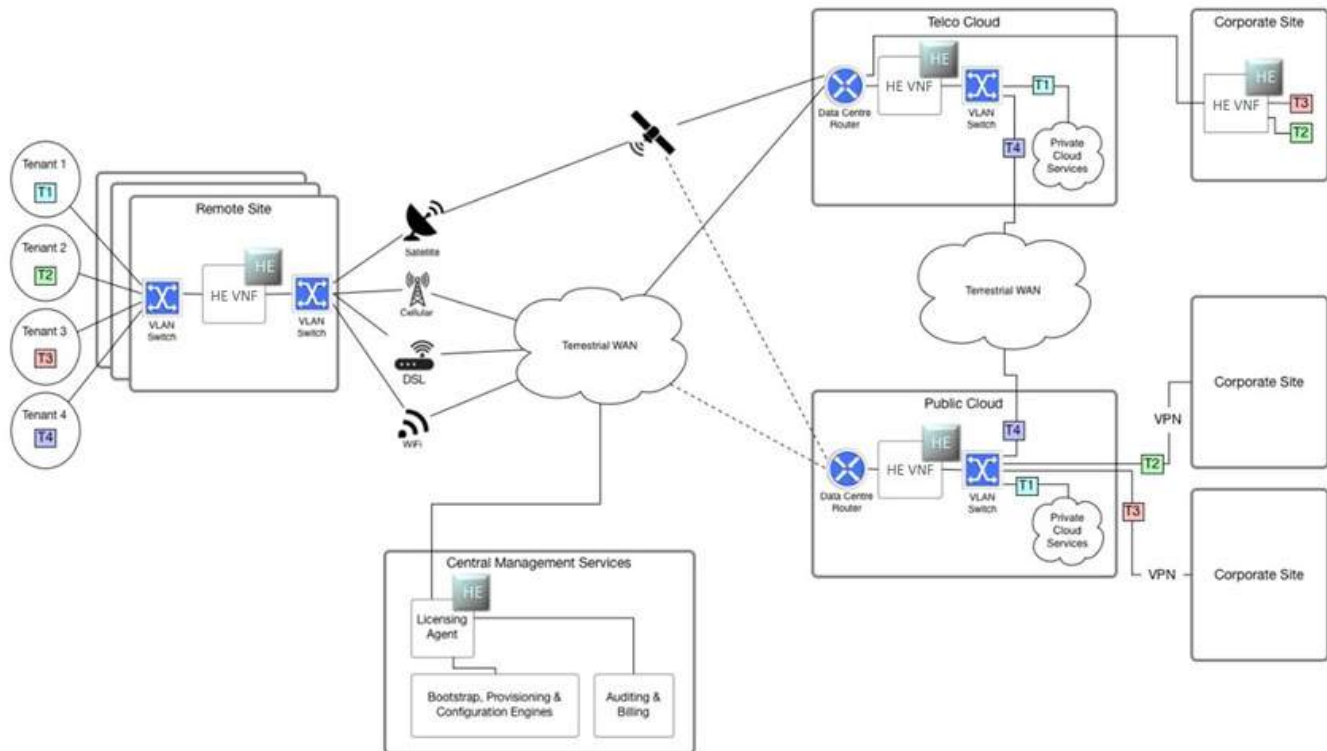


The CMS SD-WAN Fabric:

The CMS SD-WAN provides an elastic fabric, with scaling limits determined only by the limits of the hosting infrastructure. Full separation (layer 2 & layer 3) is maintained across the entire multi-tenant-aware SD-WAN fabric.



Why CMS SD-WAN?

