Solution Brief

intel

Network Disaggregated Edge: An End-to-End Validation Approach

The Happiest Minds test automation framework helps network service providers test the elements of a multi-vendor disaggregated network. This approach reduces test-cycle time requirements while enhancing test coverage and quality.

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Network disaggregation has become an important trend in data centers, although it has yet to fully penetrate the network edge. It has become common for data center operators to procure hardware and software from separate vendors, which has led to an increase in the use of white-box edge switches, although the evolution in disaggregating the hardware is ongoing.

Advances in both software and hardware have created a robust ecosystem of networking applications that can be used as building blocks to create an industry-standard network operating system (NOS) for the telco edge. The growing traction for network disaggregation has been driven mainly by service providers seeking improved CapEx and OpEx, easier and more flexible scaling and management of devices using advanced configuration based on YANG models, NETCONF and RESTAPI against traditional CLI-based inputs.

Approaches for Network Disaggregation

Network disaggregation is the combination of disaggregated systems and networks provided with open architecture, simplified hardware and open interfaces that can run over physical and virtualized environments. In disaggregated systems, each component or layer is tied together to function as a composite system, while retaining the ability to work independently as a single entity, as illustrated in Figure 1.

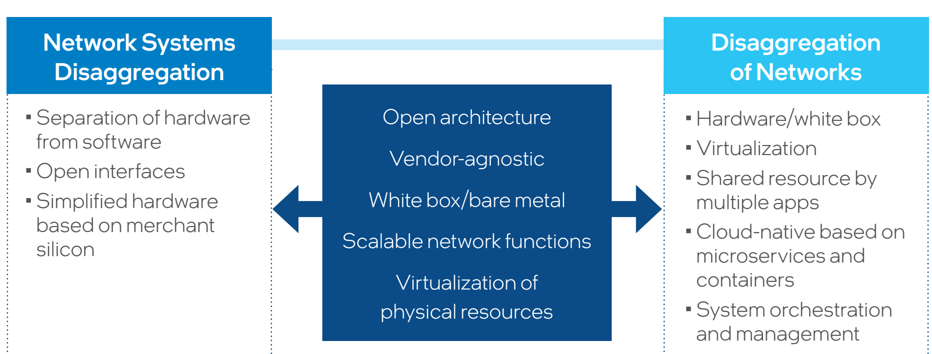


Figure 1. Disaggregation of networks and network systems.

It has become common among leading telecommunications operators to run disaggregated systems in parallel with traditional systems within field networks. These networks widely use open source NOSs such as Cumulus, SONiC, VyOS, DANOS and FBOSS, on a variety of white-box and OEM hardware. Disaggregation has penetrated particularly in access-layer, data-center and hyperscaler implementations, with a growing number of solutions also becoming available for the transport and edge layers. Disaggregated server racks based on Intel architecture have also gained some traction in the mainframe-replacement arena with the Open Compute Project.

