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Public Cloud: The Business Technology Platform

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Abstract: "The technology does not automatically improve, it only improves if a lot of people work very hard to make it better", Elon Musk. Building new things has led to some of humanity's biggest leaps forward, the "Cloud". We made tools, we forged new materials, and learned to produce them for millions and then billions and with every new innovation, comes news industries, new economies, new challenges, and we are always looking for what comes next. By the end of year 2025, approximately 75% of organizations will experience business disruption due to infrastructure and operations skills gaps, connected devices will grow to nearly 27 billion, and bandwidth demand is doubling every two years due to IoT and video consumption. The long-term goal is for the public cloud to be the data center for everything and everyone, for enterprise for government, and small business, to accommodate with the advanced shift in the technology, it is a transformation journey but it is imminent that starts with transforming ourselves in most meaningful and sustainable way we think of the future and also meet new technology situations or opportunities.
Keywords: Cloud Transformation, ENGaaS, AI, ML, IoT, Multi-Cloud, Quantum Computing.

I. INTRODUCTION

Cloud infrastructure is an operational model not a destination or a location anymore. Private cloud on-premise is usually the beginning of the transformation journey, but how to get a handle on total cost of ownership as well as giving their developers instant access to the latest advances in the public cloud environment service that is uniquely solving and delivering high operational integrity and cost controls.

The breadth of things that cloud providers are doing is actually an innovation of the things going on across the spectrum from cloud to intelligent edge. Public cloud provides a huge number and variety of services with rich depth of features and capabilities within these services across all major infrastructure components, compute, storage, database, analytics, machine learning, IoT, robotics, and video content distribution as well. These advanced services are delivered to companies no matter is their size, changing needs, or challenges. It is designed and built to deliver the most flexible, reliable, redundant, and scalable, in addition to securing the cloud computing environment with the highest quality global network performance available today.

Public cloud technologists are redefining the application experience by expanding their powerful innovation of AI and 5G by moving to the edge, bringing intelligence to everything and being able to connect with every human on the planet. Both AI and 5G are accelerating each other, and technology will have a greater impact than ever before in our lives. Enterprises and government dramatically changed their view of the cloud and have adopted public cloud in every imaginable vertical business to help them transforming themselves and their industries. "Expedia" stated that they are couple of years ahead both on functionality and with regard to maturity after moving to AWS public cloud.

This paper demonstrates why public cloud is the future business growth path through understanding the cloud provider visions, their superiority when it comes to hardware capability and wide scale deployment with just minimum OPEX for the customer to pay instead of investing in CAPEX in a gear that could get outdated in shorter period of time. Cloud providers all combined with support from other organizations, and with innovations that can reach to the customer within a single digit millisecond, that has raised the level of confidence for the businesses' owners and investors to take the journey. Mobility, Artificial Intelligence (AI), and Quantum Computing are the futuristic fields that business already depending on now and tomorrow, and there is no place but the public cloud to help businesses to grow, prosper, and succeed.

II. MINDSET AND VISION

Public cloud providers have a unique mindset, they think about costs, they think about innovation in the data centers, also they think about the way that they operate services and for how long. Public cloud's infrastructure platform has at least 3 to 5 years of items on their roadmap that customers want. Public cloud providers strategy is if something that's good for customers, they are much better off cannibalizing themselves thinking they will lose business for an unused infrastructure, rather they are doing the right thing for customers

and being part of shaping something. Whether you are a customer looking for the low-level building blocks and stitch them together to create a technical environment for your business model or if the customer that is willing to give up some of that flexibility in exchange for getting 80% off the way and get his business much faster, the public cloud is the where they should be because public cloud providers relentlessly have built very significant offerings in both areas.

Over years, senior leadership level has begun to be in alignment and committed to a new way of running businesses, through the public providers support and experts, the journey starts tarring with a portfolio analysis through all their applications, classify them into the applications that are easy to move, medium and hard to move should go last, starting with small number of applications moving to the cloud in short period. They provided education and training to their employees, build them a thoughtful methodical multi-year plan to migrate, and along the way they figured out their security model, their governance model, and their compliance model and they had success building momentum and aggressive goals toward the future with ideas started flowing and now they are completely operating on the public cloud.

On the other hand, there are other companies acting as suppliers to the enterprises to enable them to build their data centers such as Trace3 and World Wide Technology, for a while, the enterprises are struggling to keep up with designing, expanding, re-adjusting and testing applications, those suppliers are stepping in to help filling in the gaps by providing consulting, testing, and assembling before shipping but most important pushing new technologies that is already implemented in the public cloud, which is called ENGaaS (Engineering as a Service).

III. HARDWARE CAPABILITY AND INNOVATION

There are more demands for high performance computing in the form of CPU's and GPUs, it is worth to mention that Microsoft has launched recently beast v2, it has 12 TB RAM, 448 cores, with 8 sockets. Figure 1 shows the wattage off the cores over time has continued to grow. While the thermal envelope the processor has to operate at, continues to drop per processor represented by the orange line as shown in Figure 2. The challenge is the balance between air cooling and the drive for more wattage in a smaller amount of space, phase 2 immersion which is a liquid at boiling temperature it has heat coming off the servers really quickly.

