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Research Article

NETWORK SLICING: AN ALTERNATE SOLUTION FOR CONGESTION ISSUES IN NETWORK CONVERGENCE

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A B S T R A C T

Network traffic management will shift from policies based on source to management based on traffic characteristics. Adoption of cutting-edge congestion controls whether from endpoints, or advanced queue management developments should assist both the efficient usage of network capacity and improved customer experience. The existing IP stack may not be capable to fulfill demands, due to inherent constraints. Network slicing, SDN & NFV technologies are providing great resource. With the help of these technologies networks can be built in a dynamic way with more scalability & flexibility. This paper discusses network slicing with the view of how it enables operators to create and support multiple virtual networks. Network slicing is a novel technology which provides resources in the upcoming wireless networks. Rapid convergence of technologies in networks, created lot of issues of congestion and traffic management, in this regard network slicing is a good alternate for traffic management in convergent network.

INTRODUCTION

Network traffic management over the next 5-10 years will be dominated by several themes, both established and emerging. Encryption of traffic will be a given constraint for traffic management, and operators should account for traffic management solutions that improve customer experience without breaching customer privacy. These will include heuristic approaches that avoid deep packet inspection, as well as explicit signaling of desired packet treatment from content servers. Such signaling allows the network to play a defined and predictable role in optimized traffic delivery.

Traffic management will shift from policies based on source to management based on traffic characteristics. This will allow the vast range of connections and traffic types predicted for the next era to receive the appropriate network treatment based on their requirements, while allowing networks to adhere to regulations concerning non-discrimination.

Edge computing moves computation and storage functions close to the network edge, to reduce ‘distance to content’ and hence latency & remove any Internet hops to retrieve content, and hence reduce backhaul costs. Adoption of cutting-edge congestion controls whether from endpoints, or advanced queue management developments should assist both the efficient usage of network capacity and improved customer experience.

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These may cause operators to rethink which middlebox functions are still applicable, as Internet technologies evolve to solve the problems which led to middlebox deployment [1].

Future predictions

The predicted explosion in connections, throughput and mobility in the next ten years will strain existing IP-based infrastructure; and operators should engage in investigation of scalable, sustainable alternatives in order to meet the performance and cost challenges of the next era.

The 2020s will very likely see an explosion in network and internet connections (driven by IoT), latency and throughput demands (virtual reality, augmented reality, 4K and 8K video), mobility demands (automotive and high-speed train use cases), multi-homing and convergence (across cellular, Wi-Fi, fixed, Narrowband-IoT and non-3GPP networks).

Networking/internetworking protocols should be able to meet these scenarios. The existing IP stack may not be capable to fulfill these demands, due to inherent constraints. In addition, network security and mobility will become increasingly costly to operate as overlays top the existing IP stack. Traffic management considerations for the recommended architectures should include flow controls and access controls. Network slicing, Software Defined Networking (SDN) & Network Function Virtualization (NFV) technologies are providing great resource. With the help of these technologies networks can be built in a dynamic way with more scalability & flexibility [2].

Network Slicing

Network slicing allows the allocation of network resources appropriate to the service being consumed and its particular delivery characteristics like latency, pacing, durability, resilience, capacity, mobility & coverage etc. A 'slice' provides the layers, as separate logical networks. A 'slice aware' scheduler will therefore be required to allow end-to-end traffic management.

Network slicing enable no discrimination between content providers or customers a flow-centric, service-provider-agnostic approach. Network Slicing allow contention for network resources to be managed across the wide range of IoT use cases.

Network slicing will allow the configuration of these characteristic-based policies, scaling and shrinking according to demand. Any operational constraint of a single Internet default bearer, delivering 'best effort' with no guaranteed bitrate, will however leave the radio scheduler as a potential bottleneck unable to distinguish between traffic with different characteristics [3].

In network slicing a slice is a virtual network which works on top of a physical network in a way that creates the illusion to the slice user that he is operating his own dedicated physical network. A virtual link between virtual nodes A and B with capacity βAB can be realized as a multihop physical path with reserved bandwidth βAB on all physical links constituting the path. A virtual node implements a specific network functionality as a physical node would do in a traditional network. Virtual links can be easily established with SDN routers. SDN allows the administrator to remotely configure the physical network in order to reserve on demand networking resources for the slice. Virtual nodes can be implemented as Virtual Network Functions (VNF) running on general purpose hardware forming a cloud infrastructure. Network Slicing requires a high degree of flexibility which was only made possible by the recent advent of NFV and SDN. On a physical network consisting of SDN routers and datacenters with NFV functionality, it is possible to rapidly instantiate and reconfigures slices with diverse and time-varying requirements.

