Communications Software
and Network Solutions

ribbon®

Disaggregated IP Routing and Network Operating System (NOS)

IP WAVE:
State-of-the-Art IP and Optical Networking

White Paper

What's Driving the Need for Disaggregation?

With the almost limitless access bandwidth offered by 5G and Fiber rollout, we are seeing consumers demanding services with ever-increasing bandwidth. These services are becoming increasingly complex and often require service performance guarantees such as guaranteed latency, bandwidth, availability, and so on. In addition, the majority of services are hosted in the cloud, and not only do these services evolve rapidly themselves, but the cloud model also makes it relatively simple to introduce new services, if the network is able to support them.

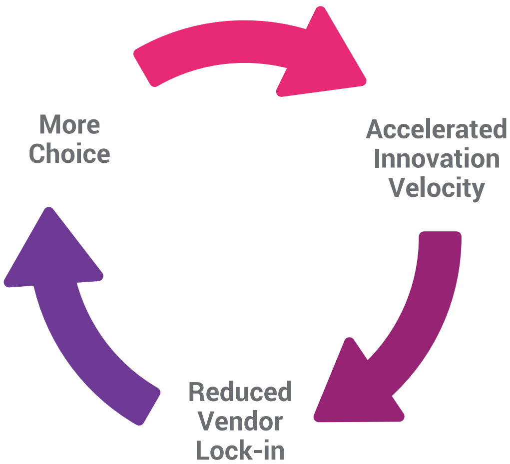
So operators now find themselves in a dilemma, they need to keep network costs static or ideally reduce them when at the same time the network needs to support new bandwidth-hungry applications and have the service agility to rapidly introduce and support new services with ever more complex service performance guarantees. To make matters worse, this dynamic service mix is making it increasingly difficult to forecast traffic patterns, demand, and capacity accurately, they require a network that has the agility to rapidly adapt to changing demand, service mix, and consumer endpoints.

Traditionally, the IP/MPLS Wide Area Network (WAN) was been built from fully integrated routers, and this approach was so successful that integrated routers providing IP/MPLS became ubiquitous for the WAN. But this integrated approach lacks the agility and innovation velocity to meet the needs of today's highly dynamic services and service mix cost-effectively. With the tight coupling between the vendor hardware and software; if the routers are scaled for today's service forecasts, there is little or no ability to scale or adapt in the future without deploying additional hardware, or if scaled for the future, the network has to be over-built at day 1, with no guarantee that the over-build will provide scale where it is needed. In addition, with traffic, applications, and service complexity all surging, we see rapid advances in IP routing capabilities and protocols, the tightly coupled routers we have today just don't allow this innovation to be rapidly introduced into a deployed network.

So network operators have become increasingly interested in disaggregation as a mechanism for increasing network agility and controlling the TCO of their network.

The Promise of Disaggregation

The aim of disaggregation is to address a number of key objectives:



Key Objectives of NOS and Disaggregation

Objective: Accelerated Innovation Velocity

Meets the service agility and scalability needs by allowing new hardware and software innovation to be rapidly introduced to the network. Requires a common open disaggregated platform with a plug-n-play hardware and software architecture that supports the introduction of new hardware and software innovation into the deployed network. This approach allows operators to select best-in-class components and upgrades are much quicker as they are based on the innovation cycle of each component rather than on the whole platform, as is the case with a traditional monolithic router.

Objective: More Choice

A disaggregated routing approach enables network operators to select best-in-class hardware and software for their own specific network and service needs. In terms of hardware, this allows a white box or NOS vendor hardware to be selected that best meets the performance characteristics required for the given applications and architectures for which it will be deployed. By definition, all of the hardware has to be carrier-class but characteristics such as number and type of interfaces, capacity, size, airflow, redundancy, environmental hardening all vary or are configurable from hardware to hardware. And when looking at the needs of specific architectures and applications functions such as synchronization, buffering, latency all need to be considered.

The software known as the Network Operating System (NOS) should be fully portable allowing it to operate on any NOS certified hardware and merchant silicon. Moreover, it should provide fully open, standards-based northbound interfaces allowing easy integration into any network orchestration system or ecosystem.