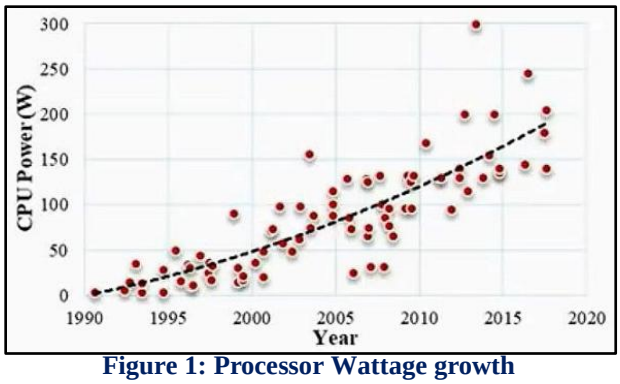

Figure 1: Processor Wattage growth

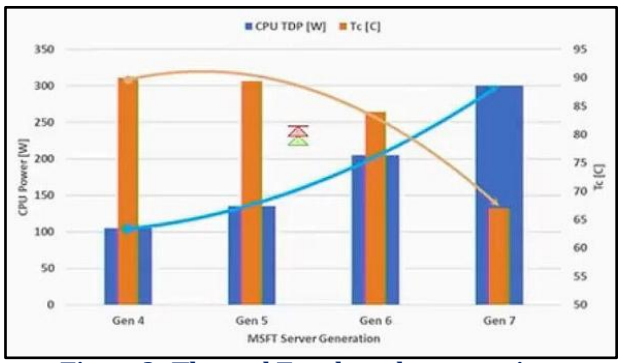

Figure 2: Thermal Envelope drop over time

The public cloud providers' pace of innovation in the number of instances is totally accelerated in a very significant way, almost four times more instance types with many processor choices from Intel and AMD and ARM based just in couple of years, also instances with powerful GPU machine learning trading instances, and powerful GPU graphics rendering instances, the largest in memory.

Innovation is constantly on the go, spending a significant amount of time enhancing, improving, and in many cases reinventing the virtualization hypervisor itself. For instance, AWS nitro chips take the virtualization of the security and the networking and the storage off the main server where the lightweight hypervisor and the customer instances are and gives back all that CPU it was consuming before which means getting performance indistinguishable from bare metal at a much lower cost (See Figure 3). In addition, taking all these pieces off that main server and put them on nitro chips that helps building and innovate in a much quicker fashion offering network optimize instances (See Figure 4).

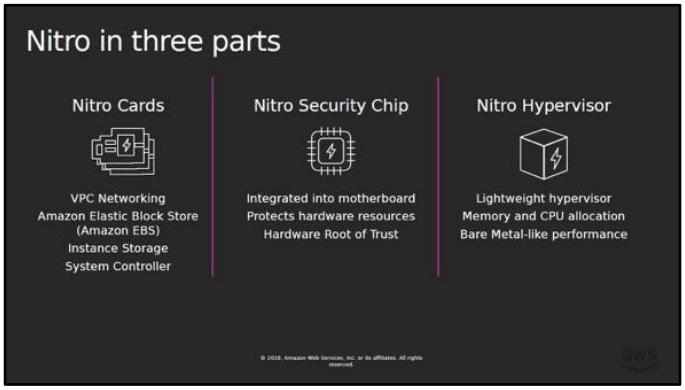

Figure 3: AWS Nitro Chip Advanced Architecture

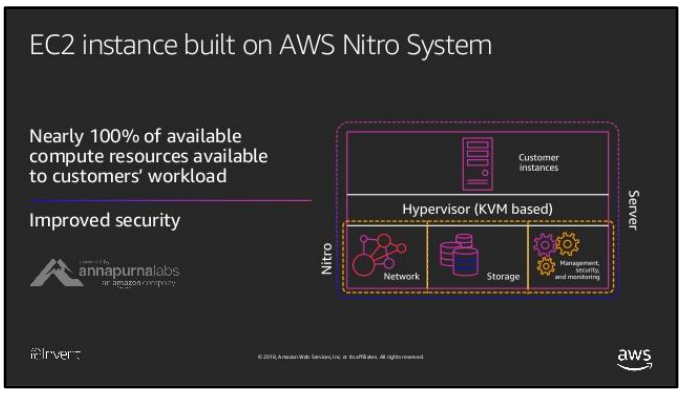

Figure 4: AWS EC2 instance with Nitro Chip

The progress on the hardware is continuing alongside with the wide deployment, public cloud providers are now designing and building their own chips to give the customer more capabilities and to push the price performance envelope which is a big turning point. An example of that is Amazon EC2 A1 instances powered by an ARM based chip "Graviton". The partner ecosystem has really stepped up and supported ARM based instances in a very significant way, it is publicly used by CBS corporation, Symantec Security corporation, Ancestory.com, and RedHat. With the success of Graviton first generation, AWS has announced December 2019, the launch of instances M6g, R6g, and C6g instances for EC2 build on new generation of ARM based instances powered by AWS "Graviton 2" providing a significant difference, four times more compute cores, five times faster memory, and overall seven times better performance than the first graviton chip but arguably most importantly they have 40% better price performance than the latest generation of x86 processors (See Figure 5).

