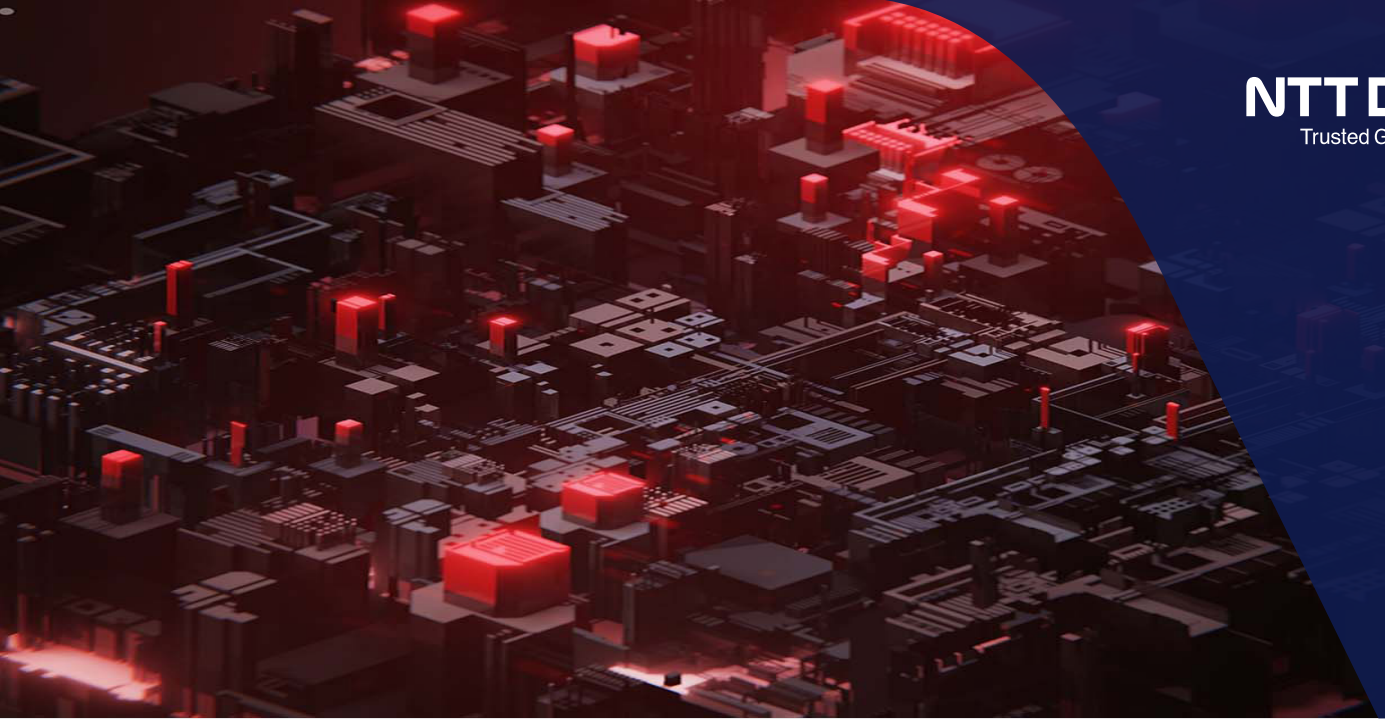


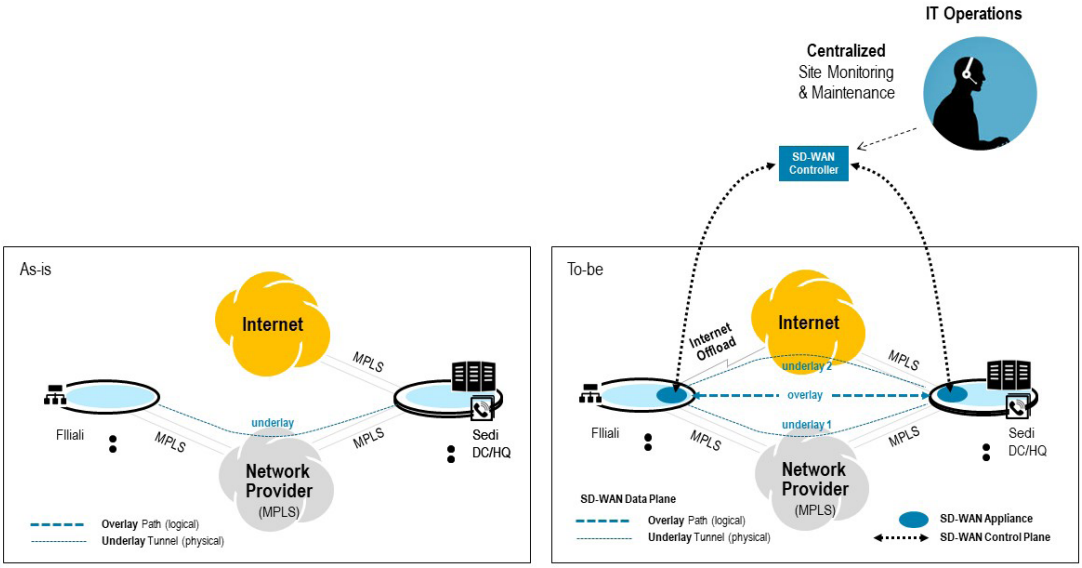
NTT DATA
Trusted Global Innovator

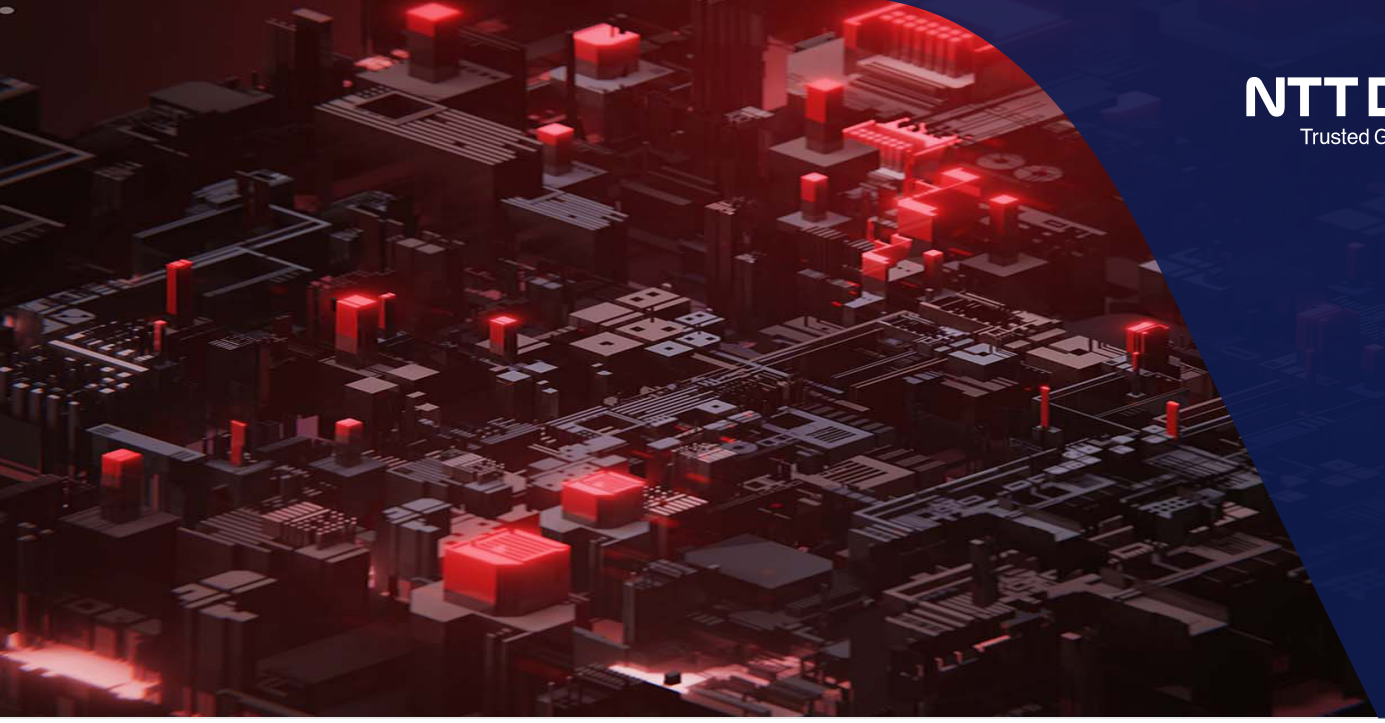
5G / SOLUTION

SD-WAN Connectivity

"The SD-WAN service is at disposal of Business Customers or (4G/5G) Mobile Network Operators"

The technological field of Software Defined Network (SDN) Wide Area Networking (SD-WAN) products has been developing in Europe since quite recently, driven by the growing affirmation of SDN technologies, designed and built with the strong impetus of the Open Source world and the university system as a whole, particularly the United States.