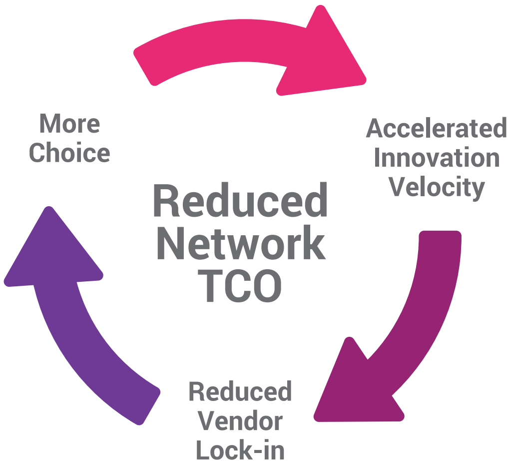
Going one step further, the software can use a containerized software architecture, with functional software blocks split into their own software containers, this has a number of advantages in terms of choice. Firstly it accelerates innovation velocity by allowing independence in the development, testing, and deployment of individual software components. Secondly, by only running the essential NOS components, the NOS is able to run on hardware with very limited specifications, increasing the hardware flexibility while keeping the same NOS. Thirdly software components can be sourced from best-in-class software component vendors, not just from a single vendor, this is taking the SONiC approach used in data centers and making it Telco-grade and applying it to the WAN.

Objective: Reduced Vendor Lock-In

With the traditional approach, the router hardware and software are fully integrated, so operators are locked into this combination of hardware and software and their innovation time cycles for the duration of the router's life in the network. Disaggregation and the associated NOS open up both the hardware and software, for new hardware and NOS components to be added to the network, so new innovation can be added from other vendors, without the need for forklift upgrades. In addition to accelerating the innovation velocity, breaking vendor lock-in will also allow more vendors to compete, which will inevitably increase price competition.

Objective: Lower TCO

All of the objectives described previously contribute to a disaggregated architecture with a containerized NOS allowing an operator to reduce their TCO when compared with the traditional single-vendor integrated router:



Key Objectives of NOS and Disaggregation

- More choice enabled by Disaggregation and an Open NOS
  - The same NOS can be used on integrated routers and/or ODM hardware in the same network
  - Enables the economies of scale which be gained from the use of standard hardware and software components
  - Allows selection of best-in-class components for optimal price-performance
- More choice enables right size scaling
  - Allows choice of "fit for purpose" software functionality with no over-engineering and only paying for functionality when it is required
  - With a containerized NOS, only the required software components are used, meaning the hardware can be scaled to support this functionality, it does not need to be scaled to support the whole NOS functionality
- Reduced vendor lock-in
  - Allows more competition.
- Accelerating Network Innovation
  - Increasing the innovation velocity means that functionality that increases network efficiency and/or reduces the cost per bit can be rapidly introduced to the network
  - Provides the ability to support new service types without the need to replace or add an overlay network if the existing routers cannot support the functionality required

Why Now

As discussed previously, an increasingly complex service mix, with exponentially increasing capacity and complexity and difficult to forecast demand is driving operators to look for a new approach that provides them with network agility they require whilst controlling the TCO of their network. Disaggregation with NOS provides them with this.

Whilst a disaggregated approach has been common in data centers for many years now, the use cases and business objectives are not the same in WAN. In addition, there has been a lack of suitable ODM (Original Design Manufacturing) hardware suitable for the IP transport network, and the barrier to entry to creating a Network Operating System has been high due to the quantity and complexity of the functional requirements. With virtual routers we saw the start of this disaggregation approach in the WAN, however, this only provided limited hardware disaggregation and was generally tied to non-optimized white boxes with an X.86 chipset and was really only suitable for limited low complexity applications such as vCPEs, firewalls, and route reflector.