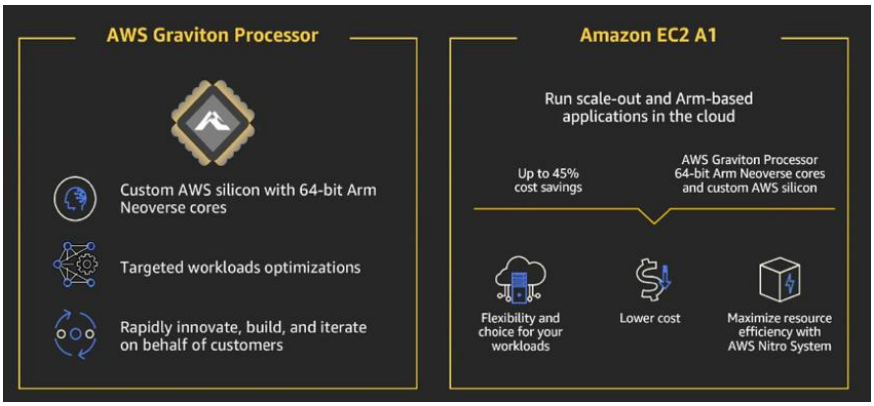

Figure 5: AWS Graviton Processor

Building Container and Orchestration engine such as AWS's ECS/EKS, Azure's AKE, or Google's GKE have supported industry leaders such as Verizon, GoPro, Fox, McDonald, and million others, but those servers or clusters also required the customer to manage. Public cloud providers took it further to the task level, new services are born such as AWS's Fargate that the converted Container and Orchestration engine to a serverless service makes it easy on the developer to focus on their applications, less hassle to worry about the servers and the clusters, and significantly cost effective (See Figure 6).

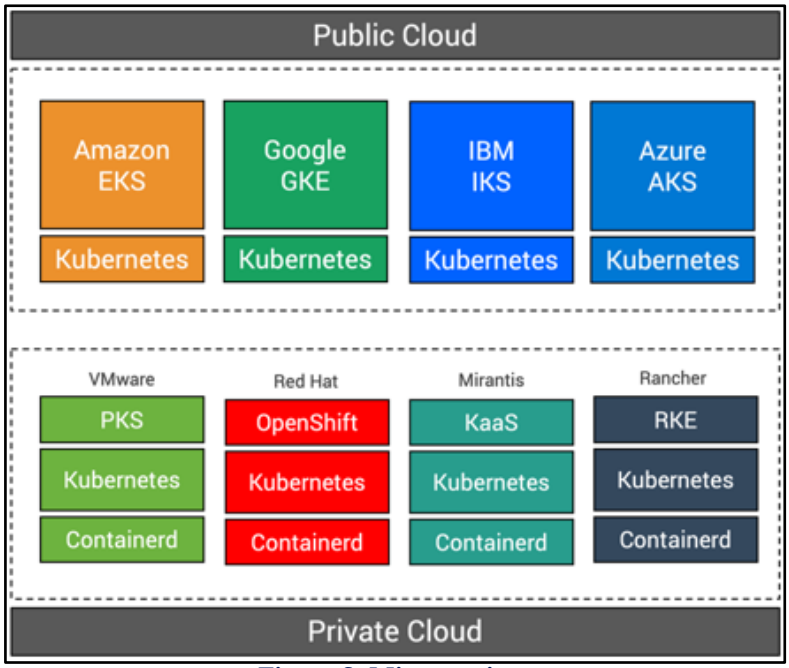

Figure 6: Microservices

The Partnership between Dell and VMware manifested itself in "Project Dimension", availability of VMware cloud on Dell EMC, a solution co-engineered by VMware and Dell that is operating the VMware cloud foundation built on the industry-leading hyper-converged infrastructure of choice VXRail, combining common cloud management with the VMware cloud, offering a rich set of enterprise services from Dell that enables simplicity scalability, and security. In addition, with the partnership with Equinix who's becoming a hosting partner to deliver this in their centers so that more customers could take advantage of VMware cloud on the Dell EMC solution as shown in Figure 7.

Figure 7: VMware and Dell-EMC - Project Dimension

IV. LOCATIONS

Public cloud providers have been expanding the data center deployment to cover more geographical areas but importantly this happens in shorter period of time. There are very selective to the locations when it comes where to build it and many factors contribute to the final decision. Besides all the calculations with respect to the serviceability of the customer, peering locations, and many other factors, there is one factor sticking out and becoming a significant and a major decider which is the environmental and economical factor. For example, Microsoft azure datacenter in Virginia and Washington, USA are utilizing renewable energy, natural resources for cooling and more such as Columbia river. Microsoft Azure is already at six of the seven continents, and they believe they will end up being in Antarctica at some point and they are ready for it (See Figure 8).

Figure 8: Microsoft Azure Data Centers Significant Growth

Public cloud providers have increased dramatically their footprint of POPs and abilities to get more customers on their backbone, more places to do direct connect to enterprise on-premise data centers with hundred gigabit per second. Other helpful services such as AWS Transit Gateway, the most capable network hub which allows you to connect your on-premise data centers with AWS and but also set up across different regions. It has the ability to connect your branch offices utilizing SD-WAN more easily (See Figure 9) [1].