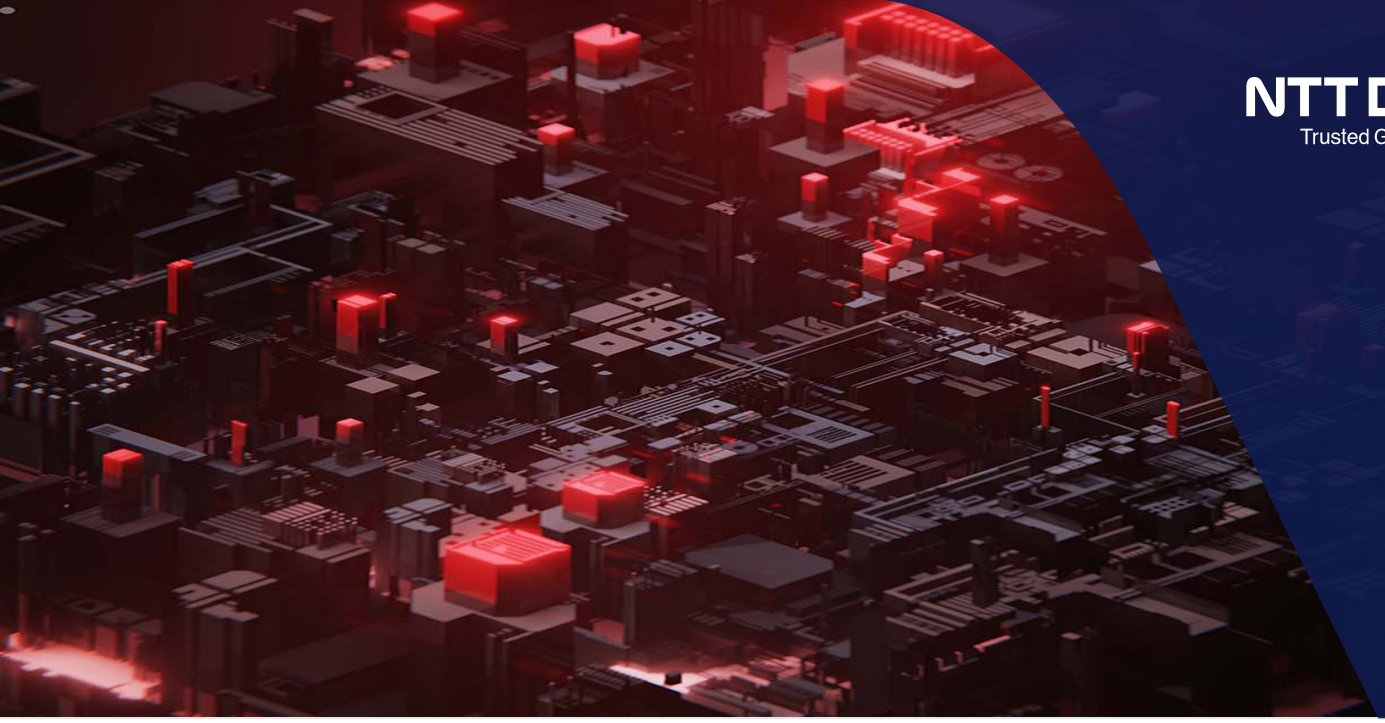


Since about early 2010 years, the first SDN achievements in the networking field have been developed mainly oriented to the deployment of data network infrastructures, moreover focused on the connectivity of Data Center nodes distributed in large geographical areas. At the base of these solutions there was a modelling of the network topology, able to describe the end-to-end connectivity service (Network Service Descriptor, NSD), the LAN emulation in the geographical area (through VxLAN, IPSEC) and the definition of traffic paths that aggregate different types of transport (hybrid media) and classes of service (QoS).

The SDN hierarchical architecture provides an Orchestration system (Controller) and a command language (Openflow, Netconf) to instruct the network nodes (router, switch, access gateway, firewall) with the necessary traffic management rules (policies) and security. These network elements are equipped with SDN agents, capable of implementing the networking rules received from the control node in surprisingly rapid times (“Zero Touch Provisioning”, ZTP concept) even on a large number of elements at the same time.

The proven ability of SD-WAN systems to implement flexible networking rules has been focusing on the ability create differentiated path-routes. It means to route, in a different way, types of applications that differ from each other in terms of resource occupation (bandwidth required, transfer latency, reliability of packet delivery), for the quality of the service required (as in case of VoIP or video distribution). It must be achieved also according to the path (Cloud applications, P2P) or Internet access.

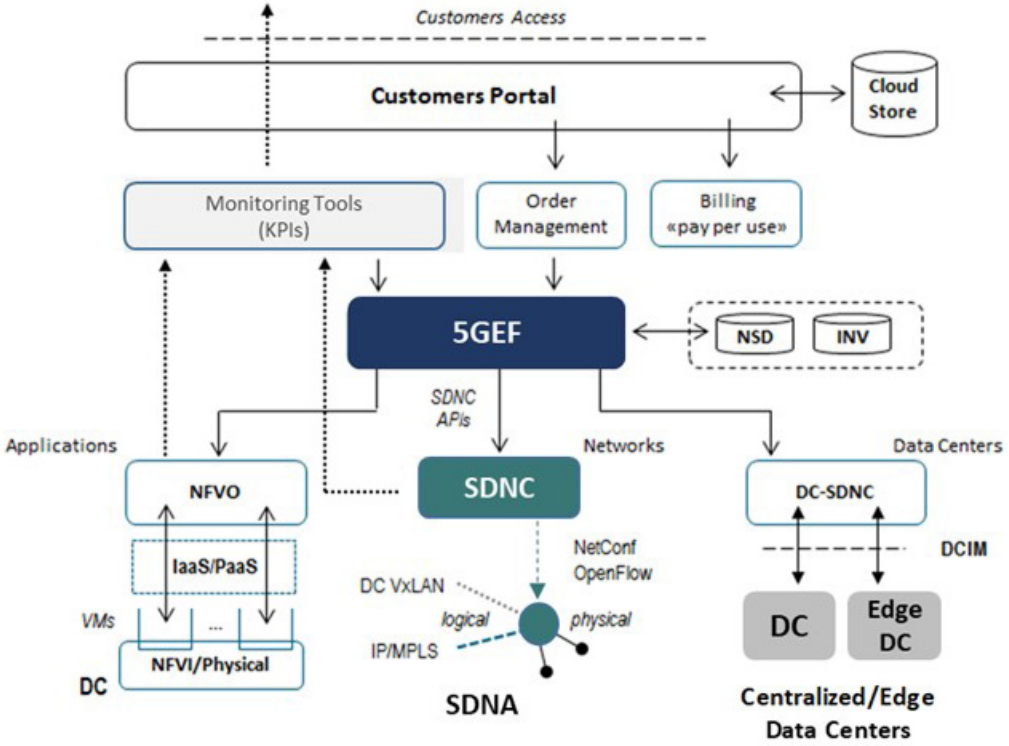
Application level routing brings with it the ability to monitor and provide detailed reporting both for the different applications, for the different network sections, and for traffic statistics and traditional IP QoS parameters (jitter, latency, packet loss).



