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5G as a Service (5GaaS)

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Abstract

5G technology is considered the foundation that comprises the world telecommunications infrastructure for the next years. Many applications and web services have already moved to the public cloud; 5 G infrastructure could also easily be built and grown in the same manner utilizing the public cloud provider regions and edge services to reduce the latency accessing the applications, which have been one of the driving factors of 5G technology. With tightening budgets, as a service, "aaS" allows organizations to consolidate and more effectively utilize their resources, control costs, and align those costs with consumers of the resources and also provide the organization with the ability to easily adapt to and deliver services that in a seamless and automated fashion. No doubt the technical calculations are correct about the 5G future, but what about the financial expectations? Not to worry, when the other companies see that one or two are committed to rapidly achieving success, they tend to get onboard faster. The startup organizations will benefit from the experience, maturity, reliability, security, and performance of cloud providers with the broadest and deepest choices for computing, storage, and networking to maximize the performance of new applications

Keywords — *5G wireless network, Public Cloud, Internet of Things (IoT), Multi-Cloud, Remote Cloud Services, Fiber Optic Network worldwide.*

I. INTRODUCTION

2G technology let us the text for the first time, 3G technology brought us online, and 4G got us to the speed we are enjoying today. With the exponential growth of the number of the devices, the need for higher speed and low latency becomes a must; 5G is the technology going to offer at least 10 times if not more speed as 4G with a latency of milliseconds, which qualify it to fit with the future demands appropriately.

5G is noted for taking the communication to unprecedented speed and capabilities, public cloud as a service is noted for agility and scalability, and lastly, artificial intelligence is noted for making our lives smarter and easier. The three technologies combined will shape the future of mankind for the next few decades, and we require all three.

The promise is high cost and hardships as well as a high reward, but we cannot wait any longer; there will be challenges and mysteries to be solved, but there will be knowledge to be gained as well, it is one of the greatest adventures of all time

With public cloud and as a Service (aaS), you just need to plug in and subscribe, and business is ready to go so you can get started much faster than before, and it costs less. These technologies collectively will create a great number of new companies and tens of thousands of new jobs, generating new demands, investment, and skilled personnel. We have just begun, and we might be behind for some time, but we should move forward. No one can fully grasp how far and how fast we will become with 5G technology (see Fig. 1).

Fig 1: 5G as a Service (5GaaS)

This publication will begin with an overview of 5G architecture and IoT technology, followed by introducing the public cloud proposal model and the business angel of the architecture, and will end with the planning and funding phase of the design architecture [1].

II. 5G ARCHITECTURE OVERVIEW

Ericsson and Nokia are considered the leading 5G architecture found in the western hemisphere. Fig. 2 depicts Ericsson's view of the 5G infrastructure for the future. 5G network architecture goal is flexibility and efficiently meet the frequent evolving technology demands. In addition to utilizing the software-defined networking (SDN) and Network Functions Virtualization (NFV) supporting the underlying physical infrastructure that allows for better support and fast deploying, and provide enterprises and individuals with a real-time response [1], [4].

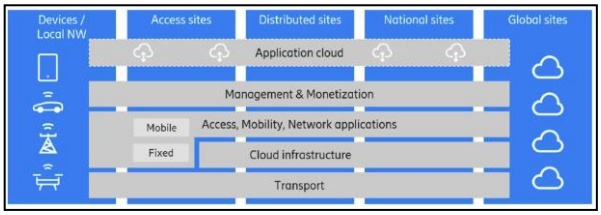


Fig 2: 5G Architecture view

The existing mobile network architecture was designed to meet requirements for voice and conventional data services; however, the driving force behind 5G development, according to Huawei that is considered the dominant leading 5G development company in the world, is to be able to provide diversified services of different KPIs, support co-existent accesses of multiple standards (5G, LTE, and Wi-Fi), and coordinate different site types (macro, micro, and pico base stations), improving the lifecycle management processes. Fig. 3 shows Huawei 5G visionary architecture [2].