Services offered by Network Slicing

Network slicing has significant benefits for a number of industries, such as automotive, manufacturing and transport, by providing different efficiencies in latency and speed depending on service requirements. Resources for the network slices can be set up based on various service characteristics e.g. bandwidth demand, latency demand for fulfilling resources for Massive IOT, Augmented Reality, Capacity or coverage on demand.

In this changing world modern products and affordable services are needed rapidly to fulfill the demands of all level of industries. Network slicing provides medium approached connectivity standard that will provide lots of advantages to industries. Network slicing offer a smart way to segment the network to support particular services or business segments. Slices possess characteristics like latency and grater bandwidth. Since the slices are isolated from each other in the control and user planes as well supported use case, the user experience of the network slice will be the same as if it was a physically separate network [4].

An example, a mobile operator will be able to split its physical network resources into multiple logical slices and lease these slices out to interested parties. Network slicing technology virtually partitions a physical network into multiple co-existing logical networks in order to provide the most suitable resources and network topology to different types of services.

Is Network Slicing economical?

Network slicing is proven to be a smart investment to reduce operating expenditures and increase efficiency, while enabling fast implementation and better utilization of devices related to the Internet of Things (IoT). Data traffic especially mobile data traffic is growing very fast. Cars, meters, machines, sensors and lot of other electronic devices will be fully connected in the near future. Network slicing allows operators to segment the network to support particular services and deploy multiple logical networks for different service types over one common infrastructure. Implementation of network slicing provided benefits of nearly 35-40% reduction in OPEX, and nearly 30-35% more revenue potential and a very huge economic benefits.

Architecture and technology

The network slicing architecture contains access slices (both radio access and fixed access), core network (CN) slices and the selection function that connects these slices into a complete network slice comprised of both the access network and the CN. The selection function routes communications to an appropriate CN slice that is tailored to provide specific services. The criteria of defining the access slices and CN slices include the need to meet different service/applications requirements and to meet different communication requirements.

Each CN slice is built from a set of network functions (NFs). An important factor in slicing is that some NFs can be used across multiple slices, while other NFs are tailored to a specific slice. The mapping among devices, access slices and CN slices can be 1:1:1 or 1:M: N. For example, a device could use multiple access slices, and an access slice could connect to multiple CN slices. The pairing between access slices and CN slices can be static or a semi-dynamic configuration to achieve the required network function and communication needs [5].

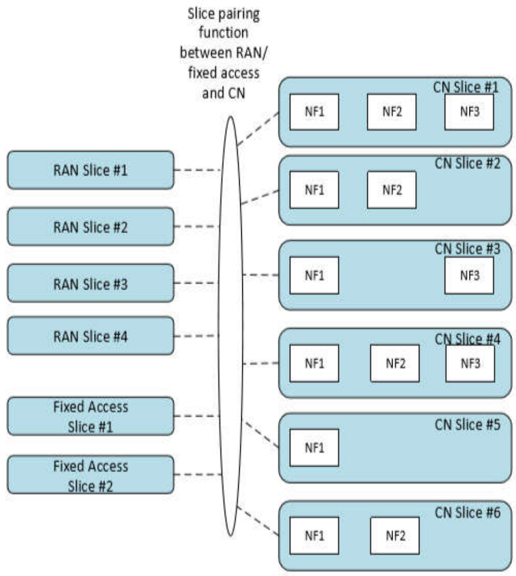

Figure 1 Network Slicing Architecture [5]

Network slicing allows core networks to be logically separated, with each slice providing customized connectivity, and all slices running on the same, shared infrastructure or on separate infrastructures as the operator requires. This is a much more flexible solution than a single physical network providing a maximum level of connectivity. The flexibility of 5G core networks will improve significantly by supporting a full separation of control plane and user plane, and through adopting selected SDN principles and technologies [5].

Network Slice Management

Network slicing architecture is composed of three layers Service instance layer, Network Slice instance layer and Resource layer. A network slice may be dedicated to a particular service type. For example, IoT communications may be directed to a slice whose low overhead and minimal features are designed to provide the best performance for IoT devices. Another example is the support for business verticals, where additional capabilities may be provided by other administrative domains. Therefore, the services, network service instances or network slice instances need to be operated across multiple administrative domains. In this context, a network slicing orchestration function, responsible for managing network slicing, is needed at the service layer. At the resource layer, network slice management is performed by the resource orchestrator, composed of NFVO and of application resource configurators, where applications are 3GPP services, transport, etc. [1][5].

