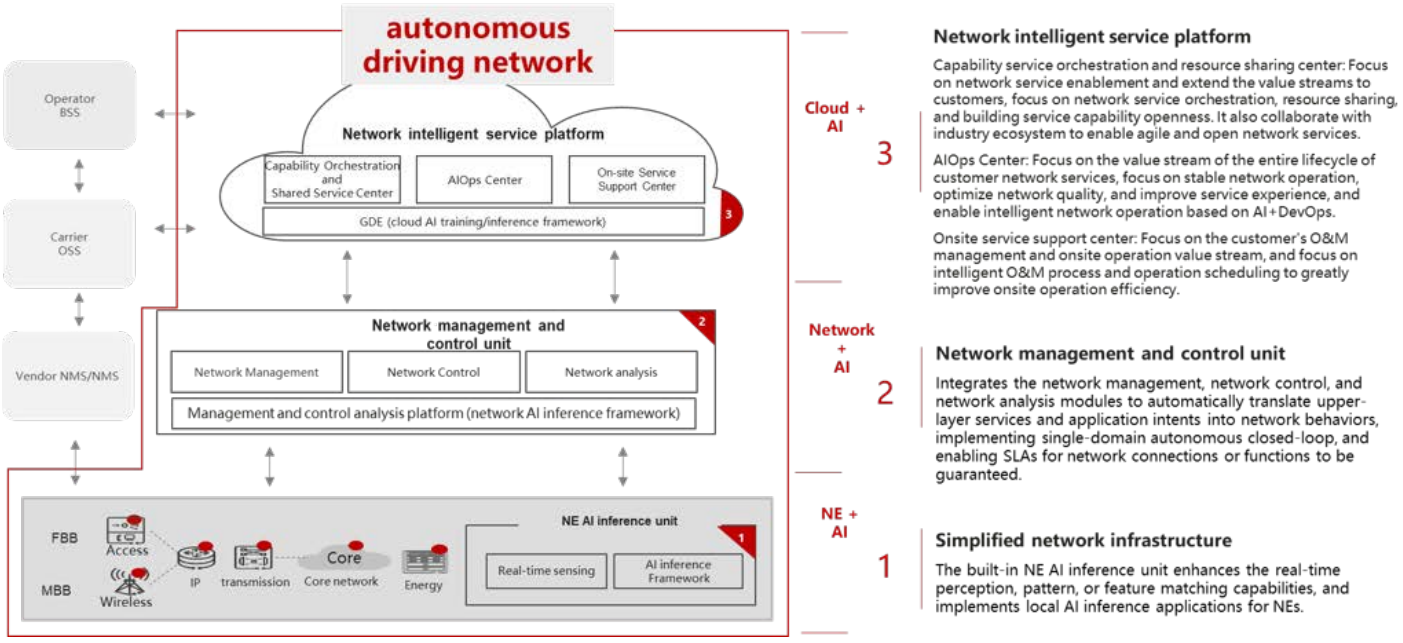

Figure 1. Autonomous Networks Vision (Source: Huawei 2020)

However, it also includes greater operational 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, the Huawei ADN Vision foresees simplified wireless sites with ubiquitous blades for supporting 2G through 5G services with improvements in both power consumption and frequency utilization as well as 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.

ADN Product Architecture

The four major Huawei ADN solution components are shown in Figure 2.