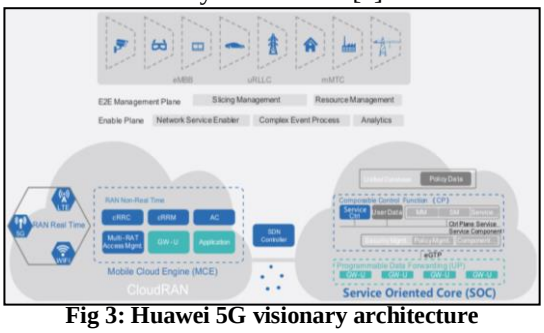


Fig 3: Huawei 5G visionary architecture

III. 5G IoT

The Internet of Things or IoT is influencing our lifestyle from the way we react to the way we behave, from air conditioners that you can control with your smartphone to smart cars providing the shortest route, or your smartwatch, which is tracking the daily activities. IoT is a giant network with connected devices; these devices gather and share data about how they are used and the environment in which they are operated (see Fig. 4).

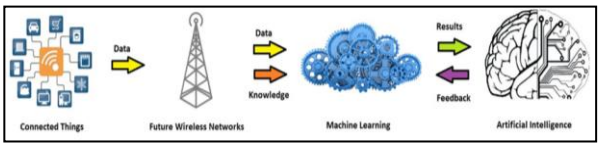


Fig 4: 5G and Artificial Intelligence

It is all done using sensors that are embedded in every physical device. It can be your mobile phone, electrical appliances, barcode sensors, traffic lights, and almost everything that you come across in day-to-day life. These sensors continuously emit data about the working state of the devices, but the important question is how do they share this huge amount of data, and how do we put this data to our benefit (see Fig. 5).

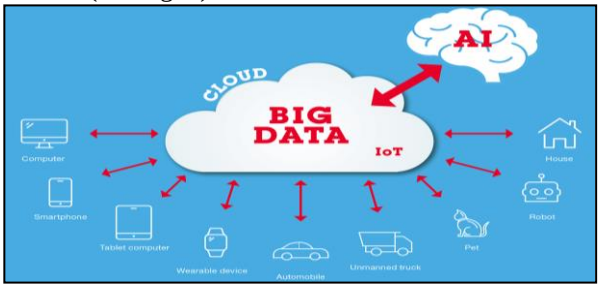
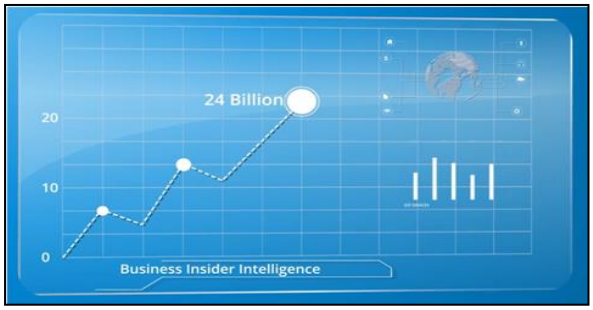


Fig 5: Internet of Things (IoT)

IoT provides a common platform for all these devices to dump their data and a common language for all the devices to communicate with each other. Data is emitted from various sensors and sent to an IoT platform that integrates the collected data from various sources, further analytics is performed on the data, and valuable information is extracted as per requirement. Finally, the result is shared with other devices for better user experience automation and improving efficiencies.

We have smart appliances, smart cars, smart homes, and now smart cities where IoT is redefining our lifestyle and transforming how we interact with technologies. The future of the IoT industry is huge; Business Insider Intelligence estimates that 24 billion IoT devices will be installed by 2020, and ITC predicts that IoT Revenue will reach around 375$B in 2019, resulting in many job opportunities in the IT industry (see Fig. 6a and Fig. 6b).



(a) Business Insider Intelligence

(b) IDC reports

Fig 6: Business Reports

IV. 5G CORE-EDGE CLOUD INFRASTRUCTURE MODEL

A. Public Cloud for 5G Architecture

5G architecture comprised of three major components; Core, Edge, and the last mile RAN. The core component simply is nothing but few virtual machines and some virtual network resources such as Load Balancers, NAT, Gateways. a most important thing about the core components' compute resources, they should not be time-sensitive due to the distance to the last mile RAN aka the small cells. The Edge component is also nothing but virtual resources, but they need to be closer to the last mile RAN for faster communication dependency. Regarding the last mile,

RAN is the radio frequency small cells, as mentioned, that need to be accurately spread over all the geographic locations to guarantee the best coverage [3].