Figure 9:Public Cloud Providers' Global Locations

So far, public cloud providers along with other service providers have provided locations to cover in some cases almost a whole country in centralized fashion (See Figure 10).

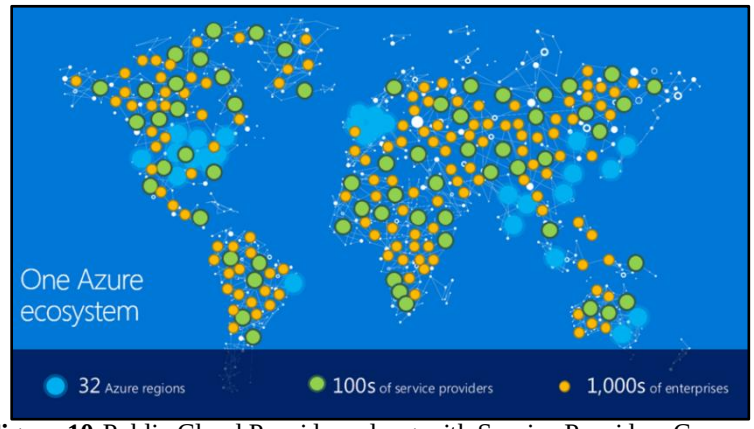

Figure 10: Public Cloud Providers along with Service Providers Coverage

Centralized cloud computing could soon be old hat. Today's internet "cloud" is made up of huge racks of computer servers packed into data centers. Some 200 warehouse-size, high-performance, "hyperscale" data centers span the U.S., says Synergy Research Group [2].

The new era of edge computing is growing due to the applications demand. "I'm convinced edge computing is here to stay," said Marco Argenti, former vice president of technology for Amazon AWS, it is a natural evolution. Not all data needs to be transferred to the cloud to be processed. There might be bandwidth costs, cellular costs or it may be difficult to connect to the cloud. Or, it just needs to react really fast, like in the case of a robot.

A common example of edge computing is when some workloads must remain on-premise somewhere not in the cloud but the customer wishes to operate it the same way the customer operates it in the cloud. AWS took an aggressive productive approach called “AWS Outpost”, a new solution to distribute the cloud providers' gear from compute, storage, database, and analytic service, even Microservices (containers and orchestration kubernetes) to the customer premise with all different compositions for the customer. It is delivered to the customer, maintained, and patched by AWS. Customer can now run those workloads that must stay on the customer data centers using same AWS API, the same AWS control plane, and the same AWS hardware and tools that allow you to leverage that learning and seamlessly connect with all other AWS applications in the AWS public regions. It comes in two variants, Native AWS Outpost, or VMware Cloud (VMC) on AWS but on-premise as well. Other companies such Dell-EMC through “Project Dimension” has supported this approach to take the burden off the customer shoulder from installation, maintenance, and support as well (See Figure 11).

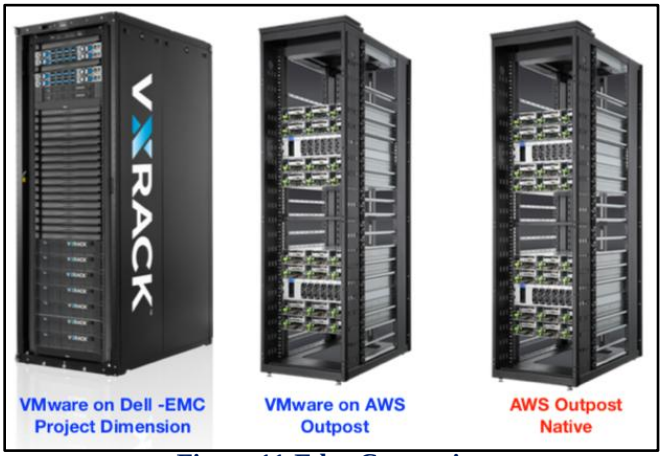

Figure 11:Edge Computing

Cloud providers have done a great job so far but realistically the cloud provider’s data centers are very expensive to launch everywhere closer to every customer. What about organizations in a particular geographical area that have workloads and their applications are latency-sensitive where they need single-digit millisecond latency and there is no data center but they do have some kind of COLO and customer does not want to manage. An example of that is the media company where they do content creation or video games, those workloads need

single-digit millisecond latency, a new challenge indeed to accommodate with to exist in specific geographic area for the customer. The good news is, it is resolved, with an innovative significant solution, Amazon "AWS Local Zones", a new type of public cloud provider infrastructure that places compute, storage, database and more services close to large cities.

Another different situation when the application is running on the cloud will be utilizing public cloud native services, however, there are some workloads could be moved to the cloud but need to run the same way running on-premise, workloads are running non-cloud native platform such as VMware. This could be stalling the digital transformation to the cloud. A new mechanism was invented to help with that such as the partnership between VMware and public cloud providers, AWS, GCP, and Azure, that allow customers to use the same software and tools they have used to manage their infrastructure via VMware on-premise but also to use it to manage their infrastructure in the public cloud and seamlessly migrate workloads from the on-premise to the Cloud (See Figure 12).