Contribution to Linux Foundation DANOS Project

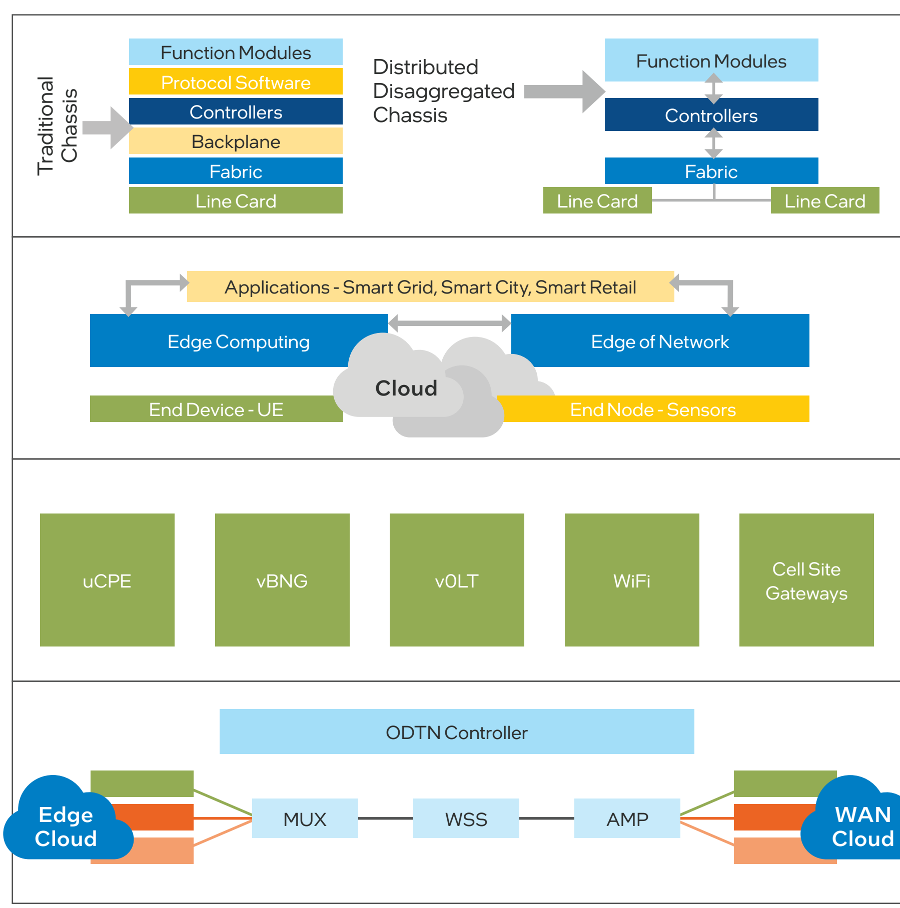
The Disaggregated Network Operating System (DANOS) project enables community collaboration across network hardware, forwarding and operating system layers. Happiest Minds has upstreamed some of the test framework reference implementation including test plans and test scripts to enable faster adaptation and adoption within the CSP community. Learn more

The state of network disaggregation across the core, edge, access and transport layers is represented in Figure 2. At the core layer, disaggregation is well established, with AT&T having deployed its first-generation disaggregated core onto the production network. AT&T followed a distributed disaggregated chassis (DDC) design using the Broadcom Jericho 2 chipset with the DriveNets network cloud solution and converged network operating system.

At the edge layer, ecosystem factors helping to drive disaggregation include the Open Edge Computing Initiative, OPNFV and Intel® Smart Edge. The latter, Intel Smart Edge, is an edge-native distributing computing platform for the deployment and management of container-based workloads including AI, media and software-defined networking functions. Disaggregation at the access layer has included adoption of network functions virtualization (NFV) technologies such as vBNG, vOLT, vONT/ONU and uCPE. At the transport layer, the industry is starting to see white-box adoption and disaggregation on the ROADM and DWDM in the transport network.

Challenges Raised in Testing and Validation

Network disaggregation initiatives face common challenges that are summarized in Figure 3. The first of these is complexity, including the difficulty of manually testing and benchmarking the function of many combinations of disaggregated elements. Second, KPIs must be developed to assess network operations (e.g., link/node/path failure rates and resolution statistics) and performance (e.g., latency, throughout, frame loss, jitter and bandwidth), with testing methodologies to support them across workloads and microservices. Third, network teams must ensure that the new disaggregated elements can coexist in a compatible manner with existing hardware and software solutions, including testing across traditional APIs and newer REST- and NETCONF-based services.



Core Layer
- Data center switching solutions based on modern workloads and virualization enviroments
- AT&T's Distributed Disaggregated Chassis (DDC) using Broadcom's Jericho2/Ramon chipset, based on UFISpace hardware and Drivenets DNOS (OCP, TIP)

Edge Layer
- Improved solutions for edge and WAN connectivity based on SD-WAN services
- Solutions based on an open ecosystem: Open Edge Computing, OPNFV, Intel® Smart Edge, etc.