Applications are the heart of every modern organization. Due to digital transformation, the nature of applications is changing, with a greater demand for innovation. Customers are turning to the cloud to deliver differentiation, accelerate time-to-market, and increase scale. The cloud has become the standard approach to building and delivering applications for the modern enterprise. Utilizing public cloud manages the cost of cloud operations through simplifying budget tracking and spending analysis to reduce waste and lower overall costs in the cloud.

A public cloud provider is certainly the environment for the core component; however, for the edge, it depends on the public provider access locations around the nation. The three dominant public cloud providers worldwide, Amazon AWS, Microsoft Azure, and Google GCP, are actively expanding their reachability in more locations. With improved technology, condensing more compute, and integrating with quantum computing as well, and it is expected by 2025, a public provider will handle the core and edge component just fine [5], [8].

Spinning 5G architecture in the public cloud should not be surprising. In the last decade only, a significant number of applications are running in the cloud already and are still increasing by second. Furthermore, with the complexity of managing these applications is also reasonable to grow the 5G architecture in the public cloud environment, moreover using of public cloud is now intricately connected to business success.

5G world will be non-stop growing with applications and complexity; the combination of a rapidly growing user base, hundreds of different services, and a very high rate of change creates a situation where keeping up is extremely difficult, which could be alleviated using the public cloud network to quickly detect anomalies impacting cloud-native SaaS applications in production, easily see and correlate application performance trends, and leverage intelligent alerting that is responsive to dynamic behavioral changes that impact application performance (see Fig. 7)

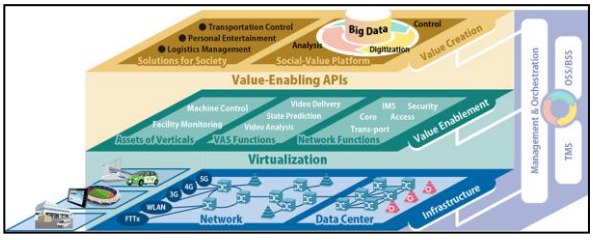


Fig 7: Public Cloud for 5G Architecture

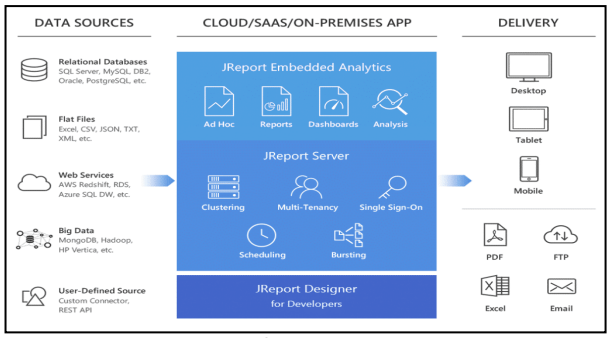
B. Multi-Cloud for 5G Architecture

Multi-Cloud provider is the other option that is very appealing and more feasible today, such as VMware that can take advantage of exploiting all regions and all edge locations of the three dominant public cloud providers was mentioned, offering reachability, scalability, and agility as well. A multi-cloud strategy supports several important business objectives such as protection against vendor lock-in, the ability to leverage the unique strengths of each provider, and expanded geographic reach [10].

Over time and as public cloud operations become more multi-cloud, teams find it necessary to support the provisioning of resources across more than one cloud. This gives rise to a need for teams to work collaboratively to design version-controlled, cloud-agnostic blueprints (templates). A multi-cloud solution should give developers easy access to resources using a declarative and iterative approach, treating infrastructure as code. Simultaneously, the solution should give cloud operations teams the ability to govern resource delivery across teams, environments, and multiple clouds.

Some of the benefits of migrating to the multi-cloud platform; balance your resources by consolidating your data centers and extending to the cloud, extend security and governance for all applications across clouds, with consistent operations, and choose the optimal environment for your applications across many of global cloud providers. VMware Cloud Foundation (VCF) is the obvious choice today. Multi-Cloud offerings are uniquely focused on driving consistent operations and simplifying the highest-priority technical challenges your enterprise faces in managing multiple clouds (see Fig. 8a and Fig. 8b) [11].