Figure 12:VMware Cloud

The public cloud infrastructure is the most secure, extensive, and reliable cloud computing environment anywhere, on and off the planet. Whether the customer needs to deploy the application's workloads across the globe in a single click, or the customer wants to build and deploy specific applications closer to end-users with single-digit millisecond latency, public cloud provides the cloud infrastructure where and when the customer needs it.

V. MEDIA SERVICES

Iridium Communications announced a partnership with Amazon AWS to develop a satellite-based network called CloudConnect for Internet of Things (IoT) applications. [3]. As much Amazon AWS has gained by bringing the rest of the world within reach of AWS and making tremendous profit, the stock shares of Iridium went up 7.1 % in trading, hitting an all-time high. AWS will let customers rent access to the satellite ground stations this is the same manner that they lease access to their compute data centers. AWS said that companies that have not traditionally had the financial resources to build and operate their own satellite transmission infrastructure will be able to get access to satellite services on demand. This is basically building Headend for video digitization processing everywhere available to customers utilizing their own network to transport it anywhere around the globe (See Figure 13).

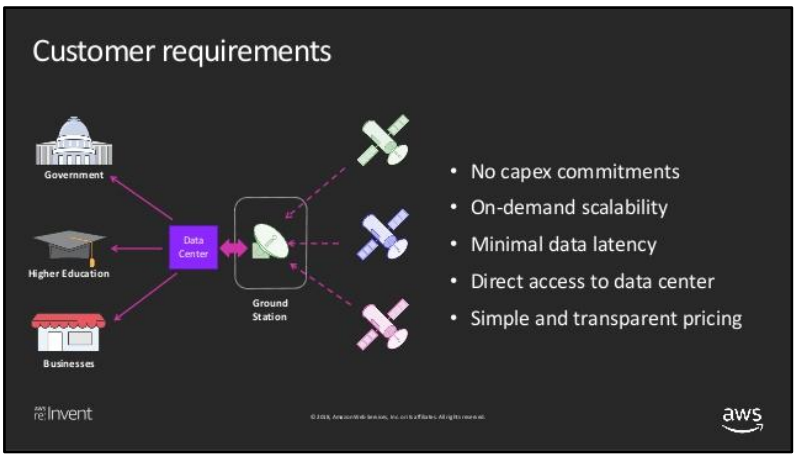

Figure 13: Amazon AWS Ground Stations

For Amazon AWS, it truly looks like that the space is the new frontier in their journey for global domination. AWS Ground Station has the capacity to reduce the processing time from one hour to less than a minute. During the test phase, it was found that in exact 55 seconds, data could be sent from a satellite to Amazon Ground Station, which is nothing short of a breakthrough given that normally downlinking a satellite image and getting it into the cloud takes around 60 minutes. Amazon Ground Station can be called Amazon Cloud customized for satellites, and the analogy holds true. Just like with the advent of Amazon Cloud, companies no longer needed their own mega cloud servers and data centers but what they can do, is renting space on the Amazon Cloud. Similarly, AWS Ground Station satellite companies can rent a slot on demand and pay only for the service they want [4].

The Ground Station would be fully operated, managed, and supervised by Amazon and its technical teams. Companies will not even have to build their own antennas or worry about technical glitches, as it would be handled by Amazon. This would not only save time, money, and efforts but would also provide greater liberty to the company to focus only on its core projects (See Figure 14) [5].

Figure 14:Global AWS Ground Stations

Another milestone toward the future has been reached, a strategic partnership between NFL and Amazon AWS is a representation of what you can do with computer vision and machine learning algorithms enabling building a virtual digital athlete which is really like a digital twin of each athlete. We will be able to know what does it look like when they are healthy and compare that when it looks like they may not be healthy, also we will be able to simulate all kinds of different combinations of player hits and angles and different plays so that injuries could be predicted and with the help of the right equipment, problems could be avoided. Because NFL could lose even more players to lower extremity injuries, so predicting those injuries can have an effect on rules and equipment they use, it is a huge game changer when we look at the next 10 to 20 years (See Figure 15).

Figure 15:Public Cloud and NFL - Reducing Head Injuries

VI. MOBILITY

The next communication evolution is mobile applications and 5G and with more mobile and connected devices all over the world that have to be connected, the demand arises for a single digit millisecond latency. Moreover, mobile applications and 5G go along with Big Data, Machine Learning (ML), Deep Learning (DL),

IoT and soon with quantum computing. Public cloud providers are conquering this territory full speed today in particular 5G which is a transformative technology that is going to transform consumer behavior and businesses and ultimately it is going to transform society.

This technology needs fiber, frequency spectrum, Software Defined Networking (SDN), and to bring the processing out to the edge, all that need a lot of real estate at the edge in a form of mobile edge compute for 5G where machine learning at the edge, autonomous industrial equipment, smart cars, smart cities, and augmented and virtual reality they cannot afford and do not want that long round-trip communication back and forth.

