5G technology: An investigation in cloud architecture and “Blue/Green” strategy for software upgrades

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Abstract – The 5G mobile network technology is the new generation wireless technology being commercially launched globally. It promises to provide a plethora of new digital services both for humans and machines. It is also an attempt by telco industry to regain their market power by providing new services with the same speed, agility and scalability as internet companies. This study looks at key architectural concepts to deploy the 5G network on cloud platform. It also investigates Blue/Green deployment strategy for continuous software upgrade. A software defined network build on microservices and containerization is the future of 5G mobile technology.

I. INTRODUCTION

The 5G networks are set to revolutionize communication across the globe and successfully compete with the web-scale companies. To deal with the constant increase of network traffic and dynamic user needs, future 5G network should be designed to be flexible in terms of scalability and ease of reconfiguration. This can be realized through the implementation of the mobile core network functions on a virtualized software (sw) environment [1]. Unlike previous mobile network architectures, 5G mobile networks are expected to be highly software centric. At the heart of 5G lays virtualization techniques that will help in the dynamic sharing of the underlying hardware (hw) resource utilization. 5G network is therefore a shift from deployments relying on proprietary hardware to commercial of the shelf (COTS) hardware, running a dynamic software defined network [1].
In a software defined network, the virtualization layer is referred to as Network Function Virtualization (NFV), which functions as Infrastructure as a Service (IaaS). The NFV is implemented on top of the COTS hw [2].

II. BACKGROUND AND RELATED WORK

A. Telco Cloud

Virtualization has long existed in the IT-industry, but it has only recently been applied in the telecom industry. It is however only in recent years that the availability of the IT cloud industry has achieved almost the same level as telco grade availability. This has also led to the interest of virtualization in the telco core networks.
The drivers of virtualization of telco networks is the need to overcome the problems with the proprietary hardware systems, long service deployment time, and network adaptability. The proprietary hardware and software make changes difficult today, as data, sw, and hw is integrated into a monolith. This can lead to long down time for single failure in any component [2]. The mobile operators solution has been to deploy redundant parallel systems. This redundancy is based on active-standby node scheme [2]. This scheme requires 100% overhead of the max system capacity, which is expensive.

C. Network Function Virtualization (NFV)

NFV is the infrastructure layer on which the telco specific applications are running as either virtual machines or containers. The NFV layer abstracts the hardware resources, like compute power, disk storage and network interface, and make them available for the telco core network functions. Example of NFV providers are VMware, KVM, and Xen.

III. PROBLEM STATEMENT

The deployment and operations of mobile networks today require patch fixes to live system, rollout of new software versions, and rollback of failed deployments. These activities have traditionally been undertaken during dedicated and planned maintenance windows, when network has low load of traffic due to impact on live traffic. However, 5G networks requires a flexible system that allows the continuous delivery of new software services and patches without causing frequent service unavailability. There are several approaches that can be used to achieve continuous service delivery in 5G environments with minimum disruptions. In this paper we will discuss how the DevOps approach of Blue/Green deployment is used for introducing new services in 5G network.
We will also make a comparison of deploying telco applications using virtual machines and containers in 5G networks. More specifically we want to analyze the mobile network deployment strategy on a cloud platform and what type of virtualization to use as a design solution in 5G network with requirements on scalability, and continuous sw improvements.

IV. A COMPARISON BETWEEN CONTAINERS AND VM FOR DEPLOYING APPS IN 5G

A. Efficient scaling

It is more efficient to implement a telco application as a composite of multiple microservices, where each microservice is delivered by different types of containers. This allows a more efficient scaling which is more granular than it would be with scaling a full VM [8]. This means the scaling of a VNF using containers is more optimized to the actual bottle necks that can exist in the deployment.

B. Increased density

A container doesn't include the full guest operating system like a VM; therefore the resource overhead is much higher for virtual machines then than for containers.

C. Portability

The containers includes the application services and all the dependencies. This support the continuous sw delivery pipeline process in DevOps, which is required at each stage of the software lifecycle, from design, development, test automation to production of services in mobile network [10]. These small containers compared to the virtual machine benefit from their smaller batch sizes at deployment.

D. Orchestration

Cloud native applications contain a wide number of sw modules due to the use of microservices and stateless processing which requires (state storage and transaction processing). There can exist multiple instances of the microservices. A scalable system with high load can be composed of several thousands of virtual machines or containers.

The orchestration of VM provisioning is still more complex and immature compared to Containers that have less requirements on configuration and management [11].

V. BLUE-GREEN DEPLOYMENT STRATEGY

A. The concept of Blue/Green deployment

Blue/Green deployment strategy is simply a DevOps approach that is designed to continuously improve the sw quality in production and the roll of new end user services supporting quick delivery of applications and services. The Blue/Green approach of service delivery is achieved through the hosting of two different versions of a software releases [12]. One sw version is live ensuring service availability to end users, while the other version is available for maintenance, test and verification. Once there is need for a system upgrade or maintenance, the non-live sw version is upgraded and tested without any impact on the live version. If the test results are approved, all the live traffic is re-directed from the previous sw release to the new sw release. This ensures that there is no downtime during the continuous delivery of sw updates and upgrades to the system.

