Multi-Domain Service Optimization

1. High-level summary

New solutions need to be fifth-generation (5G)- and service-ready while covering the entire network along with individual network slice instances (NSIs), including the associated end-to-end Quality of Experience (QoE).

Another important topic that needs to be addressed is scalability; 5G will require densification of the network. Densification requires additional hardware and software along with an intelligent network automation system to decide when and where to expand the network (scale out), particularly the virtualized part, or conduct load balancing as an alternative.

The service provider needs end-to-end service assurance and a means to control it. Cisco has all the technologies (Evolved Packer Core [EPC], Policy and Charging Rules Function [PCRF], analytics, and Cisco® Self-Optimizing Network [SON]) required for the end-to-end solution; Therefore, Cisco is the only vendor that can address this need by providing an intelligent controller to coordinate across the network.

Adding complexity and scalability to a network requires systems to simplify and automate processes in order to minimize the CapEx investments in hardware and software and reduce OpEx.

Content-delivery quality becomes more important, especially for mobile network operators that are transforming into content service providers to offer a seamless service delivery on mobile and cable networks.

1.2 Vision

Aside from the classic Cisco Radio Access Network (RAN) Self-Optimizing Network (SON) inputs (like network element Key Performance Indicators (KPIs) and performance measurements) Multi-Domain Service Optimization (MDSO) uses Quality of Experience (QoE) and Key Quality Indicators (KQIs) as additional input. One example of end-to-end service-specific quality metrics is video quality indicators.

MDSO is connected to multiple network domains, in addition to the RAN SON, for performance data collection and configuration commands to achieve the optimization targets. MDSO is set to monitor and optimize different Service-Level Agreements (SLAs) for different services such as Internet of Things (IoT), video, and voice in automate closed-loop manner.

You can achieve significant gains by using deep learning algorithms to identify and/or predict faults and/or performance degradation, isolate, and remedy them. Machine Learning/Deep Learning (ML/DL) algorithms proved to be helpful in processing big data sources that accumulate the network performance metrics sampled at high frequency, and with breakdown to individual services (flows) rather than aggregated per RAN cell.

Contents

The MDSO allows end-to-end visibility of the mobile infrastructure and the quality of the content delivery. It allows content providers to optimize and automate the mobile network in order to meet the content customers' SLAs.

2. Further details

This section contains additional material to outline the implementation.

Mobile operators currently face severe network densification challenges. Running and coordinating multitechnology, multivendor networks (second-generation [2G], 3G, and 4G) is already a complex task. The addition of 5G can be effectively managed and sustained only by using an intelligent solution.

MDSO is designed to solve current network challenges such as heterogeneous networks including 4G, Wi-Fi, and other unlicensed networks. Effectively managing a heterogeneous network is critical for 5G and MDSO to be able to deliver tomorrow's 5G capabilities over today's network.

MDSO is the first solution that optimizes end-to-end user QoE. The existing solutions in the market focus on a silo approach by optimizing a single network domain by improving its network element KPIs. MDSO focuses on service-aware optimization of the user's session experience. In some cases configuration of more than one domain must be modified in order to yield the best results. One example of the conventional optimization is to shift traffic from cell to cell without considering the load on the backhaul. Alternatively, MDSO will be able to change the traffic distribution by accounting for the load on the cell level and backhaul simultaneously.

The MDSO is a management layer solution that manages, controls, and optimizes the multivendor mobile network. Particular domains may have their own local optimizers, working in near-real-time cycles. MDSO runs across domains; it can solve a detected problem in one domain by modifying configuration in another, achieving global end-to-end optimization.

For performance data collection and optimization actions, open (standardized) interfaces are used. In addition, in the networks where Cisco core network solutions are deployed, additional proprietary capabilities will be used to further boost the network performance. MDSO will be used to make the EPC aware of the RAN state and bring user, flow, and application awareness to the RAN SON optimization actions.