(a) Carriers



(b) Infrastructure

Fig 8: Multi-Carrier Cloud Operator

If you are using VMware Cloud Foundation technologies on-premises today, you can also simplify your hybrid IT operations using those same technologies, including vSphere, vSAN, NSX, and vCenter Server across your on-premises data centers and on the AWS cloud, Google GCP, or Microsoft Azure. VMware Cloud on public cloud providers is mentioned you maintain consistent operations across your hybrid cloud architecture without having to purchase any new or custom hardware or rewrite applications [14]-[16].

With multi-cloud, the operators extend their own data center to the cloud as your enterprise expands to new geographic regions while maintaining consistent infrastructure and meeting regulatory requirements. Also, securing the data with disaster recovery and backup delivers business continuity, simplifies disaster recovery, reduces site costs, and protect mission-critical systems and data.

Broad visibility and data analytics across all of your public clouds are fundamental and crucial to the architecture's success. These capabilities enable enterprises to drive accountability, manage margins, and do chargeback across the organization. They also allow the organization to track spending across multiple clouds and set budgets by any logical business grouping, whether it is a project, application, department, or team. The ability to optimize costs across multiple cloud environments is also a key capability that organizations should look for. In 2017, Cox Automotive saved more than $2M on their cloud bills using CloudHealth by VMware. CloudHealth helped Cox Automotive improve application migration planning speed and accuracy and to gain comprehensive visibility across their multiple public and private clouds [13].

C. Edge and Remote Cloud Services

For applications that remain on-premises, AWS Outposts or VMware Dell services bring the same hardware and software in the cloud, the same services, and APIs, the same management tools, and the same support and operating model to virtually any data center, co-location space, or on-premises facility.

There are many services offered by almost all cloud providers that will certainly help with applications based on 5G architecture that could never be born without high speed and low latency, such as AWS Kinesis fire hose, which is a way that you can take streams from hundreds of thousands of devices and direct them into an s3 bucket, do things like the real-time transformation of the data real-time querying and analytics of the data as its streaming in it is quite a few use cases and in possibilities that you can have with Firehose [8], [12].

Snowball Edge is a compute-optimized, storage optimized, and intense graphical compute-optimized with GPU. It is S3 compatible; all data is encrypted, physically ruggedized, can be a check on an airplane with no harm, it is plug-and-play; you take it and open it up, plug it into your network, give it some power and turn it on, unlock it, and you can immediately use it. With the compute functions, you can run lambda, file interface for NFS, scalable, and cluster them together.

In remote edge locations such as research vessel or in an industrial situation where you need something that's ruggedized and can stand up to the environment. Using the snowball edge to capture all the sensor data from the self-driving cars so that then they can get back and transfer that into s3 where they can start to process the data so there are many use cases and where the need for more intelligence inside of the snowball edge, ability to run EC2 instances, or GPU capacity, basically when industry or the business necessitate edge computing and storage hybrid capabilities where data generation is not centralized or at distributed locations, data quantity are significantly high but network connectivity is at low bandwidth

Data sync services is an online transfer service that helps accelerate and manage and automate a lot of the steps of doing a data transfer from a location to another very fast, easy, secure, and reliable, of course. It helps with a data transfer that's maybe time-sensitive; you can quickly and in the real-time transfer that data from your data center from your remote offices; it also lets you do replication of data for business continuity purposes and disaster recovery (see Fig. 9).

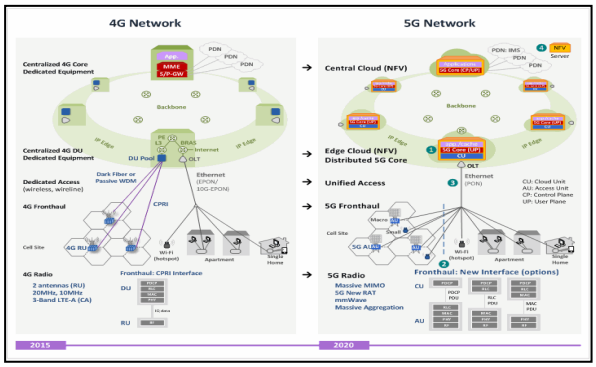


Fig 9: 5G Edge and Remote Cloud Services

D. Public Cloud providers and Fiber Optic Network worldwide

Fig. 10 illustrates how the whole world is almost covered by regions, data centers, Edge location of public cloud providers Amazon AWS, Microsoft Azure, and Google GCP.