Amazon AWS is taking the lead by offering their new service for mobility and more "AWS Wavelength" which allows customers to build applications that deliver single-digit millisecond latency to mobile and connected devices. With AWS compute and storage embedded at the edge, virtualizing network all the way from the radio to the packet core and then bring in AWS Wavelength there with low latency and massive throughput are the excellent ingredients for 5G. As a result, AWS and Verizon have started a collaboration partnership for the efforts on this path, bringing the unlimited resource capabilities of public cloud provider at the 5G city aggregation. Other companies such as KDDI, SK Telecom, Vodafone are joining this effort as well soon (See Figure 16).

Figure 16: Public Cloud and 5G

Public cloud providers mission is giving the customer, the tools to increase your knowledge, success, health, and happiness by serving billions of users across the world, creating things that improve people's life, that empower individuals, and benefit society as a whole. Google GCP believes their mission is to organize the world's information and make it universally accessible and useful, and this approach is constantly evolving. Google is helping the user to write emails faster with automatic solutions from "Smart Reply", helping the user to find the fastest route and backing up the precious picture's moments automatically, etc.

Utilizing mobile devices' resources is something Google is focusing on, search engine for example not only txt anymore, simply pointing your camera at something and the search engine make all information available in the palm of your hands without typing, indexing the physical world, billions of places and products and so on much like search indexes the billions of pages on the web. Also, simply pointing your camera at the menu at a restaurant, Google Lens automatically highlights the popular dishes, and from there it links it to the number of calories, customer review, other places offering same meal and prices, and pointing the camera again at the receipt, it calculates the tip and even split the total if needed, all in real time. Pointing the camera at a sign, it can read it and translate it vocally and visually to another language (See Figure 17).

Figure 17: Google GCP Mobile Intelligence

With computer vision and augmented reality, that camera in our hands is turning into a powerful visual tool to help understand the world around us, adding a new dimension to your search using the camera, decoupling the research results from the conventional page and overlaying it a life camera motion of the mobile devices, bringing a result motions search with your location background and present it to audiences improve learning curve and the reality of the subject. Shopping for a new pair of shoes, yesterday you could see 360 look, but today you could from a mobile device camera overlay it with the rest of your clothes to see if it fits. It's one thing to read about something but to see it in front of you at scale is jumping to the future. Bringing the camera and AR capabilities to the search results is beyond amazing, you can even bring John F. Kennedy with his famous moon speech life in 2020 at NFL Cowboys stadium.

VII. ARTIFICIAL INTELLIGENCE

Public cloud providers believe that machine learning continues to evolve and tend to classify three macro layers of the stack of machine learning, the bottom layer is for expert machine learning practitioners who are very comfortable at the framework level and this group deals with the three primary frameworks, PyTorch, MXNnet, and TensorFlow which has the most residents in the largest community today.

Artificial Intelligence (AI) off the bat means Machine Learning and Deep Learning, it is not easy to buy nor to operate on company's expenses especially if the customer doing a lot of machine learning at scale and in production. The good news is", AWS were working for a quiet a time on an inference optimized chip called "Inferential", and on December, 2019, Amazon AWS announced the launch of "Inf1" instances for EC2 backed by new AWS Inferentia chip, custom designed by AWS's high performance machine learning inference chip, 3x times higher throughput, 40% lower cost per instance, low latency, integrated with all the major framework, TensorFlow, MXNet, and Pytorch since 90% of data scientists use multiple frameworks, in addition it will be made available for microservices early 2020 as well.

Public cloud providers did not stop there by the hardware and resources when it comes to Artificial Intelligence, they have invented new software tools within this path as well. Amazon AWS new service called "SageMaker" provides the developers and data scientists with the build, train, tune, and deploy machine learning models and amazing to know that tens of thousands of customers are now standardizing on top of SageMaker such as, AVIS, Chick-fil-A, Dow Jones, GE, Liberty Mutual, Panasonic, and Siemens. Most importantly, SageMaker provides hundreds of algorithms from others to use in your machine learning aided with reinforcement learning.

"SageMaker Studio" is also another step forward, it is the first fully integrated development environment for machine learning, it is a web-based IDE which allows you to store and collect all the things you need whether its code or notebooks or datasets for settings or project folders all in one place with one pane of glass and makes it much easier to actually manage all those pieces in building a model.

Public cloud providers truly are the pioneers when it comes to support the bottom layer of the stack which is for expert machine learning practitioners, but also with SageMaker and SageMaker Studio supporting the middle layer of the stack for everyday developers and data scientists, that is making a giant leap in AI. The top layer of the stack called "AI services", because the services most closely mimic human cognition, public cloud providers have made a broad array of services available to the customers to close the gap on AI stack support. As explained, it is an intense work into the artificial intelligence, makes public cloud providers also enthusiastic about virtual reality and robotics and amount of functions that are going to be done by these robots, robotic applications are much more expansive than people realize.

On the other hand, in order to process speech today, we rely on complex algorithms that include multiple machine learning models from mapping incoming sound bites into phonetic units to assembling into words and then predicting the likelihood of these words in a sequence, so complex operations that requires 100 gigabytes of storage and a network connection and at the end bringing these models to your phone as putting the power of a Google datacenter in the user's pocket. The story has just begun, with further advances in deep learning allowed to combine and shrink the 100-gigabyte models down to half a gigabyte, small enough to bring it onto a mobile device, this eliminates network latency and makes the smart apps such as Google Assistant so much faster since it is running on the mobile device itself, it can process and understand requests in real time, and deliver the answers up to 10 times faster. Eventually word "Hey" used currently with Siri, Google or word "Alexa" is slowing down the progress, so it will be eliminated and substituted with more intelligence humanized algorithms.