The CMS SD-WAN solution provides:

- Horizontal and vertical scaling options, with no hard limit on fabric capacity
- True aggregation, providing sum-of-all-parts bonding, even when combining diverse link combinations
- Very low overheads compared to alternatives
- Future-proof for 5G, LEO and beyond – any IP-capable underlay can be accommodated, with no restriction on the number of supported underlays.
- Near-zero configuration required to support new underlays
- Highly effective TCP acceleration
- Multi-tenant networking that is seamlessly decoupled from the underlays, and transparently resilient to underlay transitions
- Increased profitability through granular control over service allocation and airtime usage on a per-user or per-application basis
- Rich data to facilitate service assurance over hybrid connections, and provide proof of service delivery

- Comprehensive on-the-fly control over QoS, traffic-steering, and aggregation – effective in real-time, and with programmatic interfaces allowing for highly customisable integration and control
- Vastly increased service reliability and resilience to failures
- Granular definition and control of customer service level agreements (SLAs) • Communications to central services is entirely optional

Unique features & benefits:

The CMS SD-WAN has been designed from the ground up to deal with hybrid networking over challenging networks. With a heritage in providing hybrid satellite and cellular SD-WAN networking within demanding environments including maritime, vehicular and across diverse global architectures.

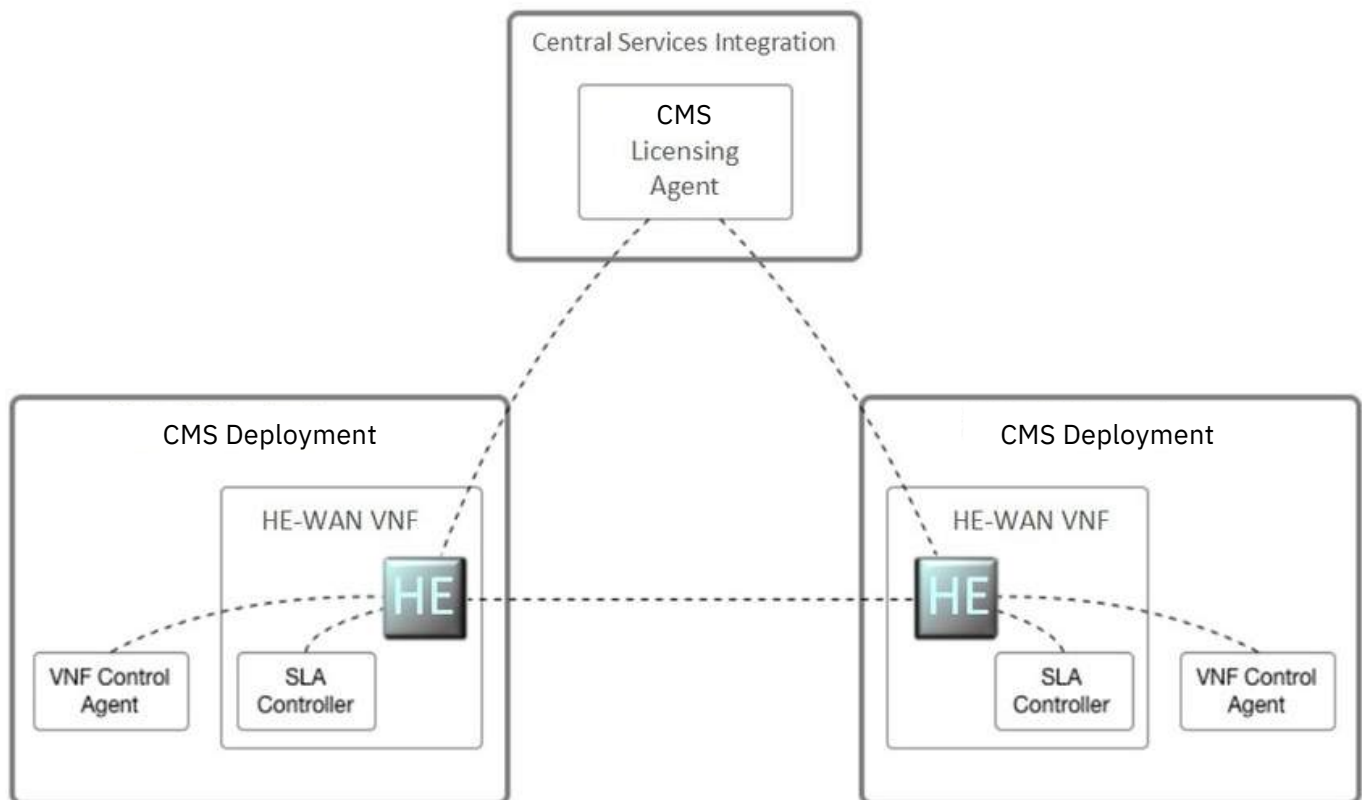
The SD-WAN fabric is highly resilient to underlay degradation and failure – even single TCP connections are maintained and accelerated (assuming some level of connectivity exists) regardless of underlay availability and performance. Traffic scheduling is handled by the CMS Edge Smart Networking Protocol Engine(SNPE) a proprietary transmission protocol, facilitating packet-by-packet intelligence and control, and unparalleled mobility, providing optimised use of network underlays under ever changing link conditions.