MDSO can target network- and cell-level KPIs and/or subscriber-level KPIs (KQIs) for subscriber-level SLAs and service-level assurance. The latter is mandatory for supporting 5G. These requirements cannot be fulfilled by using traditional network- and cell-level KPIs alone. Therefore, subscriber-centric optimization across network domains targeting the QoE is essential for being 5G-ready.

MDSO is an automated closed-loop optimizer evolving from the Cisco SON product that targeted the RAN domain alone to include additional domains.

Along with the classic SON solution, a typical MDSO application has three phases:

- Trigger
- Action
- Feedback

The classic SON uses RAN KPIs for triggering and feedback and RAN configuration for action. The MDSO uses the SON platform for collection of RAN KPIs and for actions in RAN while using open Application Programming Interfaces (APIs) in other domains and for the same purposes.

A similar action could have the MDSO detect a problem in a virtualized part of the network and trigger action on the Management and Network Orchestration (MANO) (for example, to add network functions virtualization [NFV] resources [scaling up]). The MDSO acts as an intelligent engine that identifies problems from network- and cell-level and/or subscriber- and service-level metrics and triggers action to resolve the problem. Cisco SON may use deep learning algorithms, for example, to allow proactive actions and avoid QoE degradation.

This technology identifies adverse conditions that degrade QoE. This degradation could be due to the conditions in various network domains (such as access, packet core, Gi-LAN, transport, backhaul, application servers, and NFV domain) and triggers reconfiguration of the corresponding network elements to fix the problem. For example, when applied to video streaming, the MDSO technology allows improvement of video quality by reducing or eliminating stall. The actions triggered by the MDSO are based on awareness of the situation in RAN and other network domains, including potentially the NFV domain. The MDSO technology creates a proper balance between the resources consumed by different services.

With MDSO, the capacity of the network is used in the best possible manner in accordance with the policies provisioned by the network operator. In addition to CapEx and OpEx savings, this technology is setting new service levels and encouraging new business models in the wireless industry. The MDSO technology allows network operators to significantly reduce time to market for newly introduced products and services. Some examples of new business models that MDSO can enable include "slice-as-a-service" with user QoE assurance, for any service such as video, IoT, or voice over LTE (VoLTE).

The system includes analytics software with performance and QoE measurement collecting tools and prediction algorithms. The system also contains a management interface to the RAN and other domains for autocollection of measurements and autoconfiguration. For example, network expansions can be done automatically according to predefined service providers' rules and policies, and for cross-domain global optimization.

Leading network operators both welcome and promote the MDSO solution.