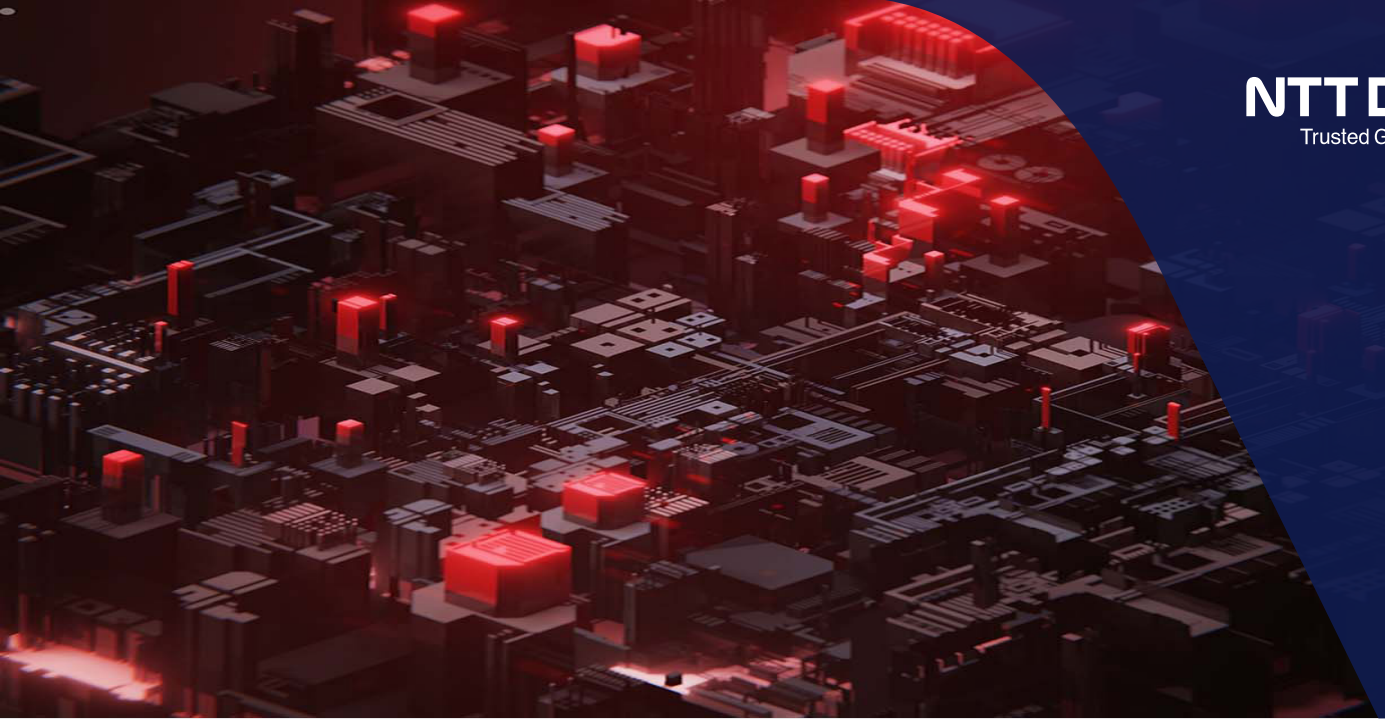
5GEF for connectivity service

"5GEF enables Data Center networks"

It is not purpose of the present note to talk about SDN technology. However, it may be useful to describe the selection criteria by referring to the following diagram.



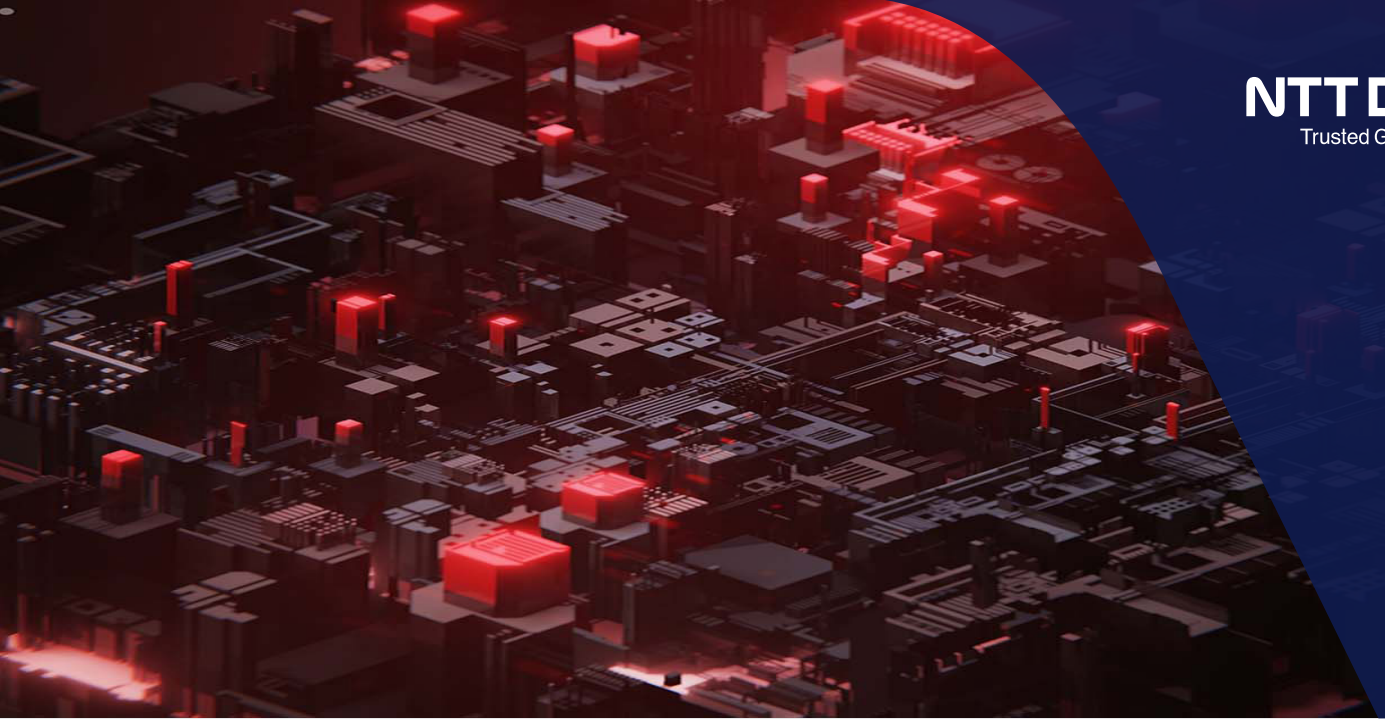
The diagram shows how SDN technology is positioned as elements of interoperability between the functional level of business support (BSS), which in business enterprise companies hosts the application systems of the corporate IT world and Customer Care (CRM, Service Desk).