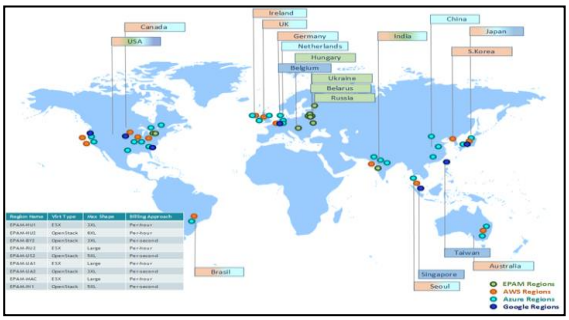


Fig 10: Public Cloud Providers across the world

The world is connected with an undescribed fiber-optic network, as shown in Fig. 11 below, that facilitates communication and expansion when needed.

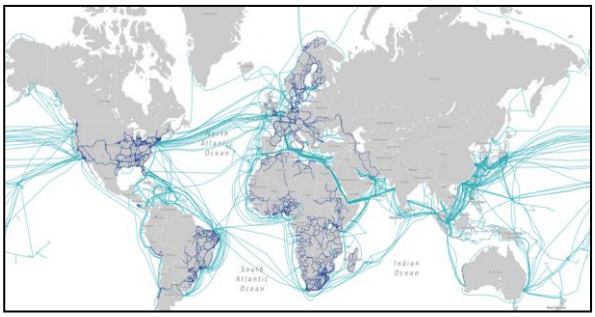


Fig 11: World Fiber Optic Network

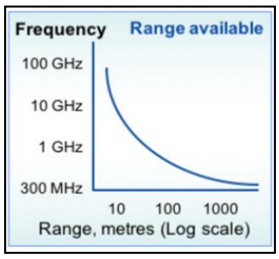
Between public cloud providers' locations across the world and the world fiber-optic network, this will improve businesses' growth and new opportunities to be developed on a massive scale, such as artificial intelligence, biomedical researches, and national security.

V. 5G Business Model

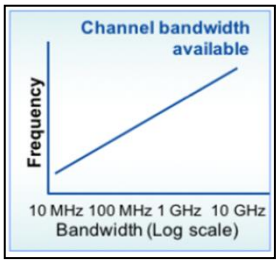
5G technology promised to offer mobile and fixed internet access at broadband speeds of the order of 10 Gbps, about a hundred times faster than theoretically possible with the current LTE technology. The business drivers behind this advance are the need for a high volume of delivery data rates in minimal response time.

With 5G, the technical approach to attain much higher data speeds and lower latency is complex compared to previous generations of mobile infrastructure for the base stations, their antennae, the software, and handsets. 5G attempts to revise the basic cellular radio technology model with focused beams, potentially much higher frequencies and greater bandwidth for higher data rates, shorter range, more interference, and indoor penetration.

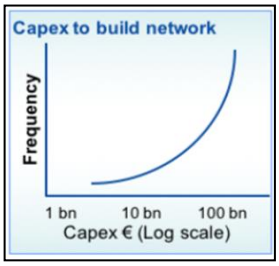
Physics controls the Economics of 5G, besides the network economics, which is dictated by the signal propagation characteristics. A shorter range implies more base stations and higher cost, as indicated in Fig. 12a, Fig. 12b, and Fig. 12c.



(a) Range Available



(b) Channel Bandwidth Available



(c) Capex to build a network

Fig 12: 5G Economics

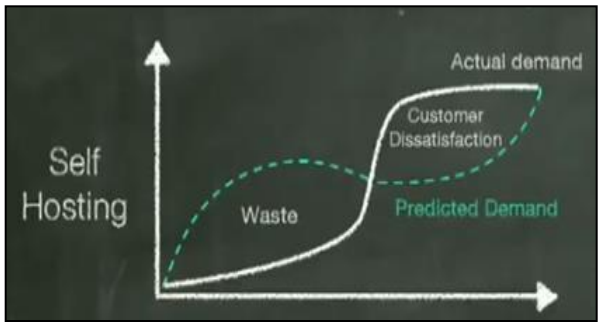
The signal propagation range decreases as frequency increases with the frequency's square, so more base stations are needed to cover a given area as the cell size shrinks. Consequently, capital expenditure for the network goes up as the cell radius decreases. However, at the higher frequencies, more spectrum is unused today, and the wider channel bandwidth can give higher data speeds and serve many more users and devices such as connected cars in traffic flows [18].