Text-to-speech, computer vision, the power of translate, and decades of language understanding from search all coming together. all of these technologies with AI capabilities are just over 100 kilobytes not on the cloud but on the mobile phones that cost as little as $35. Helpfulness is also about saving time and making your day a little bit easier, Duplex technology enables Google Assistant to make restaurant reservations on your behalf by actually placing a call, it is available in almost 50 states across the USA with a great feedback not only from users, but from businesses as well [6].

By moving these powerful AI models right onto your phone, they are envisioning a paradigm shift will let you instantly complete complex actions, all with nearly zero latency and even work offline. This technology is called Federated Learning, this is a new approach to machine learning developed by Google, it allows Google's AI products to work better for the user, work better for everyone without collecting raw data from the user devices. Instead of sending data to the cloud, Google has flipped the model, they ship machine learning models directly to the user device. Each phone computes an update to the global model and only those updates, not the data, is securely uploaded and aggregated in large batches to improve the global model, and then the updated global model is sent back to everyone's device. Using Federated Learning improves next word prediction, as well as emoji prediction, across tens of millions of devices and in fact, it does not need to be connected to the internet at all, it could be done in airplane mode (See Figure 18).

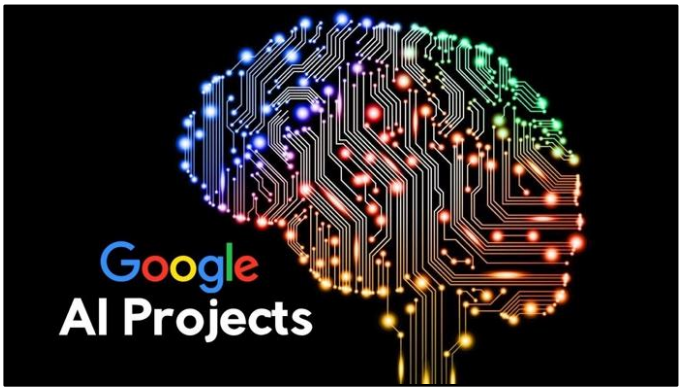

Figure 18: Google AI

VIII. MULTI-CLOUD

One of the most exciting topics for all cloud providers are the support for multi-cloud/multi-edge. Azure Arc support that approach by manage data services to be anywhere the compute is, it fundamentally redefines Hybrid, bringing Azure innovation to customer datacenter, and virtually anywhere. Azure Arc unifies operations, enabling consistency and agility across all of datacenters, the true innovation of empowering customers to achieve more across on-premises, multi-cloud at the infrastructure, and data services layer (See Figure 19).

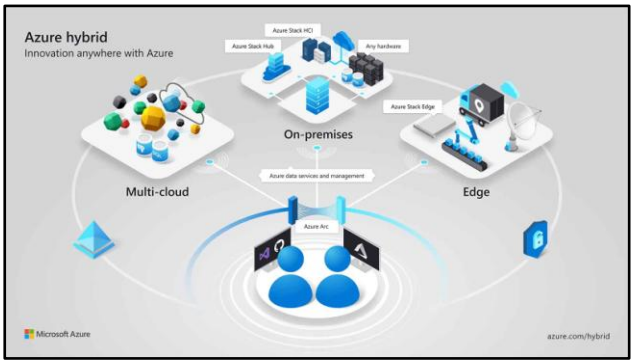

Figure 19:Microsoft Azure Arc

Financial wise, the multi-cloud model works very well for large-scale enterprises because they have the budget, resources and the expertise to work on each cloud technology to produce a profit. However, in the case of medium to small-scale businesses, they need the same agility and advantages of multi-cloud architecture but they cannot afford the cost associated with it. A new strategy is born that resolved this issue, called Virtual Cloud [7].

VMware cloud foundation (VCF) is the platform for virtual cloud this is how we provide consistent infrastructure and operations, this is the cornerstone for on-premise data center, public cloud, and edge as well. VMware cloud foundation combines that with a complete lifecycle management, test, and validation on a broad set of use cases.

VMware multi-cloud strategy with partnership with Amazon AWS, Google GCP, Microsoft Azure, enabling on any cloud environment where you can build, run, manage, connect, and protect across that environment. VMware has taken the challenge further and beyond virtual machines platform on multiple cloud, they tapped into managing microservices (containers and orchestration kubernetes) from one single pane of

glass, the VMware product is called VMware "Tanzu Mission Control" the one product enterprises will use to manage their kubernetes clusters enterprise-grade providing the control and visibility necessary for production at scale deployments across multiple teams, multiple clouds, multiple clusters, it can manage all the customer's kubernetes clusters no matter where they are, including and not limited to vSphere PKS, native microservices of AWS EKS, Azure AKS, and Google GKE (See Figure 20).