However, more recently industry groups such as the Telecom Infra Project (TIP) and big operators like AT&T and Telefonica have made major progress in showing the viability and applicability of disaggregation and NOS for the WAN. On the back of this work, we now see the wide availability of ODM hardware suitable for the WAN, particularly the 1RU white box range. At the same time, merchant silicon vendors such as Broadcom now have chipsets that meet the routing "speeds and feeds" required for even the most complex WAN applications. The software has also evolved with real-time Linux providing a powerful platform for network operating systems and ONIE providing an open environment for installing a compliant NOS onto third-party white box hardware. With the predominance YANG data models and Netconf interfaces we now also have a commonality in the data modeling and northbound interfaces, making it much more straightforward to manage functionality from across the ecosystem.

So in answer to why now. Operators have the need for disaggregation and NOS and the technology is now available to make it a reality in the WAN.

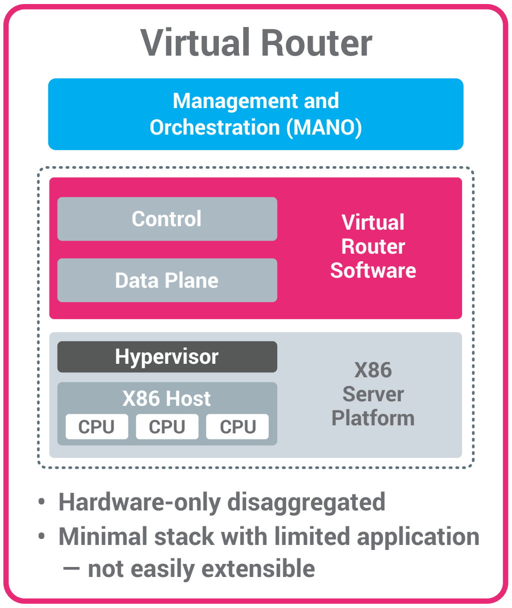
Disaggregation Approaches

Not all disaggregation approaches are the same, so when someone says they have a disaggregated router it can mean different approaches, so it is important to understand which approach they are talking about:

- Network Function Virtualization
- Hardware and Software Disaggregation
- Hardware Disaggregation
- Software Disaggregation

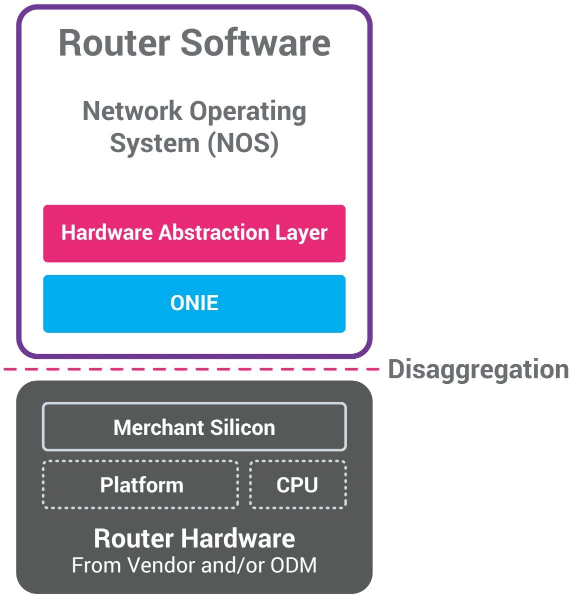
Each of these approaches is very different from the other with its own advantages and disadvantages. So it is worth spending a little time understanding each approach.

Network Function Virtualization
Although the approach does separate the software from the hardware, it isn't really about disaggregation at all, it is virtualization and NFV. An example of the Network Functions Virtualization approach is the Virtual Router, which was targeted at the Enterprise space.



In this approach, the virtual router is loaded with different functional blocks running as their own virtual machines (VM) supporting functionality such as route reflecting, NAT, firewalls being typical. These "virtual" functions can be linked together with an approach known as service chaining. Many of the leading router vendors such as Cisco, Juniper, and Nokia today provide virtual routers based on this NFV approach. These virtual router solutions generally use an X.86 hardware platform with a hypervisor providing the hardware abstraction and control of the virtual machines (VMs) on which the router OS software runs.