Advanced traffic classification and underlay management allows for applications to be allocated to any number or specific combination of bonded underlay networks, and underlay transitions or re-allocations are seamless to the application. A rich and expansive data set is available in real-time, directly from the SNPE transmission protocol, allowing for advanced control over QoS and traffic-steering policy and comprehensive assurance data.



CMS SD-WAN Components

Figure 2: Example CMS SD-WAN Deployment



CMS SD-WAN VNF

The CMS SD-WAN VNF is the only mandatory component within a CMS SD-WAN deployment. It is responsible for interfacing with LAN networks and WAN underlays and maintaining the SD-WAN fabric in cooperation with peer VNFs. Web-UI and programmatic API based interfaces are provided by the SD-WAN VNF, and 'phone-home' capabilities provide control & auditing paths to centralised systems.

CMS VNF Control Agent

The CMS VNF Control Agent is a bespoke entity, abstracting deployment-specific control, and logic from the VNF core. The role of the VNF Control Agent is to facilitate customer-specific objectives – such as bespoke geofencing logic or traffic-steering policies based on data from external systems. VNF Control Agents may be implemented by a customer / 3rd party or provided by Systems in Technology (subject to commercial agreement).

CMS SLA Controller

The CMS SLA Controller abstracts SLA-based control logic from the SD-WAN VNF core, providing a REST API and automated control framework, allowing granular control over SLA objectives and targets, and based on rich metrics available from the CMS SNPE.

The SLA Controller also provides an extensible framework, for customer-driven bespoke SLA objectives.

CMS Licensing Agent

For integration with operational support and configuration management systems that exist within the customer environments, a Licensing Agent (see Figure 2: Example CMS SD-WAN Deployment) can be provided that is bespoke to the customer environment and required system interfaces (subject to commercial agreement). The licensing agent terminates CMS Smart Networking Protocol connections and mediates between CMS VNF Phone Home requests and back-end configuration and management engine implementations.

Hosting and platform support

CMS SD-WAN components are platform-agnostic and hypervisor-agnostic, for platforms based on Intel x86 or ARM architectures.

Hosting options include (but are not limited to):

- Bare-metal installation
- Virtualisation hypervisors including Linux KVM and VMWare ESXi
- Container orchestration platforms such as K8s and micro-K8s
- Public cloud providers including AWS, GCP, Azure, DigitalOcean
- Private cloud platforms including OpenStack



CMS SD-WAN Features

Feature	Linux (Standard)	Linux (SD-WAN)
Network Acceleration	✓	✓
Network Bonding	Basic	Advanced
Network Resilience (Reliable Delivery)	✓	✓
Network Security (AES Encryption)	✓	✓
Traffic Prioritisation	Basic	Advanced
Network Statistics & Accounting	Basic	Advanced
Traffic Shaping	Per WAN Service Only	Per WAN service, Per LAN network, Per-application, Per-user/per-host, Per-traffic-flow, Layer 7 (DPI-based)
5G Support	✓	✓
Bearer Group Support	Basic	Advanced
Link Nailing	✗	✓
Multi-tenant separation & isolation	✗	✓
Multi-tenant aware data-plane handoff	✗	✓
Bi-directional routing	✗	✓
IP Transparency	✗	✓
Firewalling	✗	✓
Deep Packet Inspection (DPI)	✗	✓
Advanced QoS	✗	✓
Advanced SLA Control	✗	✓
SLA Auditing & Rich Assurance Data	✗	✓
Automatic Failover	✗	✓
Terminator Roaming	✗	✓
Advanced Traffic Classification	✗	✓
Application-Based Routing & Bonding	✗	✓
Dynamic Multicast & IGMPv3 Support	✗	✓
Dynamic Routing Advertisements & BGP	✗	✓
Scaling	Basic	Advanced
Centralised Provisioning & Configuration	Basic	Advanced
Bespoke OSS & Central Services Integration	✗	Optional

Integration

CMS SD-WAN provides the integration points described in the subsections below.