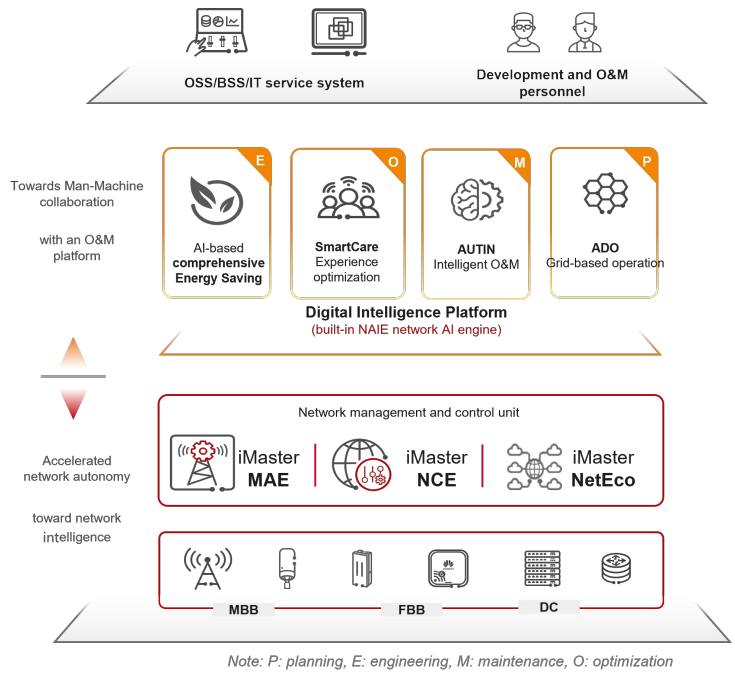

Figure 2. Four Major Huawei ADN Solution Components

Super-Orchestrators for Fixed and Mobile Networks: iMaster NCE and iMaster MAE

The super-orchestrator of the fixed broadband network is the iMaster NCE; mobile broadband networks are orchestrated by the iMaster MAE. Both these systems are built on a common technology platform and share many components. Underneath these super-orchestrators there are additional tiers of cross-domain orchestrators and domain controllers.

Intelligent OA&M Platform: iMaster AUTIN

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. iMaster AUTIN runs on a Digital Intelligence Platform that also supports other non ADN applications such as an AI based energy saving solution, a SmartCare solution for experience optimization, and ADO for grid-based operation.

Network AI Unit: iMaster NAIE

The iMaster NAIE brings together all the data and best-practice machine-learned intelligence, optimizes it, and distributes it to the various AI systems. Provided as a cloud service by Huawei, it simplifies AI model development, improvement, and management.

The NAIE incorporates a data service that uses a data-lake to continuously collect data and monitoring points for network and service insights. They are fed into the training service component for machine learning and continuously adjust the weights in the algorithms to maintain or increase the accuracy level. Data can be gathered and used within a CSP, created by Huawei professional services or shared among participating CSPs that opt into the sharing process.

NAIE also has an AI model development framework to generate new and update algorithms supporting many of the machine learning frameworks and libraries, such as TensorFlow, PyTorch, Caffe, and CKNet.

HUAWEI ADN RESPONSE TO THE CHALLENGES OF IMPLEMENTING AN AUTONOMOUS NETWORK

There are still some major challenges to be overcome to fully implement the vision of autonomous networks, but there are approaches that are already on the horizon to meet them as network autonomy progresses from the current levels to full Level 5.

Mixture of Legacy Physical Elements and New Physical and Virtual Elements

Much of the network is not still legacy equipment, not virtualized, which gives it the quick-response elasticity, nor software controlled, which provides the configuration agility. This means that some parts of the nonvirtualized part of the network will be left behind or will have be adapted to the new AN structure through northbound interfaces to its current EMS/NMS systems. Some network elements will have thin adapters added.

Huawei Approach to the Challenge

Huawei is a supplier of a full spectrum of network functions (both physical and virtual) with a large, embedded base in CSPs where they are often the dominant provider of network technology for a domain or multiple domains. This means that there are many Huawei-provided element and network management systems already in place. Huawei is evolving its current EMS and NMS systems to the iMaster line to support current and future customers in evolving to autonomous networks. It is providing domain controllers with defined northbound intent-based interfaces for integration with other vendors' cross- domain orchestration (CDO) systems. It is also, on a per-request basis, building interfaces from its DC and CDO systems to other vendors' systems and physical and virtual network functions.

MyTake

This is a very practical approach, beneficial to the current and future customers. It is especially compelling for the T2–3 CSPs that lack the operations architecture and systems integration muscle to create their own detailed plan for the evolution of their network and operations architecture to autonomous networks. It provides an orderly transition to autonomous networks, allowing the CSPs to absorb the organizational and workflow changes to transition to an autonomous network without having to write their own software. The overall transition can be planned and hastened through the application of Huawei professional services.

Trusting Closed-Loop Operations

Although much automation has been implemented using simple robotic process automation (RPA)[6] macros, many CSPs are loath to allow software systems to implement any large-scale changes in their network without human supervision, adding additional cost and delay[7]. The potential problems include:

1. Managers trusting the AIs,
2. Global versus local optimization,
3. Black swan behaviors from the interaction of multiple AIs with different and potentially changing optimization goals.

Huawei Approach to Challenge

1. Huawei's plan for introducing the autonomous networks over time via the maturity model should give the managers time to adjust to the AIs providing advice, with open loop operations gradually becoming closed loop. The NAIE infrastructure will enable the best current machine learning to be shared across the CSPs' operations or even among CSPs (if they opt in). Huawei benefits from over 30 years of data and experience in network management and operations, knowledge that is being embedded in its networks and systems.

2. The problem of orchestrating distributed control AIs, each of which desires to optimize within its sphere of influence but may need to mute its own domain optimization to provide a more global optimization, is viewed by Huawei as a small problem. Each AI inference unit is responsible for the policies or agreement assigned to it. Most of the breakdown would have little overlap between them. In ADN, the cloud-network synergy platform of the NAIE allows it to train at a higher level for those affecting global optimization, building on the local optimizations that the lower autonomous levels put in place.