5GEF provides a portal, characterized by a management GUI and a configuration system of the systems that make up the SDN ecosystem. The creation, activation and provisioning of the various network elements are carried out automatically, based on workflows and orders to support these requests. The coordination in the management of operational workflows is the end-to-end Orchestrator, implemented by 5GEF back-end layer as core functionality. This system relies on a network description model (NSD) and a particularly accurate Inventory system.

The portal also supports a monitoring dashboard on the network infrastructure, capable of providing detailed reporting of the network elements, its partitions (network slicing), and performance measures.

The end-to-end Orchestrator involves several items. 5GEF core instructs SD-WAN schema by interoperating via REST APIs with the SD-WAN Controller (SDNC), which is appointed to monitor the SD-WAN overlay connectivity. 5GEF core also take care of the control and instruction of the Data Center network elements, as well as of the virtualized applications running in the same DCs (for example, virtualized VNF functionalities, according to the ETSI NFV standard model, or Docker/Kubernetes container as CNF). Finally, 5GEF core takes care of the SDNA (SDN Appliance) deployment, as the actual SD-WAN items. The SD-WAN controller is therefore the SDNC element dedicated to these features. 5GEF manages the multi-point connectivity graph and SDNC functions in a single orchestration process.

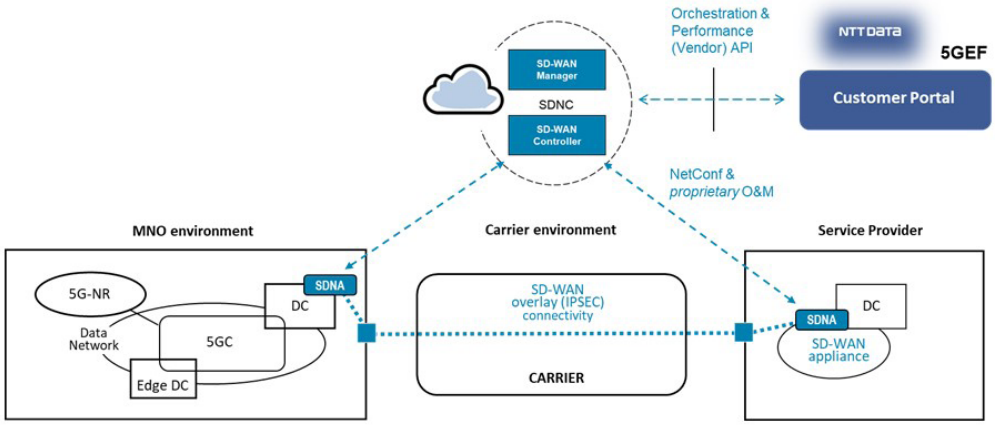


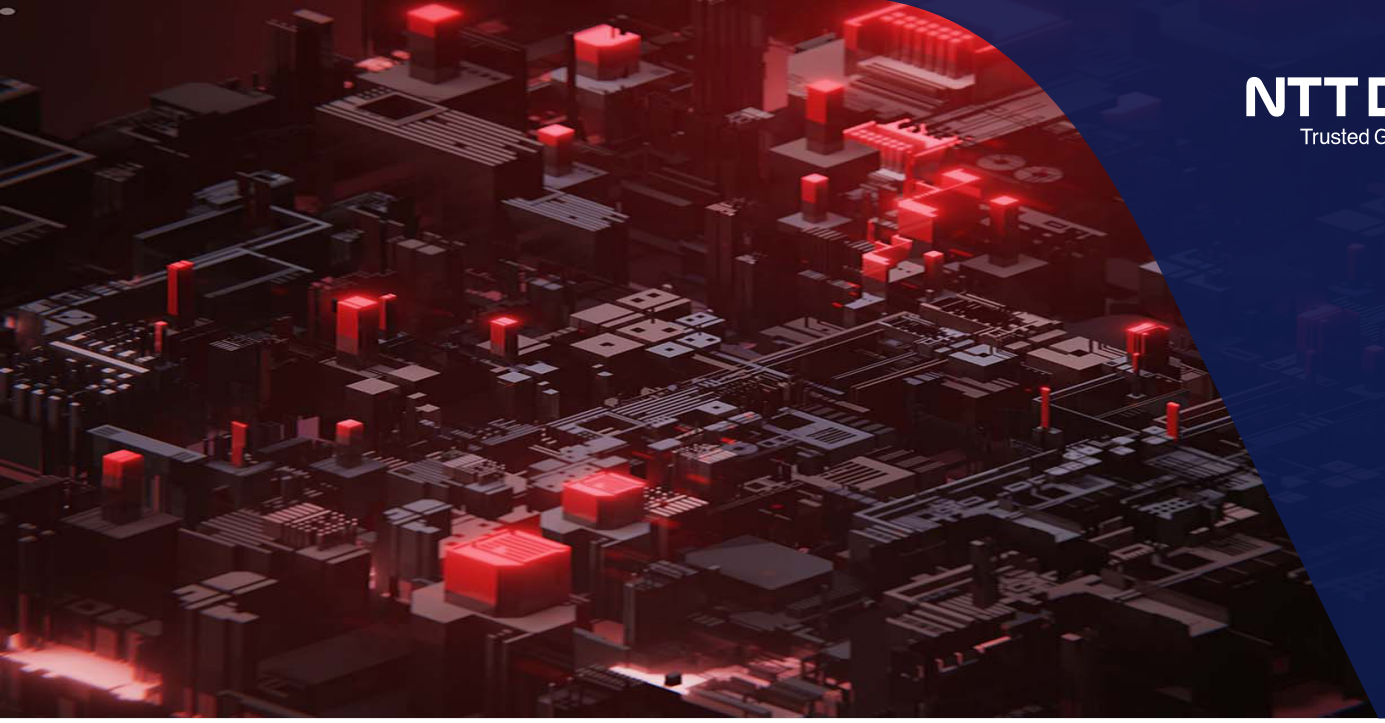
5GEF and SDNC integration

"Virtual connectivity established in automatic way"

Rather than using manual SD-WAN configurations, the integration of Vendor-provided SDNC and SDNAs is fully supported by 5GEF through automatic procedures. For SDNA and cloud SDN Controller (SDNC), a commercial (leading product Vendor) for SD-WAN VNFs and Orchestration's API Exposure is involved.

The SD-WAN software components (SDNA, SDNC) are developed by worldwide best-of-breed Technology Partner of NTT DATA.





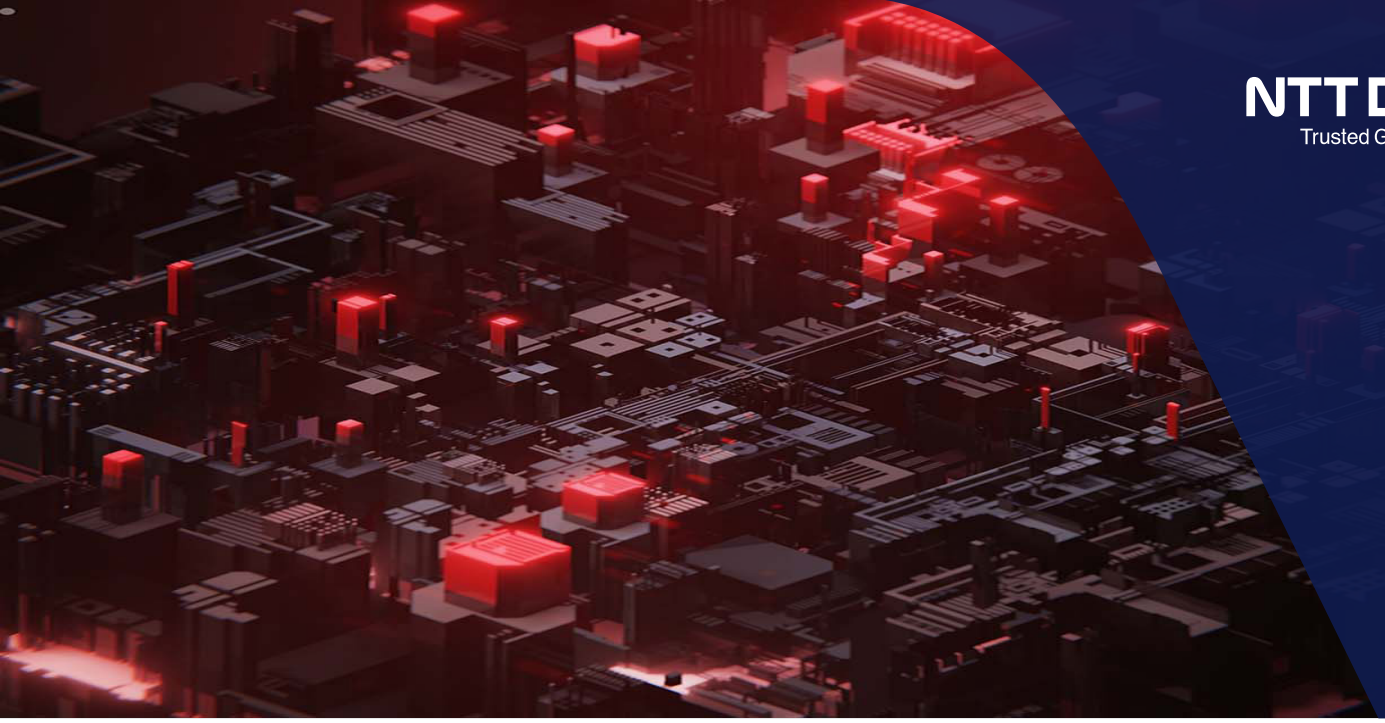
Application-based routing

"For deploying and connecting SD-WAN appliances arranging an overlay network with "few"clicks."