This X.86 based virtual router approach provides high processing power for the control plane elements of the router but is limited in its I/O forwarding capacity, making it ideal for applications that fit these characteristics, such as router reflectors, CPEs, firewalls, NAT. The virtual router has the additional drawback that the hardware is not really scalable in the carrier WAN environment, where additional COREs can be added to X.86 boxes in the data center environment, this is neither practical nor cost-effective in the carrier WAN.



Hardware-Software Disaggregation
So to overcome these issues the first step to scalable, open, disaggregation is to use white box hardware, which could come from a range of ODM vendors based on merchant silicon optimized for IP routing in the WAN environment. This hardware is sometimes referred to as the bare-metal switch, and with it we have hardware that is suitable for the carrier WAN environment. Unfortunately, it is not possible to just take any white box and load with any NOS, additional software is required to open up the white box hardware to make it accessible to multiple NOS vendors. The Open Network Install Environment (ONIE) has become a defacto standard for this software, providing an open environment for installing a compliant NOS onto third-party white box hardware. A hardware abstraction layer is then required in the NOS to adapt it to run on the merchant silicon used in the white box.

So we now have hardware-software separation suitable for IP routing in the carrier WAN. This is a great first step, it breaks the proprietary linkage between the router hardware and router software and we are already seeing a range of ODM hardware vendors. However, today's ODM hardware does not provide a full range of capabilities, architectures, and form factors, for example, some operators require fully redundant hardware others require modular platforms and we are not seeing these capabilities from ODM vendors, yet.

However, with a disaggregated NOS, this is not a real problem. For the more complex hardware configurations such as fully redundant or modular, the NOS can run on the vendor's own hardware for configurations where certified ODM hardware exists, the same NOS can run on this ODM hardware.

As ODM hardware evolves, providing more advanced merchant silicon, faster or cheaper hardware, fully redundant or modular configurations these can be introduced into the network and the same NOS run over them as is already running in the network.

This hardware-software disaggregation approach is able to meet the majority of the target goals set for disaggregation:

- More choice
  - The same NOS can be used on integrated routers and/or ODM hardware in the same network
  - Enables the economies of scale which be gained from the use of standard hardware and software components.
  - Allows selection of best-in-class ODM hardware for optimal price-performance
- Reduced vendor lock-in
  - Makes the process of adding new ODM hardware vendors and/or new NOS vendors to the network much simpler, no need for forklift upgrades
- Accelerating Network Innovation
  - Much simpler and quicker to deploy innovative new ODM hardware with the next generation of merchant silicon to the network

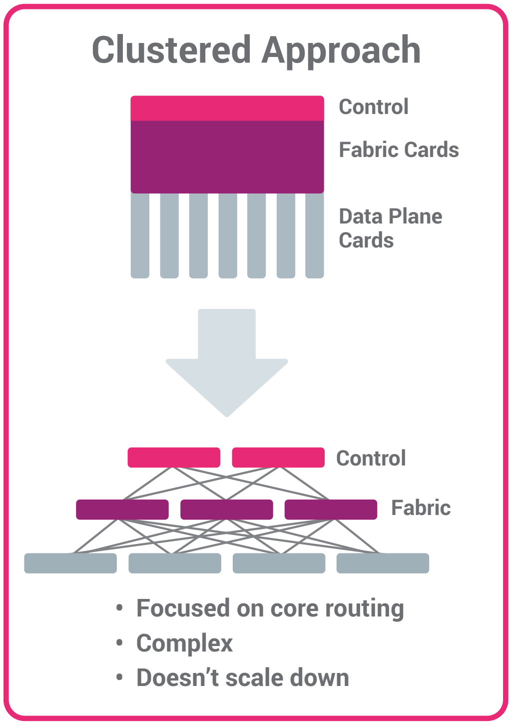
With the distributed cell site gateway DCSG) we are already seeing the first commercial deployments of this type of disaggregation.

Possible extensions to hardware-software disaggregation could be chassis disaggregation or disaggregation of the software into containers. Whether you need these extensions and whether you want hardware or software disaggregation, or both, depends where on the network you are targeting, and what you want to achieve.