The blue-green deployment requires two identical production environments. An advantage of keeping two parallel environments with previous and new sw versions is the ability to create an instant rollback environment as a backup if the new sw deployment fails with live traffic. When the bugs have been identified and fixed then the traffic would be re-routed again to the blue environment. In this way, the blue-green deployment environments are re-cycled between different sw versions [13].

What makes the Blue/Green deployment strategy suitable for 5G core network deployment is the fact that it is designed to allow minimum down time in rollout of new mobile and digital services to end users, with the option of fast rollback, as the old and new sw versions are always running in parallel. High availability with new sw releases is an important requirement in 5G. Once all tests have been confirmed and the new release is working fine, public traffic to the network is diverted from Green to Blue environment using a DNS router.

B. Automation in Blue/Green deployment

Infrastructure automation is about automating the process of creating, installing, testing, and operating the virtual environment of the telco network nodes required. There are various factors around 5G networks that necessitate an increased detail in infrastructure automation as it helps the entire network to be able to deal with the dynamic demands for network infrastructure whenever and wherever customer demand arises. The other level of automation is the automatic deployment and acceptance test of the telco specific applications running as tenants on top of the NFV platform. It is important to note that application deployment is a time-consuming process today with manual testing and preparations. These steps need to be automated in Blue/Green DevOps strategy for the roll-out and rollback of production sw within the 5G network.

VI. CHALLENGES IN BLUE/GREEN DEPLOYMENT

Database synchronization:

The Blue/Green deployment strategy has its own challenges, the biggest challenge that faces this deployment strategy is the potential risk of accidental change of the database schema between the two versions of the production environment. This has the potential to cause an irreversible loss of functions. Therefore, it is important for all DevOps teams to coordinate the switch between Blue and Green variations to avoid messing up the database schema. Large database migrations are tough. Databases schema changes should be forward and backward compatible. We may need to move back and forth between the old and new versions. The problem is complex when there are two databases, one for blue and one for green. To keep data in sync is hard. Some strategies to deal with this involve using replication or making one database read-only.

VIII. DISCUSSION AND CONCLUSIONS

In 5G the aim is faster development cycles with low operational risk, efficient resource utilization and scaling on-demand, these are key benefits being sought. For this shift to be successful, the automated operations must understand the domain-specific characteristics of each telco application. Failure to do so is likely to lead to sub-optimal results. This is most efficiently achieved by embedding application domain-specific logic within the application itself, so that it can be reused across different cloud environments and different service providers with minimal effort or risk of error.

As the vendors are migrating their telco applications to the cloud, most of these applications where actually not designed to be fully cloud native. Therefore, many operators today deploy their VNF in Virtual Machines, due to HW are OS dependencies. In future, Telco applications needs to evolve from today's VM-based applications and Infrastructure-as-a-Service (IaaS) clouds to containerized or even serverless models. Cloud-bursting and the sharing of resources between IT and NFV payloads promise further optimization of the resource requirements for Telco business. Culturally, the shift to cloud requires that engineering, planning and operations teams to come closer together, applying scarce people resources to high-value operations and fast decision making. Automation enables this, but wider organizational buy-in is required to move to a true DevOps model.

Blue/Green DevOps deployment strategy is the proper deployment strategy that can be used in the deployment of NFV platform & applications for 5G core network deployment with new services. 5G network has brought a shift from hardware reliance into the software-based implementation of core network functionalities. What makes the Blue/Green deployment strategy particularly important in the deployment of 5G core network, is the flexibility and low risk. This is availed through the reduction of downtime for frequent sw deployment, as there are always two variations of a production environments available and as a result, there is always room for a rollback in case the upgrade has issues. There is also the advantage of automation that comes with this approach as more of the deployment and verification functions can be automated to help reduce time to market and the lead time. The shift between various builds and rollout of minor changes can easily be achieved with the automation and a fall back plan of rollback;
Some issues we see with frequent changes between blue/green telco environment is that it creates interruption of ongoing long lasting sessions. In 5G Internet of Things and machine-to-machine communication will be important services. These services can have stream sessions lasting from days to years. If the production environment is changed the sessions will be broken and re-established. This outage can create problems in certain mission critical systems.
We also believe that Blue/Green deployment strategy should be combined with canary testing. Instead of redirecting all live traffic in one go to the new sw version, it is safer to redirect only small portion of traffic to new software version. When making major sw upgrades only part of the overall traffic should therefore be migrated to the new sw version. This migration should then be monitored for some days or weeks before we have confidence to migrate the rest of the traffic. We believe that it is only when running traffic with real customers that you can discover hidden bugs, that the test automation has failed to identify.
Also having two parallel production environments is expensive, compared to the N+K model (where $K < N$). This model gives us enough redundancy and less cost compared to a N+N model or Blue/Green deployment.

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