5G Enabling Fabric is focused on use cases and then applications diversity. SD-WAN technology introduces functional features that allow you to monitor the data traffic generated by software applications, offering flexibility that allows you to manage (re) routing policies based on network performance conditions.

The Customer has provided indications on the categories of traffic currently managed on the network, avoiding entering into the detailed context of the individual software applications in the field and the related licensing rules. The traffic segmentation criterion is therefore the following:

- VoIP traffic (real time).
- Internet traffic, divided (a) into SaaS applications (for example Microsoft Office365, or SalesForce CRM) authenticated and used in Cloud mode, and (b) into Web browsing traffic (best effort).
- Traffic generated by the Customer's core applications, generically referred to below as ERP / Finance, installed for operations in the Data Center (CED) offices and used directly by users of the various Branch and Headquarters offices through the MPLS connectivity made available by the Carriers.
  This is traffic, with a centralized topology, typically carried out between the offices and the CED sites, with the exception of the case of Data / Folder Sharing, which may involve, to a lesser extent, access from office to office (for example, from Branch office



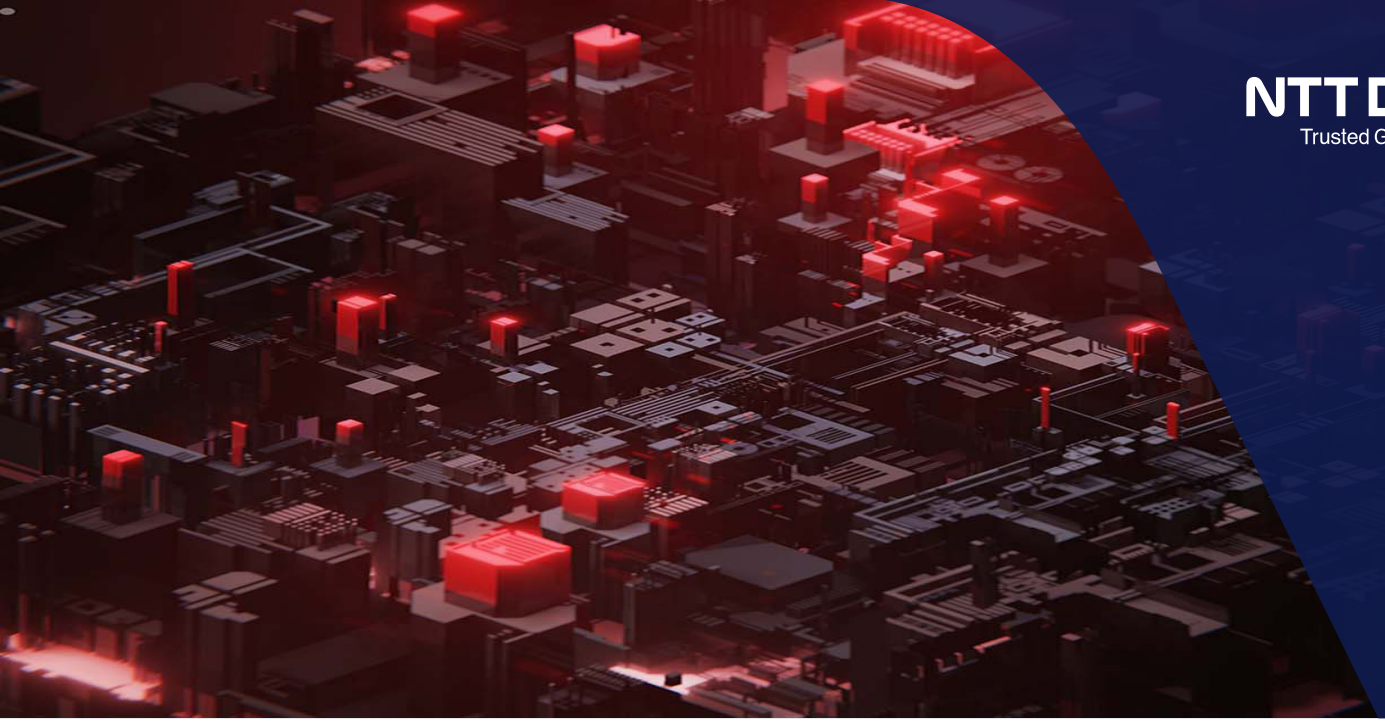
As a sub-case of real time VoIP traffic, the Customer indicated the presence of Video over IP traffic, usable both in distribution mode (multicast) and in video-conference mode (star topology) on the MCU equipment supplied, typically hosted in offices Directional.