Automation for network slices is a key strategy to achieve operational goals. It starts with transferring the software for network slices, which may come from vendors, to the operator, followed by initial testing of the slices in the operator's network. Various suppliers electronically deliver updates to different components that make up a network slice to the operator, where they are automatically integrated with any operator updates or configuration changes. Automation then continues with deploying the network slices in the production network and further controlling the scaling of slices and performing longer term maintenance on the slices.

Benefits of Network Slicing

With the introduction of slicing, operators get the opportunity to differentiate through service customization. In the case of connected cars, for example, different car vendors may be operated in different slices. Operators get the ability to allocate dedicated virtual resources to different car manufacturers and operate them independently. Each car manufacturer may be equipped with different services such as traffic efficiency, traffic safety, infotainment, security and emergency support. Service differentiation allows mobile operators to create different pricing strategies.

In the next era network has to support low-cost bandwidth at one end of the spectrum while providing low-power, low speed IoT connections and low latency, high-speed, ultra-reliable connections on the other end. Today's "one-size-fits-all" approach to wireless networks for a highly connected world with different types of devices everywhere is not viable. The key to this shift lies in how end-to-end networks will be designed, architected, implemented and operated [6].

Network slicing enables operators to create and support multiple virtual networks by slicing the network into multiple virtual networks running on a common network infrastructure that includes the RAN, backhaul and the CN to support different service types. This approach offers several benefits by enhancing the ability of operators to deploy only the specific functions needed to support specific use cases and customers.

Although network slicing holds major promise in optimizing networks in addressing a wide variety of use cases, a lot of questions need to be addressed to enable it, such as network slicing criterion and granularity, the air interface and protocols, the slice-specific RAN, CN operations and the coordination and co-existence of the slices. The 3GPP work on network slicing in relation to 5G is currently in progress [1].

Dynamic Network Slicing

Dynamic Network Slicing is designed to support elastic networks, i.e., networks that change shape over time. In elastic networks, the classical resource reservation explained in the previous section may not be enough, since the slices may need to scale in and out over time, or even change shape. To correctly drive the resource management decisions in the dynamic setting, the network operator needs to maintain an accurate depiction of resources that are currently used.

Current network monitoring tools provide a static view of utilization for each network resource (link and node capacities, VNF capabilities, etc.). In a dynamic environment, the impact of embedding a particular slice on future slice requests is unclear. For example, consider the case of optimally embedding a slice based on static information. Once a new slice request arrives, a reconfiguration of the old slice might be needed due to resource contention. However, slice reconfiguration comes at a cost and hence a prediction mechanism of future resource utilization can be helpful.

Typically, prediction mechanisms rely on the use of historical data. In our context, techniques from machine learning can be used to exploit the raw monitored data from the SDN controllers and derive predictions for the impact of new slices into the network [6].

Challenges for Network Slicing

Network slicing is a promising paradigm in future 5G mobile networks, but realizing it is not without challenges. Major challenges and open issues on network slicing are network reconstruction, slicing management and cooperation with other 5G technologies [1][7].

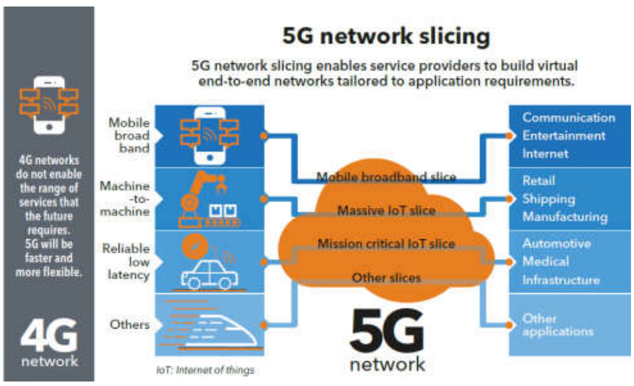

Figure 2 Network Slicing in 5G [8]

CONCLUSION

As we discussed above rapid development is going on in all sectors, and there is huge demand for wireless network connections with fast and error free data delivery in all formats. Network slicing is a novel methodology for provisioning resources in the upcoming wireless networks. Tools from the operation research, theoretical networking, and computer science are envisioned to provide network optimization algorithms and control techniques which can give practical answers to these challenges. The methodology of dynamic Network Slicing creates an arena of online optimization problems. The *online Network Slicing* problem is related to other classical online problems.

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