CMS Smart Networking API

The CMS Smart Networking API (SNAPI) provides aJSON-over-HTTP interface allowing for all control and configuration functionality to be programmatically driven. SNAPI provides a broad control set, allowing for the configuration and monitoring of CMS SD-WAN nodes.

The capabilities of SNAPI cover the following primary areas:

- System, network, user provisioning and configuration in real-time
- Control of operational aspects, such as link enablement, disablement, rate limiting
- Activation of link analysis tests, and performance probing
- Traffic & QoS policy control, on-the-fly and with immediate effect
- Control and status for directly accessible satellite / cellular modems & terminals
- Network interface management and state control
- Monitoring of associated link information, such as signal quality metrics
- Configuration of low-level SNPE transmission parameters
- Monitoring of low-level information, such as link characteristics and SNPE metrics
- Access to, and control of, system analytics and diagnostic information

A web-UI is also available, providing a graphical interface onto SNAPI.

CMS Smart Networking Protocol Engine (SNPE)

The CMS Smart Networking Engine(SNPE) provides request-driven and push-based streaming of rich data, covering **the following key areas:**

- Accounting & Billing
- Monitoring of system performance
- Monitoring of detailed link characteristics
- Service assurance

CMS SD-WAN VNF Phone Home

The CMS SD-WAN VNF Phone Home functionality provides programmable and automated contact from SD-WAN VNFs to central services (where connectivity permits). Phone Home behaviour is highly configurable, providing capabilities ranging from the reporting of simple health and online status, through to reporting of detailed state and assurance data, and the collection of updates and configuration profiles from central services. Where customers choose to host their own SD-WAN Licensing Agent component, Phone Home is possible directly to customer infrastructure and integrated with customer core services.

Network Integration

VNF integration into the customer network is by means of Ethernet (physical & virtual) presentation. 802.1Q VLAN separation is supported. Integration for access to the WAN underlays is possible via Ethernet (physical & virtual) with 802.1Q support, also via direct interface with PCI-based and USB-based devices including WiFi, Ethernet and cellular modems. Modem and terminal AT interfaces, in addition to PPPoE, QMI, and MBIM protocols are supported for direct control of session establishment & management.

Summary of Available Features

Summary of features below:

Network Acceleration

CMS Network Acceleration provides highly effective acceleration for connection-oriented protocols such as TCP. This allows applications to overcome the delay and packet loss that can occur when operating over a WAN, radically improving the application performance.

Network Bonding

Basic Network Bonding

Bond any combination of IP-capable WAN service, such as 3G, 4G, 5G, Wi-Fi, DSL and satellite to increase the available bandwidth and to offer a backup network for your critical application. Bonding provided by CMS SD-WAN is truly sum-of-all-parts, even for a single TCP connection. Overheads of CMS Bonding are minimal, allowing full use of all available network capacity.

Advanced Network Bonding

Advanced Network Bonding in CMS SD-WAN provides additional capabilities, allowing for policy and control over which applications, hosts and users may use which available WAN services. Any combination of available WAN services can be assigned to given applications, hosts, or users, and target objectives such as bandwidth, jitter or packet loss thresholds allow for SLA-driven bonding operation.

Network Resilience

CMS transmission protocols(SNPE) provide a truly reliable delivery and overcome the limitations of using UDP across WANs resulting in more efficient use of network capacity and lower latency.

Network Security

CMS provides end-to-end encryption, whilst maintaining maximum performance. Security encryption models are modular, extensible, and future proof – currently supporting encryption up to AES-256.

Traffic Prioritisation

Basic Traffic Prioritisation

CMS allows prioritisation of network traffic, so the most important data is delivered first. For example, to give audio higher priority than video, or vital signs telemetry over imagery.