3. On the issue of black swan behaviors coming from interacting AIs, even though Huawei believes that the NOC change significantly in the future, service operation center will still be needed for these long-tail behaviors as the few fringe black swan use cases may not be cost effective to automate. However, the dominant model will be person-in-the-loop to person-on-the-loop, with the people monitoring and guiding the AI powered operations.

[6] See, for example, https://www.uipath.com/rpa/robotic-process-automation.

[7] See https://www.acgcc.com/blogs/2020/01/28/five-barrier-questions-to-ai-adoption/ for a more detailed explanation of the key management issues involved in implementing closed loop operations.

MyTake

Except for the first, the issues will only arise in the longer term. There will, in the future, be a need for greater simulation capabilities to show the effect of major changes on the network and service KPIs before AIs are allowed to make major network changes. In the interim, operational slider control that gives the responsible managers the ability to control how open loop or closed loop the AI works will be implemented. Ring-fencing the actions of autonomous AIs will have to be implemented and mechanisms will need to be created for detecting and controlling AIs moving outside of their approved fencing limits.

Integration of Communications with Computing and Storage

As the physical network becomes more virtualized and additional services are added through software, it becomes more intertwined with the computing and storage in data centers. As computing power is added to the edge, the computing and storage become more intertwined with the network. This can lead to another tangled hierarchy that needs to be addressed. Integrated control structures for service chaining across communications, computing, and storage will evolve to meet this need.

Huawei Approach to Challenge

Huawei approaches the computing and storage infrastructure of the virtualized network and the autonomous networks control structure as its own domain. It constitutes one more layer in the already layered network architecture that is orchestrated at the cross-domain level. The computing and storage domain is controlled by its own set of systems, whether they are pubic, cloud, hybrid or multicloud architectures. These systems are interconnected to provide optimal management of the entire cloud infrastructure. Huawei is benefitting from its 28 businesses, working with many enterprises on their cloud infrastructure.

MyTake

This has become the standard architecture for the computing and storage cloud resources, with multi-cloud arrangements (a mix of hybrid private/public and multiple public clouds) becoming prevalent. Judicious choice of the clouds and transport resources used for supporting the NFs and the control software will be necessary. The NOC will change substantially, with the computing and storage resources becoming an intrinsic part of network service monitoring.

Integration among CSPs

CSPs do not exist in a vacuum. Because most CSPs work within defined geographical boundaries, enterprise services often need to transcend these boundaries and involve multiple CSPs. Closed-loop operations of

Network-as-a-Service intercarrier interfaces involving these entities will be difficult technically but even harder to negotiate and manage from a business perspective. The needs of large enterprises will, inevitably, drive this trend, with direct interfaces among CPS and the use of cross CSP exchanges.

Huawei Approach to Challenge

Huawei is providing at the BSS level a set of APIs for the interaction of CSPs to other CSPs for provisioning services that transcend the CSP boundaries. However, there is a still a dearth of standards in this area, especially for broadband services.

MyTake

The Huawei approach is a practical way to address this in the short term. This is an area that needs additional attention from CSPs, vendors, and standards organizations. To meet the near-term needs, brokers are arising in this ecosystem, translating orders into the various data models and APIs needed by different CSPs. Some CSPs are also building bespoke interfaces to other CSPs and doing service chaining across the boundaries. After the problem of inter CSP ordering is solved, attention will move to providing more fine-grained real-time service performance information. Just as we talk about multicloud today, we will talk more about multinetwork in the future.

Integration with Trading Partners, Suppliers, and Resellers

As with the inter CSP problem, there are the operations that go across CSPs' suppliers and resellers. Significant progress is being made in this area, with offer catalogs being automatically traded and updated in e-commerce systems. Web-scalers already have such standard and de facto interfaces available for enterprises to use in specifying, ordering, and monitoring computing resources. These need to be extended to include the communications components.

Huawei Approach to Challenge

Huawei has already included the interfaces to leading web scalers into its architecture for finding, allocating, and managing the computing and storage resources needed for both virtualized equipment and the cloud-native control software. Huawei also has in its BSS architecture the functionality for interfacing with trading partners, suppliers, and resellers.

MyTake

This is an area that will require much work in the future for Huawei, standards development organizations (SDO), vendors, and CSPs. The intent is to create interfaces that allow full Network as a Service (including Network Slices as a Service) interfaces for customers to use to order and manage their own services.

Slicing Architecture

The operations architecture for a highly sliced network is not yet understood. Several vendors have created slicing managers that directly work with network resources, others work through the domain controllers. This will take some time to sort out.