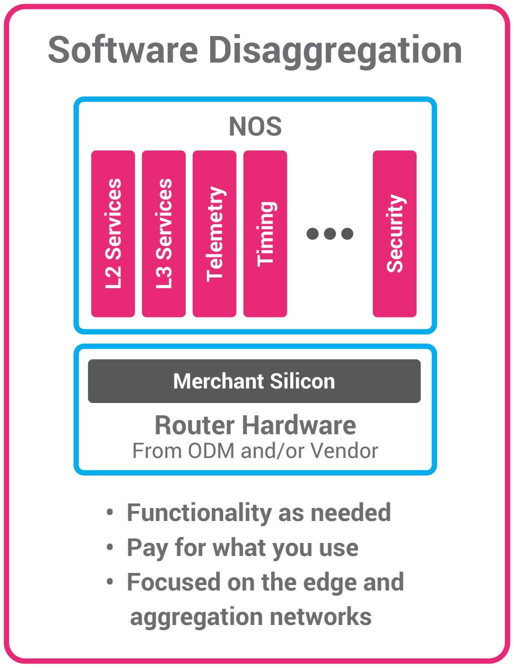
Hardware Disaggregation
This disaggregation approach is targeted at core routing or data-center-like environments, and with a number of vendors, it is close to commercial deployment.

With the old, integrated core router approach, to increase the capacity of the network, you either had to over-specify the network on day 1, deploying boxes with more capacity than was needed but leaving capacity room for growth. Or you have to deploy new chassis when growth occurs. The aim of chassis disaggregation is to provide a much more cost-effective and graceful scaling of the network.

We are seeing a clustered hardware disaggregation approach to provide the graceful scaling, in this approach the control plane functionality is put into a control plane optimized white box such as an X.86 server, and the data plane is split into white boxes dedicated to providing the fabric and white boxes dedicated to providing the line card or packet forwarding capacities. Not only does this enables graceful scaling, but it also allows the fabric capacity and the I/O forwarding capacity to be scaled independently.



Whilst a very elegant and granular approach, it is by definition a multi-box approach that requires huge management overhead. This type of approach is well suited to the core routing or data-center-like environments it is architected for, but realistically it cannot cost-effectively scale down to the access edge or aggregation regions of the network.



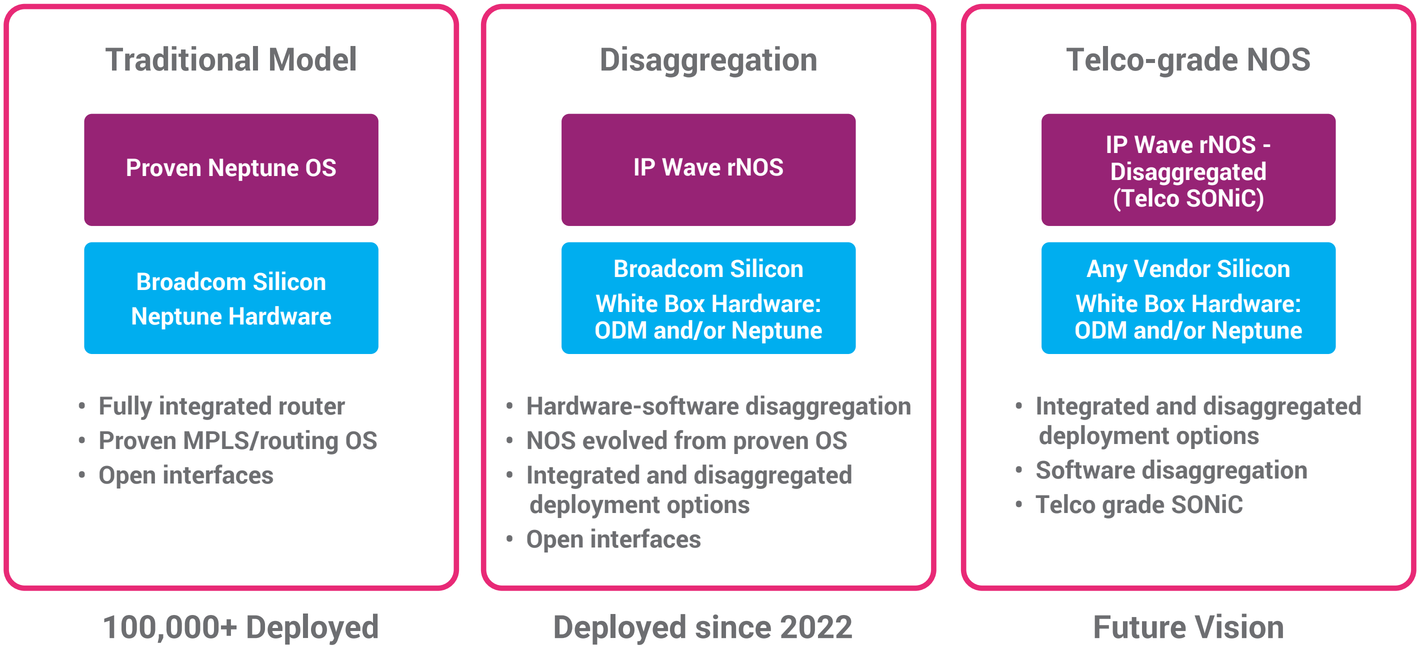
Software Disaggregation
This disaggregation approach is targeted at access edge and aggregation parts of the network.