Advanced Traffic Prioritisation & Queuing

Advanced Traffic Prioritisation in CMS SD-WAN allows for multi-tiered prioritisation schemes, providing low-latency queuing where required and with control over per-application contention ratios.

Network Statistics & Accounting

Basic Network Statistics & Accounting

CMS provides bandwidth statistics and accounting information in real time, with data available via UI, API (Smart Networking API), and JSON-based streaming data. A rich data and metrics set is available, providing information on per-WAN-service throughputs and WAN network characteristics such as round-trip-times (RTTs), error characteristics, and loss rates. Accounting information is again available on a per-WAN-service basis.

Advanced Network Statistics & Accounting

Advanced Network Statistics in CMS SD-WAN provides detailed information on a per-application, per-host and per-user basis, allowing for enhanced performance monitoring and traffic accounting with detailed and specific auditing.

Traffic Shaping

Basic Traffic Shaping

CMS provides bandwidth-management controls on a per-WAN basis, allowing control over exactly what proportion of your available WAN services may be used by CMS.

The CMS SNPE (Smart Networking Protocol Engine) provides dynamic and automatic traffic shaping, optimally utilising available WAN capacity in line with service capacity and characteristics on variable-bandwidth networks such as LTE and 5G.

Advanced Traffic Shaping

Advanced Traffic Shaping in CMS SD-WAN provides enhanced configurability for the policing of traffic on per-WAN, per-LAN, per-application, per-user/host, per-IP-field, and application layer 7 criteria.

5G Support

5G support in CMS provides native integration for 5G-capable modem devices and control over 5G cellular sessions along with 5G-specific status information

Bearer Group Support

Basic Bearer Group Support

Bearer Groups in CMS provide service management and cost control by means of global WAN-service grouping (i.e. Bearer Group) levels that can naturally be associated with “preference” or “cost of use” into which traffic priority levels are assigned. Application traffic may use available WAN-services in a hierarchical cost-driven manner, and when permitted based on user-defined policy.

Advanced Bearer Group Support

Advanced Bearer Group Support in CMS SD-WAN abstracts from the basic model, providing complete flexibility in terms of bearer grouping structures and the associated assignment of application traffic to defined combinations of WAN services (i.e., bearers). In CMS SD-WAN, any application, user or host can be assigned to any combination of bearer groups, and with policy-based control over which bearer groups are used and when.

Link Nailing

For scenarios where it is beneficial to have an application fixed to a specific WAN service only, CMS SD-WAN provides Link Nailing.

Any specific application, user or host can be ‘nailed’ to any chosen WAN service, at any point in time. Real-time control allows for changes and (re-)allocation of WAN service assignments on-the-fly.

CMS SD-WAN Link Nailing capabilities integrate with QoS and SLA controls, allowing trigger-based and constraint-based updates to application link-nailing assignments.

Multi-Tenant Separation & Isolation

The CMS SD-WAN fabric is multi-tenant aware, and multiple tenants, customers and networks can be transported across the SD-WAN overlay. Full tenant separation (layer 2 & layer 3) is provided across the entire fabric.

Multi-Tenant-Aware Data-Plane Handoff

CMS SD-WAN provides controllable data-plane handoff at both remote and data centre sides, on a per-tenant basis, allowing for easy integration and network interworking. Common tenancy, within multi-site global architectures, is supported with configurable hand-off policy and controllable network separation and consolidation.

Bi-Directional Routing

CMS SD-WAN provides a fully routable overlay. Data-plane traffic is routable bi-directionally between SD-WAN sites in accordance with defined rules and policies.

IP Transparency

The CMS SD-WAN is IP transparent, maintaining full visibility and traceability for traffic traversing the SD-WAN overlay.

Firewalling

CMS SD-WAN Firewalling allows for highly specific control over which traffic flows are permitted across the overlay, and via which WAN services.

Deep Packet Inspection (DPI)

CMS SD-WAN includes layer-7 Deep Packet Inspection (DPI) mechanisms, to allow for comprehensive identification of application traffic (for example YouTube Video, or Facebook). DPI capabilities may be used for firewalling, and to control which types of application traffic are subject to which QoS profiles.