Huawei Approach to Challenge

Huawei is building into its DCs and CDOs the ability to plan, provision, inventory, and assure network slices for both wireless and fixed networks. Full 3GPP standards implementation is planned. This will require no additional software modules specific to slicing, although multivendor slicing architectures will require additional professional services to implement.

MyTake

Huawei has a very comprehensive plan for network slicing. It offers a set of advanced capabilities for controlling latency that I have not seen elsewhere, including an inventory of the latency available from various transport resources for low-latency slice designs and probes for measuring latency on demand for verification of low-latency slice designs during initial provisioning or backups when QoS violations occur or are predicted to occur.

Overall Network Inventory Architectures

The issue of whether inventory should exist at a domain level (and what information should be made available to the higher levels) or at an overall network level or both is still to be addressed. Several approaches with advanced federation capabilities to allow flexible architectures are available already in the marketplace.

Huawei Approach to Challenge

The iMaster system stores the inventory of the domains that it oversees, synchronizing it with the equipment that is capable of auto-discovery.

MyTake

Like all vendor architectures that seek to support both software controlled and legacy equipment, Huawei uses a combination of automatically-synchronized inventory caches and master inventory information (where auto-discovery is not available). Its approach is to keep the master information as close to the network as possible to keep it current.

Integration with NFV Computing and Storage Infrastructure Control

In some architectures, especially from virtual network infrastructure vendors, the management of the computing storage infrastructure is integrated into the domain operations. In many other operations architectures[8] it is a separate domain, not under the control of the domain controller. In such cases, however, the domain controller could initiate the allocation and implementation of the VNFs/CNFs via messaging to the infrastructure controller when additional infrastructure resources are required. ACG Research believes these standards will evolve to include this feature.

Huawei Approach to Challenge

The iMaster software solution interoperates with leading domain controllers for the virtual (virtualized or containerized) computing and storage resources, following the Broadband Forum view.

MyTake

In the last year, this has become the **de facto** *architecture. Huawei is following the industry trends.*

Network Service Assurance Architecture

To fully do closed-loop operations on a domain level, the domain controller needs access to the current state of the network domain, basically incorporating all the service assurance functions. In most CSP operations, a centralized whole-network service assurance system is implemented to support the domain, cross-domain, and end-to-end service assurance functions. How to architect the information gathering, processing, and control structure is an item still to be addressed. Several possibilities exist, including the full sharing of information using data-lakes or the disaggregation of the centralized service assurance systems into individual domains with a federation of the information via a hierarchy of federated service assurance functions.

[8] For example, the Broadband forum Cloud-CO in TR-384 (see https://www.broadband-forum.org/download/TR-384.pdf) and ETSI Open Source MANO (OSM) https://www.etsi.org/technologies/open-source-mano.

Huawei Approach to Challenge

Because Huawei's ADN control architecture is layered, it needs to operate on service assurance information at all levels of the hierarchy. Close to the network, the network fault and performance information is most relevant. At higher levels of the architecture, the service-level performance information becomes paramount. The Huawei approach is to have all of the service assurance information available at all levels of the control hierarchy. It also foresees the need for more efficient collecting of relevant data from network infrastructure from network simplification by cutting down the layers (fewer hops), reducing the number of protocols, using new protocols (SRv6/EVPN) and telemetry.

MyTake

This is a strong approach that should meet the needs for the next several years. I envision an increasing need for an overall data-lake of assurance information, with autonomous AIs sipping from the data-lake (as well as taking in real-time telemetry), comparing the current state of a digital twin of the network, and looking at multiple ways of optimizing the network for QoS and resource optimization.

Need for Close Industry Collaboration

Meeting these challenges will require the collective work of CSPs, network infrastructure vendors, independent software vendors, and systems integrators. Fortunately, several industry forums and SDOs have shown themselves to be effective means for collaboration on visions, generic requirements, and interoperability testing. Although inter-forum cooperation is increasing, aligning the efforts, much more is needed.

Huawei Approach to Challenge

Huawei is involved in all the major SDOs and is a strong contributor to 3GPP, BBF, IETF, and the TM Forum. It supports standards development and implementation.

MyTake

Huawei's commitment to standards is well-known. As a major vendor of network infrastructure and the increasingly important control software, it needs to continue its strong efforts to standardize interfaces so that the inevitable multivendor architectures can be effectively managed.

Conclusion

The Huawei ADN vision that drives its product evolution plans is clearly articulated and practical. It is optimized for those CSPs that are major customers of Huawei's network resources, including in-place networks and OSS/BSS systems. It has addressed the major issues that have been identified in the near term for moving toward the autonomous networks of the future and has in place a strong framework for future evolution.

About the Author:

Dr. Mark H Mortensen (mmortensen@acgcc.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.