With higher frequencies and shortened ranges, base stations will be more closely packed into a given area to give complete coverage that avoids "not-spots". This dense network rollout will be costly, not just in terms of installations but also in the costs and delays in obtaining planning permission and any authorization. In practical terms, major efforts will include installer training and certification on a large scale.

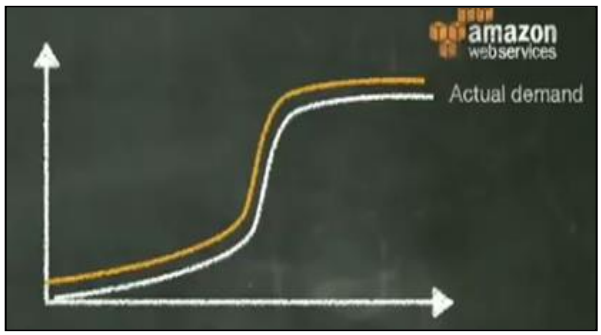
5G is not only the last mile deployment that comes with its economics, as just explained, but the core, the heart of the operation, the brain as well. The 5G core architecture should be agile, scalable, and redundant, but also should be able to be distributed

not only centralized since some of the edge components of the 5G architecture are time-sensitive to a distance for responses. The public cloud providers are the perfect candidates for that, with all edge locations and extended services that will suffice the 5G Core/Edge architecture demands.

The public cloud environment is the most appropriate resting place for 5G architecture for numerous reasons. Trade capital expense (CAPEX) with operations expense (OPEX) means pay as you consume resources. Moreover, the public cloud is an elastic environment, which means no capacity planning is required since there is no capital expense (see Fig. 13a and Fig. 13b) [18].



(a) Rigid



(b) Elastic

Fig 13: Elastic Public Cloud vs. Rigid Environment

Agility to deploy or expand in a matter of minutes, and the ability to scale up and down anytime are highly rated factors of spinning an application in the public cloud and increasing the innovation thru development with low risk.

In addition to the technical reasons why public cloud is the most suitable place for the 5G architecture, it also accelerates Engineers' talents, which expedite the delivery thru focusing; instead of focusing on infrastructure, focus on projects that move the mission or the business forward. Moreover, we can go from local to national to global in minutes and hours (see Fig. 14).

Fig 14: Public Cloud Agile and Fast Service Deployment

In the current uncertain financial state of the global telecommunications industry, the calls for new and major investors are not too welcome, especially one with tentative business models – and thus unclear overall costs and returns.

The vertical industrial sectors (e.g., aerospace and car manufacture, construction, health services, utilities) are the candidates' players may become the prevalent 5G network builders, owners, and operators. Besides, there may be multi-operator "small cell" networks with separation of application services and basic networking infrastructure, especially where the general public needs connectivity.

Thus, 5G may trigger alternative infrastructure ownership models, either sharing both physical networks and spectrum, or by separation of services and the network so that players may choose either the networking layer or services. Third parties owning and operating networks and shared licensed spectrum as alternatives to the current models of infrastructure competition.

The more 5G architecture grows in the cloud, the more integrated applications will be invented, taking advantage of the lower costs and improve operational resiliency, gain business agility, and build a foundation for rapid innovation, but also increase the workforce productivity and business agility.

VI. 5G PLANNING AND FUNDING

The benefits of the cloud are now reasonably well known. Cost savings are compelling for most companies; however, the number one reason enterprises are moving to the cloud quickly is speed and agility. Today, global organizations (Banking, manufacturing, Video Streaming, and Entertainment)

such as Capital One, Johnson & Johnson, News Corp, Siemens, Netflix, and Enel transformed their businesses to the public cloud.

Successful transformation projects need a senior executive who ensures that the entire leadership team appreciates the profound benefits of moving to the cloud. Without a strong business sponsor, the minute things get difficult, others may become skeptical, and the progress will slow.