Advanced QoS

CMS SD-WAN provides advanced QoS controls on a per-application, per-host or per-user basis. QoS parameters include traffic shaping and bandwidth allocation policies, prioritisation and low-latency queuing, burst policies allowing for the dynamic utilisation of available spare (unused) bandwidth, and specific control of traffic scheduling behaviours when available WAN services are in congestion.

Advanced SLA Control

The CMS SD-WAN SLA Controller allows the definition of customer SLAs, associated SLA targets, and advanced control over thresholds and associated actions as required to maintain the customer SLA. The SLA Controller architecture is extensible and can readily accommodate bespoke SLA objectives and associated SLA control logic.

SLA Auditing & Rich Assurance Data

CMS SD-WAN provides SLA-based auditing, along with rich assurance data as required for proof of service delivery. Traceability is available describing which users, hosts and applications are allocated to which WAN services at any given point, and comprehensive data sets providing proof of network characteristics and WAN service behaviour.

Automatic Failover

CMS SD-WAN supports multi-Terminator architectures, with failover policy controllable on a per-tenant basis. Should any given Terminator fail (for example in event of hardware failure at the data centre or Terminator host platform), CMS SD-WAN provides fast and automatic failover, with bi-directional routing, BGP, and dynamic routing advertisements, automatically maintained.

Terminator Roaming

CMS SD-WAN supports multi-Terminator architectures, with roaming policies controllable on a per-tenant basis. Roaming is controllable both programmatically (for example based on geo-location), and manually via engineering teams.

Advanced Traffic Classification

CMS SD-WAN supports advanced traffic classification based on layer 3 and layer 4 parameters – such as IP header fields or TCP/UDP port, as well as DPI-based layer 7 classification. Advanced Traffic Classification in CMS SD-WAN may be used to control bonding policies, traffic shaping, QoS assignments, SLA objectives, firewalling, routing, and accounting / auditing.

Application-Based Routing & Bonding

CMS SD-WAN supports application-specific bonding and routing policies based on advanced traffic classification mechanisms at layer 3, layer 4 and layer 7. QoS and traffic shaping can be applied independently to specific applications, and with specific routing and bonding policies applied.

Dynamic Multicast & IGMPv3 Support

CMS SD-WAN is multicast-aware, providing IGMPv3 proxy capabilities. Multicast is only transmitted across the SD-WAN overlay if there is an interested subscribed at the given site(s). Transmission of multicast is site-specific and is automatically halted when there are no more interested subscribers at a given SD-WAN site.

Dynamic Routing Advertisements & BGP

CMS SD-WAN is BGP-aware and provides dynamic advertisement of available route paths to BGP-aware peers. The elastic SD-WAN fabric provides efficient failover and roaming, maintaining available route paths amongst neighbouring routers.

Scaling

Basic Scaling in CMS

CMS allows for both vertical and horizontal scaling approaches. Up to limits imposed by the host compute platform, vertical scaling can be achieved by adding more (CPU, memory, network) resources. Horizontal scaling is possible by adding additional CMS instances.

Advance Scaling in CMS SD-WAN

Advanced scaling in CMS SD-WAN provides enhanced control over traffic and load assignments, with granularity on a per-tenant or per-instance basis. Scaling is possible on-the-fly, with real-time association and (re-)allocation of user traffic to specific SD-WAN instances.

Centralised Provisioning & Configuration

Basic Provisioning & Configuration

SIT central services allow for automatic provisioning of basic configuration parameters, such as Terminator information, SSL certificates, WAN service traffic shaping policies, and cellular / satellite modem configurations.

Advanced Provisioning & Configuration

Advanced provisioning and configuration in CMS SD-WAN allows for fully automated and centralised management of populations of CMS SD-WAN instance / nodes. Bootstrap, provisioning, and rollout of configurations across large populations of SD-WAN systems is fully automatic.

Bespoke OSS & Central Services Integration

Subject to commercial agreement, CMS supports integration with 3rd party OSS and configuration management services, allowing for bootstrap, provisioning, and configuration management to be handled by 3rd party customer systems.