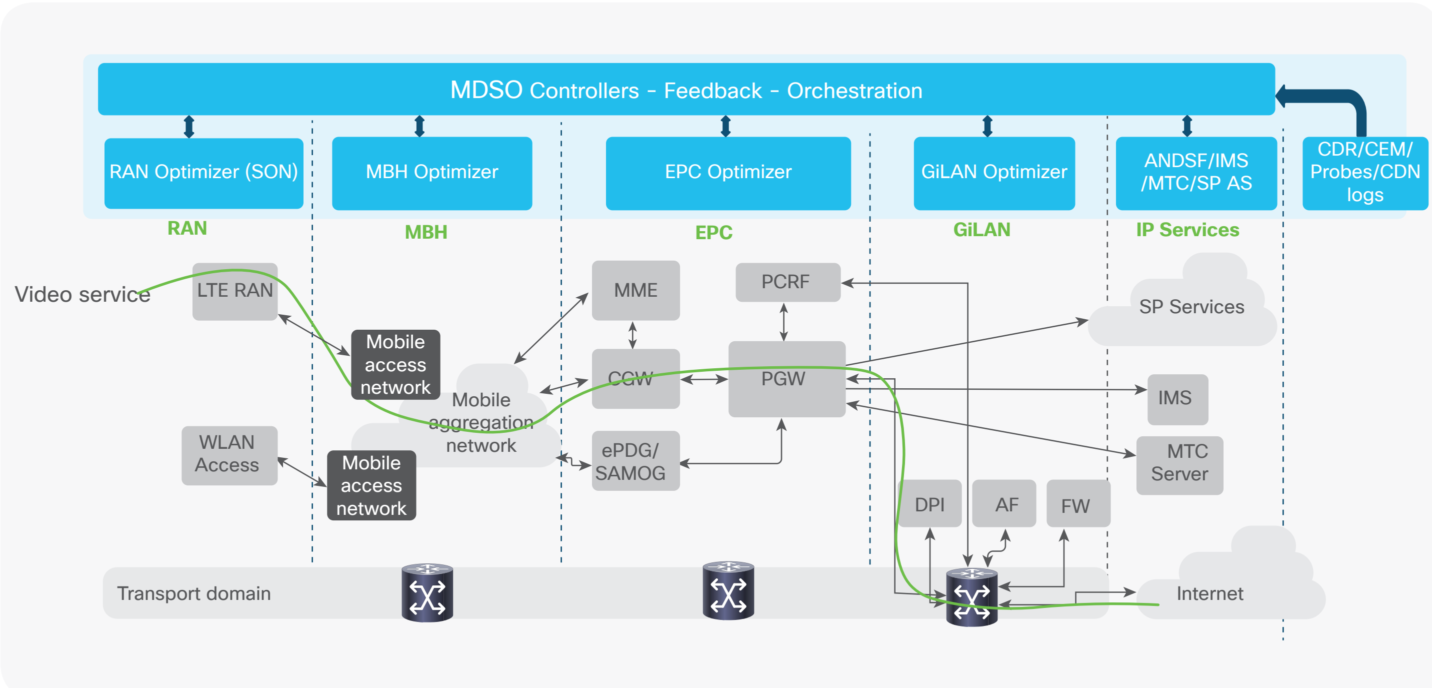
3. 5G feature in 4G network

The diagram in the Figure 1 shows the general network architecture of the MDSO in the 4G network. The MDSO deals with the following domains: RAN, Cisco Mobile Backhaul (MBH), EPC, Gi-LAN, IP Services, NFV, and transport. The figure shows an example of the video data flow crossing all network domains. The network functions listed in Table 1 act as domain controllers and optimizers.

Table 1. Network functions

Domain	Domain controller and optimizer
RAN	RAN optimizer (SON)
MBH and transport	MBH optimizer
EPC	EPC optimizer
Gi-LAN	Gi-LAN optimizer
IP Services	Various application servers such as Access Network Discovery and Selection Function (ANDSF), IP Multimedia Subsystem (IMS), and IoT

Figure 1. MDSO 4G network architecture



MDSO uses classic RAN SON data sources such as RAN performance measurements; for example, “counters” and RAN traces.

In addition, new measurement types such as Cognitive Networks (CN) traces, Call Detail Records (CDRs), and Multicast Distribution Tree (MDT) information will be used. A special kind of input is used for estimation of end-to-end service-specific quality indicators. One example is video-quality indicators generated by the video player in the user experience and delivered to the network through one of the standardized reporting procedures.

4. MDSO example: Cisco video optimization service

4.1 Overview

In adaptive bit-rate streaming, the video stream can be encoded at multiple bit rates. The encoding is selected dependently on available network resources and may change during the video session. For example, in Dynamic Adaptive Streaming over HTTP (DASH), videos are generally processed into several files representing several possible video encoding bit rates for the same content, which translate to different video qualities on different devices.

When transmitting a chunk of video to a user’s device, the aim is to transmit it with the highest bit rate that produces the highest quality the device can efficiently display without overloading the network. When a part of the network becomes overloaded and resources to support current video demand are insufficient, one solution is to reduce the bit rate for a particular user and transmit the next video data chunks with a lower encoding bit rate. Although video resolution may degrade, the stalls, which are considered to be the worst form of video degradation, may be avoided. On the other hand, the load on the network will be reduced.

When demand grows even further, a segment of the system (for example, a cell in a cellular network) may become so overloaded that even switching to the lowest possible bit rate will not help. In this case, to avoid stalls, load-balancing methods such as transferring load to neighboring cells or other frequency channels may be helpful.