The applications will then be grouped by category according to the required bandwidth, the relationship with the user (number of workstations /terminals) or the type of operation carried out by the various offices. Regarding the required IP / MPLS QoS, the model assumes the following settings:

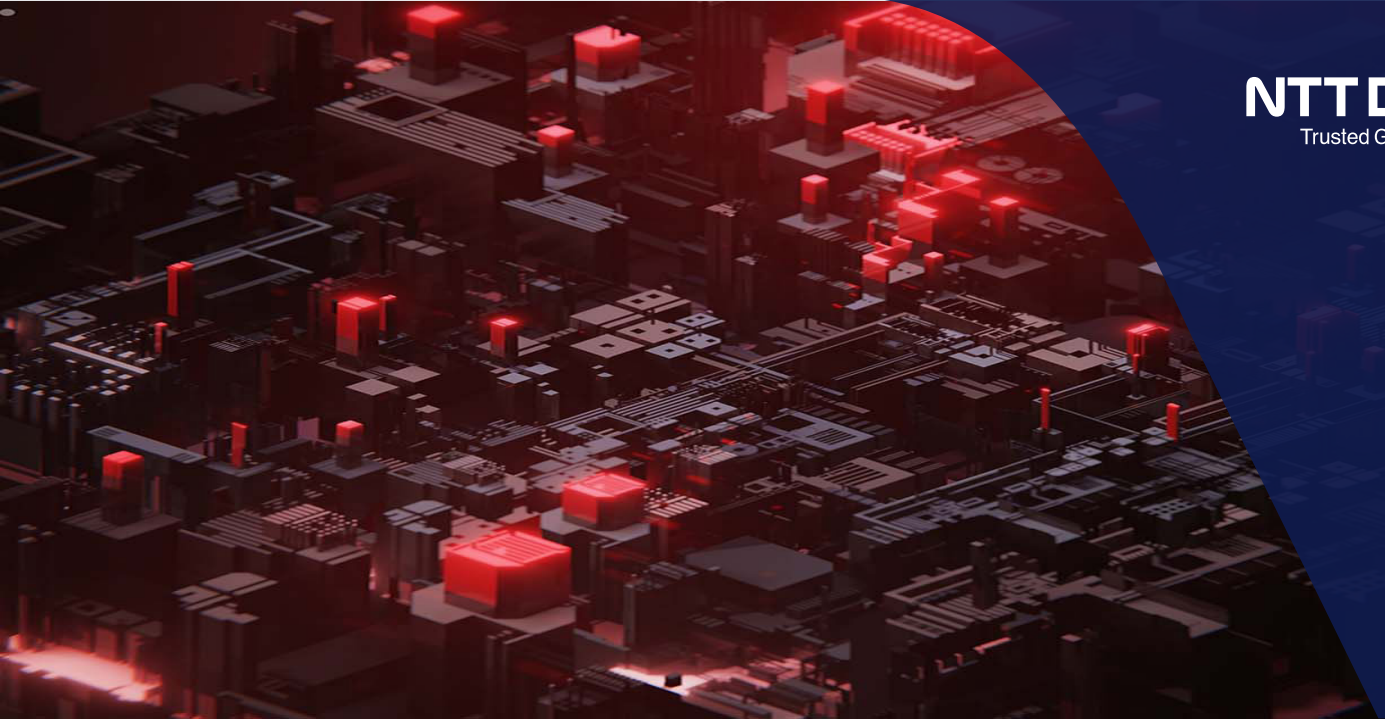
- VoIP traffic (Video over IP, Video-Conference) is modeled as real time traffic (QoS DiffServ flag: “Expedit Forwarding”, EF), symmetrical, which requires guaranteed bandwidth proportional to the number of clients and which (apart from the multicast case) requires symmetrical occupation of transport resources (peer-to-peer).

- Internet traffic for SaaS Cloud Applications is modeled as traffic which is substantially not real time but which requires packet delivery guarantees (QoS DiffServ flag: „Assured Forwarding“ with reliability parameters, AF), asymmetric, which requires a minimum guaranteed bandwidth not necessarily linked to stringent performance on transport (jitter, LLQ) but on actual delivery (packet loss).

- Internet traffic for Web browsing: it is shaped as substantially best effort traffic (QoS DiffServ flag: BE), asymmetric (the downstream band is more significant), which can be routed on sections of available band without particular performance criteria.



- ERP / Finance traffic: it is described as traffic which is substantially “not real time” but which requires packet delivery, with:
  - limited timing (QoS DiffServ flag: “Assured Forwarding” with reliability parameters and control over the end-to-end transport delay, AF)
  - typically asymmetric flows (upstream/downstream scenarios are statistically mixed), which requires a minimum guaranteed band not strictly linked to stringent performance on transport (jitter, LLQ)
    but on actual delivery and speed (packet loss, latency-controlled).



5G Enabling Fabric (5GEF®)

"Enabling 5G Solutions as use cases for Operators"

5GEF is a cloud based platform specifically designed for configuring and delivering business services to enterprise customers or Telco Operator environments.
NTT DATA's solution provides Telcos and MNOs with a modular platform for deploying business applications provided by any relevant vendor, to virtually any location worldwide.

In case of SD-WAN connectivity, SDNA components are deployed as virtualized components, fully virtualized, and activated by remote in few-clicks. SDNC is a service supposed to be in Cloud environment.

Additional key features:

- Standard Network Slicing model (GSMA)
- Now Ready for 4G or 5G NSA early deploy
- Focused on 5G SA solutions
- Deliverable for Cloud Service Providers
- Supported Pay-per-use and SaaS applications
- 3GPP NSMF, CN NSSMF.

The innovation introduced by 5GEF offers the opportunity for Telco Operators to play as Cloud Service Providers in terms of flexibility, fast service delivery and resources optimization in a completely orchestrated and simplified way for the Customers.