5G technology with everything that comes with it from data, voice, and IoT represent a great investment to CEOs since it is integrated with artificial intelligence to enable the organizations to compete against disruptive startups and provides visibility, audibility, and control to reduce the risk of a data breach or information loss.

Deploying and growing the environment in the public cloud relieving the pressure of delivering new services quicker and more efficiently, and this is in turn, offer faster insights on the customer buying behavior and dramatically improves time to market.

It is not easy to start up a new product line for an organization; it needs the whole team on board committed to achieving the vision, excited to build new skills, prepared to work in completely new ways, and that will help a lot against people resisting changes and can hinder the progress. It is worth mentioning not to stuck in analysis paralysis, start with "ship something to production" that has immediate, tangible benefits by identifying one or more applications that can move quickly and easily to the cloud and implemented, which will deliver very visible benefits to the organization.

Turning the attention to the larger-scale migrations and modernization, the expert level of help is needed through enlisting the help of people who plan, build, transition, and operate critical IT systems in the cloud every day and can help transform people and operating model to take advantage of the cloud. Professional services work side by side with teams at each stage of the transformation journey providing a production-ready environment in days. This includes a secure, compliant landing zone and an "out-of-the-box" cloud operating model.

Planting the whole architecture in the public cloud improve the chances and accelerate the pace of innovation when the need to continuously prioritize and re-evaluate what to move and what to keep.

Since the 5G endeavor is being driven primarily by the equipment suppliers, it is not surprising that there is a significant marketing campaign underway. Its long tail supply chain reinforces this industry effort – semiconductor components, software, managed operations, and equipment suppliers – that together serve the major operators.

In mobile telecommunications, it is the MNOs who have come to dominate the networking revenue streams with online access as the main growth revenue source. However, the market has become increasingly saturated, and revenues are in decline. It might also enable the MNOs to build new revenue streams in IoT applications for industrial users. The level of enthusiasm in the operators is less than it might be if there were established technology ready to go and offer proven returns. Those who have to invest are unsure of the business case for solid revenues.

All this means that there is less money available for operators at a time when their market value and share price has fallen. They claim the cost of capital is too high, and certainly, the banks do not have the surpluses available for, say, 3G in 2000. The only alternative is to seek other investment sources such as large enterprise or cloud providers, and the state is the only source with sufficient capital left. 5G business models have just begun to define the goals, scope, and revenue sources with a more diverse range of players than just incumbent operators.

Convincing business models are already undergoing the 5G campaign to convince large enterprises and governments that the social and economic benefits justify the enormous cost and, hence, the numerous studies forecasting trillions of Dollars and Euros in value to the economy and the creation of millions of jobs.

VII. CONCLUSION

5G technology is the present and the future for all mankind; it will connect almost everything to humans. It is based on transport much larger volumes of data more quickly for video and entertainment content and lives streaming on social networking, but also it reduces response time (or latency) across the mobile network for gaming and certain vertical sector business applications, e.g., for the Internet of Things (IoT) applications and real-time manufacturing and process control.

Building and growing 5G architecture in the public cloud or multi-cloud environment provide businesses with comprehensive visibility and necessary insights and tools, enabling businesses to optimize cost and resource usage, enforce consistent security and compliance standards, improve SaaS application monitoring and troubleshooting, and simplify resource governance and automation. Managing public and multi-cloud operations does not have to be difficult.

Cloud environment provides a vast array of technological functionality to users and organizations via the internet "as a service (aaS)". So, whether you need the service for thousands of users, or over multiple offices, or go global, just sign in anytime and anywhere. All upgrades and features will be taken care of; you just pay for what you use, no installation, maintenance, no CAPEX, no headaches, and no additional resources to handle it.

Taking all the analysis into account, with a public cloud environment, we get to change the capital expense for variable expense, pay a lower variable expense, no guess on capacity, we can move quicker

which enables a lot more innovation, we get to spend our resources on projects to move the business forward, and we can go global with application presence in minutes.

In short, 5G networks are likely to be based on encouraging infrastructure sharing with separation of infrastructure and services. This could be fundamental to the financing model for 5G networks to provide widespread coverage for the single digital market.

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