Access Layer
- Advanced uCPE solutions using modern x86 platforms, VNFs such as FW, NAT and VPN solutions
- Centralized management with Open APIs and effective E2E orchestration

Transport Layer
- Disaggregated optical network architecture for SP to select multi-vendor components (e.g., transponders with different bancwidths, SLAs, etc.)
- End-to-end DC/Cloud-to-DC/Cloud services for Enterprise and HCI customers

Figure 2. Layers within disaggregated networks.

Figure 3. Key test and validation challenges in disaggregated networks.

Fourth, interoperability is a key aspect of networking, and all disaggregated systems must be tested against established OEM devices. Fifth, non-standardized testing tools and software compound the complexity created by the need for extended testing, although industry motion toward standardized solutions is showing increasing promise. Finally, organizations implementing network disaggregation initiatives must address the pronounced skills shortage in areas such as networking test automation and NetOps.

These networks must be monitored and examined using modern, standardized test tools and test automation frameworks, using KPIs that meet or exceed those for traditional OEMs, across functional and non-functional SLAs. Care should also be taken in bringing up new test automation tools and frameworks, using a system- and network-agnostic approach to validate disaggregated systems and networks.

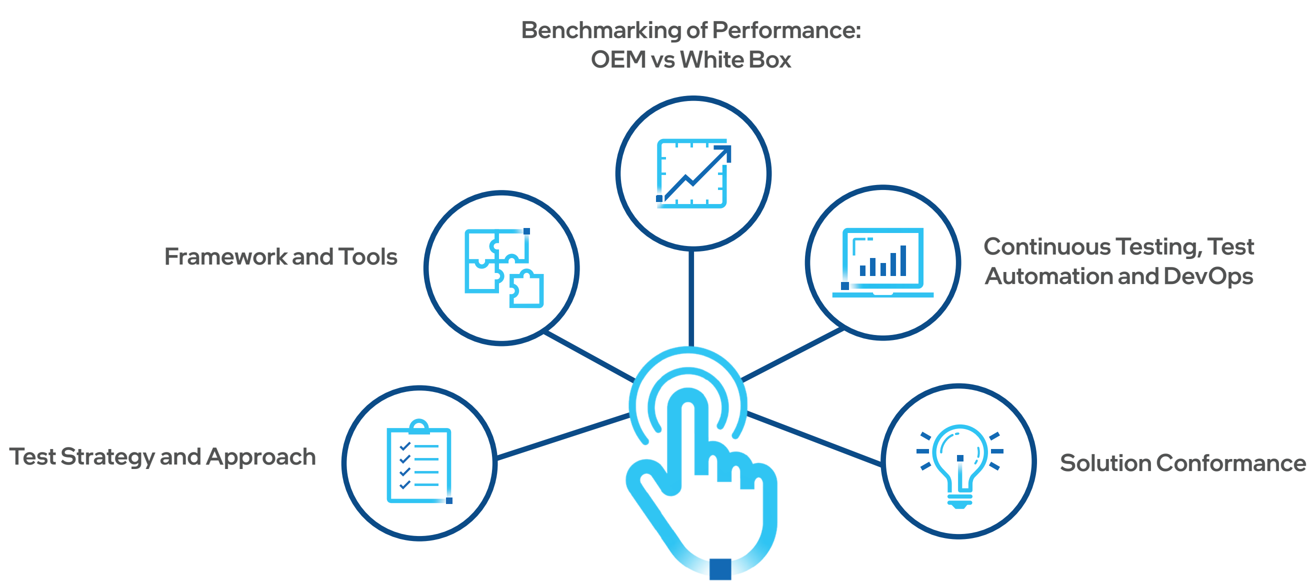


Figure 4. Success factors for testing disaggregated deployments.