How video data flows are identified depends on the deployment scenario. If the network operator has access to video streamers, the operator can receive this information from the streamers. If the operator has access to nonencrypted video data flow, the operator can use Deep Packet Inspection (DPI) tools to get the information. If data flow is encrypted, the operator can apply the techniques of pattern analysis and machine learning for detection of video flows, video buffering (stalling), and bit-rate adaptation events.

4.2 Data sources

This chapter describes the input to MDSO, per network domain.

4.2.1 RAN domain

4.2.1.1 Load per cell

Multiple metrics for the cell load are defined in the Third-Generation Partnership Program (3GPP), such as different kinds of Physical Resource Blocks (PRBs) usage.

4.2.2 EPC domain

Information about mapping of the video sessions to the RAN cells can be pulled out of Mobility Management Entity (MME) using the IP address of the video player in the user experience, as a key.

4.2.3 IP Service domain

Assuming the network operator has access to the video streamer, the operator can get information of video QoE from the IP level log (trace) at the server.

Using the log (trace) information, the video service analytics software computes video QoE, and feeds the MDSO with the list of users' IP addresses and the time series of the corresponding QoE measurements. The software holds and updates a list of active users' IP addresses.

Additionally, the analytics software can extract the video manifest information from the data flow.

4.3 MDSO actions

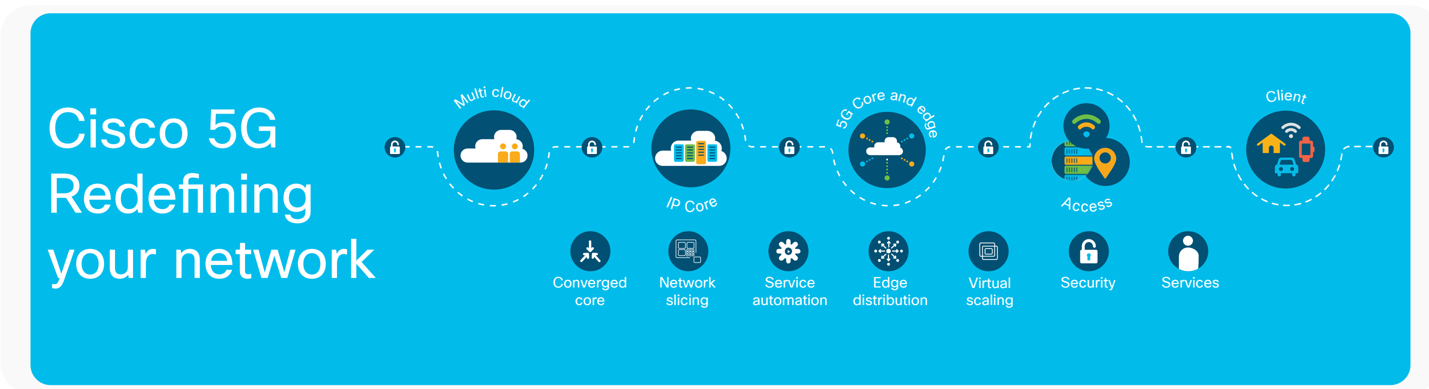
The actions that MDSO can apply to relieve congestion include, for example, load balancing in RAN and QoS Class Identifier (QCI) modification in the core.

Another domain and category of actions is applied to the transport and backhaul network; for example, reconfiguration of the transport and backhaul network elements.

5. Conclusion

Cisco SON, SONFlex, and SONFlex Studio comprise an important piece of the entire Cisco 5G value chain. Cisco takes a multicloud-to-client approach, unifying multivendor solutions into a single, secure, standards-based architecture. And we emphasize that with the proper secure network customers can start delivering 5G services today in a cloud-scale mobile Internet for business, consumer, and IoT. Thus we bring in "new 5G money" with a compelling value chain. 5G is where the breadth of Cisco matters, because we do service enablement, the services themselves, the 5G core, the IP transport, the cloud, etc. We can truly optimize and secure the network across the entire service layer (Figure 2).

Figure 2. Cisco 5G: Redefining your network



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- https://www.cisco.com/c/en/us/products/wireless/son-suite/index.html
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