This is a future evolution of disaggregation and takes the hardware-software disaggregation to the next level. In this approach, the NOS itself is disaggregated into separate functional blocks, with each of these functional blocks having its own container. This allows operators to go to the software ecosystem to use best-in-class software for each function. Or more likely in its initial phases, the NOS vendor incorporates new innovation and functionality from the software ecosystem into their NOS, thereby increasing innovation velocity. This approach allows the routers to be equipped with "fit for purpose" NOS functionality with no over-engineering, operators only paying for functionality when it is required. In addition, only instantiating the required software components of the NOS for a given application means the hardware can be scaled for its needs rather than for the whole NOS.

Ribbons IP Wave rNOS Disaggregation Approach

Ribbon's disaggregation approach is based on hardware-software disaggregation, with the Ribbon IP Wave rNOS being able to operate on both Ribbon hardware and any certified ODM hardware using any certified merchant silicon vendor, whether this is a 1RU platform targeted for the distributed cell site gateway (DCSG) or a redundant modular platform for aggregation.

Ribbon IP Wave rNOS Evolution



With this approach, Ribbon is able to provide disaggregated routers optimized for the needs of the converged multi-access edge and aggregation networks. Providing compelling, open, disaggregated solutions for:

- 5G xhaul, including 5G Cell site Routers
- Aggregation and Transport Networks
- The Distributed Access Architecture used by Cable MSOs

With Ribbon's disaggregation and NOS approach, operators, today, are able to realize a cost-optimized forecast tolerant network that has the service agility and innovation velocity to evolve their network as rapidly as their needs evolve.

But it does not stop there - Future Vision

Ribbon is fully committed to a disaggregated future and we continue to innovate our IP routers in line with this vision. Our IP Wave rNOS is architected such that it can be evolved into a telco-grade SONiC architecture, where we can use our telco-grade rNOS functionality (high availability, MPLS, Telco VPN services, Telco control plane, etc), combined with best-inclass NOS components available from the open community. With this containerized software architecture, we will be able to take advantage of independence in the development and testing of NOS components, enabling CI/CD operation and increasing our innovation velocity.

About Ribbon

Ribbon Communications (Nasdaq: RBBN) delivers communications software, IP and optical networking solutions to service providers, enterprises and critical infrastructure sectors globally. We engage deeply with our customers, helping them modernize their networks for improved competitive positioning and business outcomes in today's smart, always-on and data-hungry world. Our innovative, end-to-end solutions portfolio delivers unparalleled scale, performance, and agility, including core to edge software-centric solutions, cloud-native offers, leading-edge security and analytics tools, along with IP and optical networking solutions for 5G.