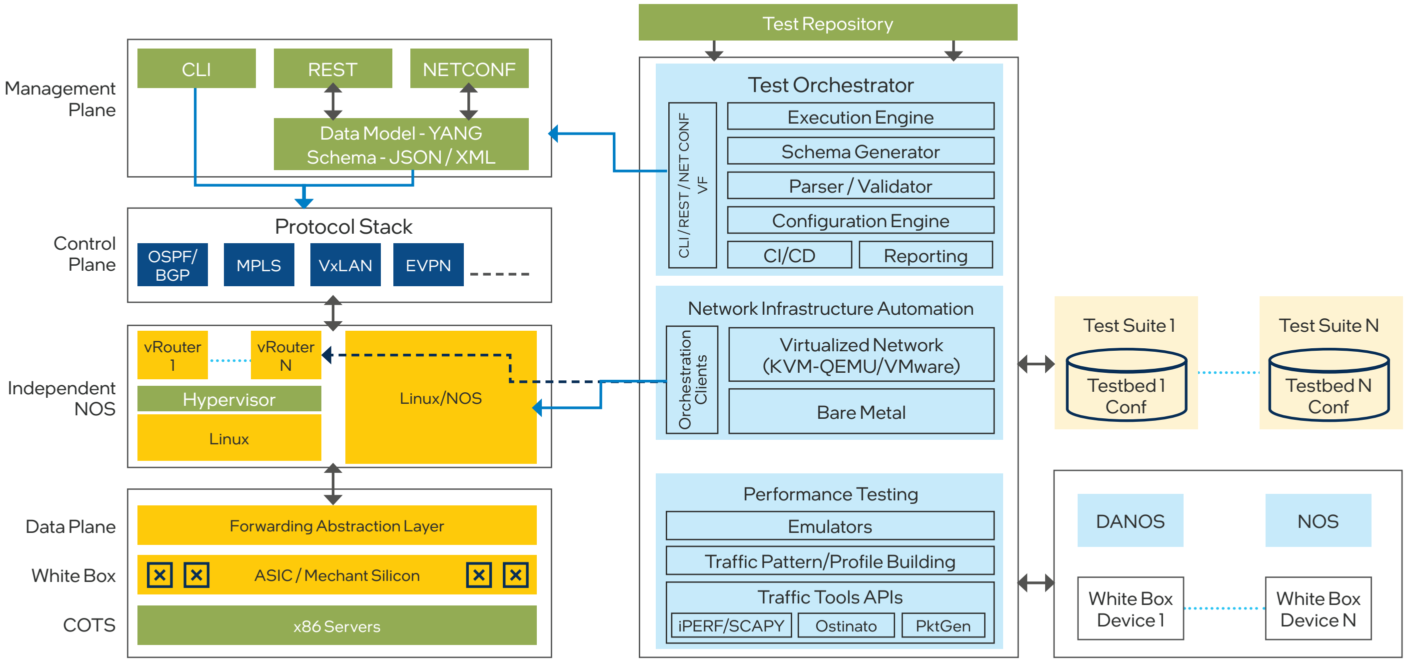


Figure 5. High-level architecture of Happiest Minds test automation framework.

Seizing the Opportunity with Happiest Minds Test Automation Framework

Testing-related factors that contribute to success in network disaggregation are summarized in Figure 4. A well-defined test strategy and approach must guide the path away from traditional manual approaches to testing, incorporating automation as a primary ingredient. Test strategy must accommodate hardware and software from any vendor on a standardized NOS, with standardized interfaces running on bare metal or virtualized deployments.

Frameworks and tools must be defined, identified and validated across the full spectrum of disaggregated network use cases. Performance must be benchmarked of OEM-based services versus a white-box system or open software-based KPIs. Continuous testing, test automation and DevOps, with continuous builds and deployment, are also critical to success. Finally, solution conformance must be established by testing the entire disaggregated solution as a composite whole.

Happiest Minds has applied its specialized expertise in testing, test automation and validation in conjunction with industry best practices to develop its test automation framework solution, targeting networking OEMs and communication service providers (CoSPs). The solution is based largely on open source components such as Python, Selenium and Robot, implementing a modular and structured approach that caters to various use cases.

The Happiest Minds test automation framework accommodates both behavior-driven development (BDD) and acceptance test-driven development (ATDD) methodologies with a simple keyword- and data-driven model that incorporates multiple test accelerators and tools as well as both legacy and modern north/south-bound Interfaces. The solution helps resolve testing and validation challenges encountered in white-box-based NOS implementations. It has been tested on Intel architecture-based servers and benefits from Intel-enabled ecosystem ingredients including throughput optimizations based on the Data Plane Development Kit (DPDK).

The high-level architecture of the Happiest Minds test automation framework is shown in Figure 5. The left side of the figure shows the fully disaggregated system under test, which is conceived in four layers. Starting at the bottom, the hardware layer is a white-box server based on Intel architecture with merchant silicon and a hardware abstraction layer that connects to the next layer, the independent NOS. The next layer up is the control plane layer with routing protocols and services, with the topmost layer comprising the management plane, with support for traditional CLI as well as REST and NETCONF-based services.

The central part of the figure is the test-orchestration system, which consists of three layers. The top layer incorporates the test engine itself, including test data, repository and files, as well as both CLI and REST interfaces and configuration engines integrated into the CI/CD pipeline. The middle layer of the test-orchestration system is the network infrastructure automation layer, which also provides orchestration services. The bottom layer, the performance testing layer, includes emulators and simulators to run the complete end-to-end system. Some of use cases designed, validated and automated through the NTAF framework are summarized below:

- **DANOS as a vFW** in testing and validation of VNF for vFW, vNAT and other functions.
- **DANOS as a vRouter** leveraging network disaggregation at the WAN edge.

Table 1. Happiest Minds test automation framework test cases.

Service Orchestration	Network and Automation	SDN (ODL and ONOS)	Switch Abstraction/ Switch/Router Functionalities	Edge/ Disaggregation	Accelerators/ Integration with Open Source
▪ TOSCA/YAML (ETSI-based) ▪ HOT (Heat) ▪ Open Source MANO (OSM) ▪ Tacker ▪ MEC	▪ Functional test ▪ OpenStack deployment ▪ NS services validation ▪ LCM ▪ Interface validation (NETCONF/REST/ CLI) ▪ Web UI automation using Selenium	▪ Functional ▪ Performance ▪ Network service ▪ OpenFlow ▪ SDN-IP ▪ YANG ▪ CSIT integration (ONF forum)	▪ BGPv2 ▪ OSPFv2 ▪ IP VPN ▪ MPLS ▪ SAI-API	▪ NAT ▪ MPLS-LDP ▪ BGP ▪ IPsec VPN ▪ OSPF ▪ NETCONF ▪ RESTAPI ▪ Firewall ▪ Performance (RFC 2544) ▪ Traffic testing (IMIX, JMIX)	▪ YANG tester tool ▪ API test tool ▪ TCL-to-Python ▪ Advanced debugger module ▪ Yardstick ▪ Rally ▪ Dovetail ▪ Functest

Table 1 summarizes the test cases for the features that have been designed and supported by the NTAF framework, which can be leveraged for the use cases.

The solution is built for Intel architecture, tested on servers based on Intel Xeon processors with Intel Ethernet network adapters and optimized using DPDK. It builds on popular technologies including Python, Selenium, Robot, iPerf3, IXIA and Scapy. Key features of the test automation framework include the following:

- Robot keyword drive and data driven.
- Pre-built libraries for CLI, REST, API, Web UI and domain-specific interfaces.
- Pre-built and reusable keyword libraries for DANOS, Cumulus, etc.
- Ready-made test repository.
- Built-in domain-specific libraries to support data center and network edge L2/L3 and edge use cases.
- Supports various network infrastructure: bare metal, virtualized and open public cloud services (OpenStack).

Conclusion

The Happiest Minds test automation framework can be beneficial to network operators as they implement network disaggregation projects. The solution can help dramatically reduce test cycle time while enhancing test coverage, for better outcomes with lower costs. It can also lend structure to operations with a repository of reusable test assets, enabling early detection of bugs. Happiest Minds helps push aggregation to the telco network edge, increasing flexibility and efficiency to accommodate a future of ongoing change.

Learn More:

Webcast – Network Disaggregation and Quality Assurance

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