Figure 20:VMware Tanzu Mission Control

Tanzu Mission Control brings developers and operators close together with one platform operators can provision clusters directly from Mission Control and then they can set policy across things like access, backup, security and more meanwhile developers get the freedom to innovate to do their best work within the guardrails set up by those operators they get API's self-service in a simpler way to collaborate.

IX. QUANTUM COMPUTING AND STORAGE

Quantum computing requires intense hardware work including new material science and extreme temperatures, the quantum computing processor itself has to run in few Millikelvin as shown in Figure 21, it is literally the coldest place in the universe, even the deep space is actually warmer, it is 7 degrees Kelvin. It is cooled by liquid Helium to control that quantum processor, however the memory RAM operates at 77 degrees, and it cannot operate in these temperatures with quantum computing processor, so it is cooled with liquid Nitrogen [8].

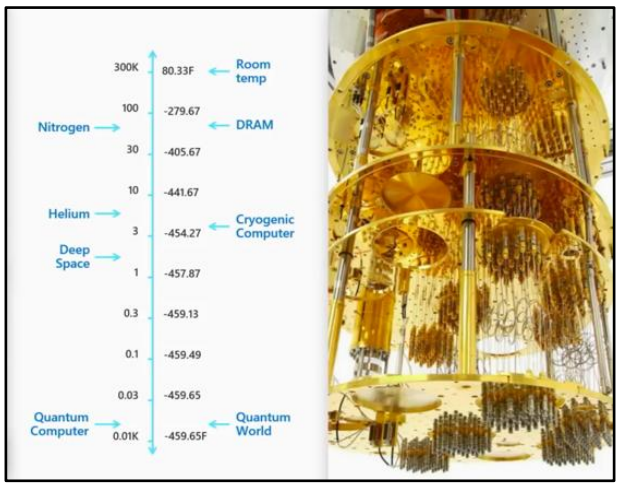

Figure 21: Quantum Computing

Quantum storage is the vision of the future storage. 5D, the fifth dimension, the humanity's new way to store information in almost just as little space, by reading information based on bending of light inside the glass, the smaller and more robust information storage devices get, the more likely we will be able to store every millisecond of our life. Microsoft Azure with university of South Hampton and Wells are exploring storing data in glass. The super high density is a terabyte today in the size of a DVD and projected to get to 360 terabytes in the size of a CD platter. Conceiving an extra dimension of digital information that a glass disk stores

information so densely that it retains three thousand times the information of a normal CD, it can last 13.8 Billion years which is the age of the universe and 3x the age of planet Earth, and sustain the blistering heat of a 1000 degrees Celsius (See Figure 22).

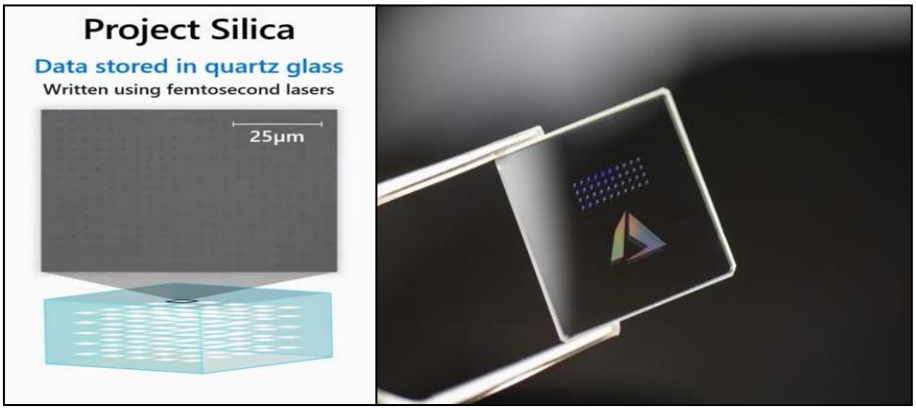

Figure 22:Quantum Storage

Public cloud providers are so optimistic about Quantum Computing and Quantum Storage and investing in them even though it may take few years before it iss really broadly useful.

X. CONCLUSION

"Change that's happening with the move to the cloud is the most titanic shift that we've seen in technology in our lifetimes", Amazon AWS CEO, Andy Jassy. So, you as an organization or a company have given a choice, either dip your toe in the water for long periods of time while the transformations that radically change industries are happening then you find yourself at the tail end of a big shift and suddenly way behind, or you take a bold step toward the future. The technology-business history has proved that companies that did not adjust to big technical transformations, were left in the dust. Cloud transformation is the logical choice, it is an approach to innovation that grow the business, totally reinvent the customer experience, build things that were never possible before and it starts with senior leaders who want to take that leap forward and try something different, organizing the data differently, organizing the team differently, and using machine learning.

Public cloud environment becomes the norm and is growing fast by the day, it is hosting every imaginable business. In financial services with Capital One, Goldman Sachs, HSBC. In life sciences and healthcare with Pfizer, Johnson & Johnson. In manufacturing with GE, Siemens, and Philips. In energy with Shell and BP. In the public sector with government agencies and academic institutions worldwide. In transportation with Lyft and Uber. In exercise with Peloton that has changed the way that we exercise. And even in food delivery with DoorDash, Grubhub, and Postmates.

So very broad adoption to the cloud by organizations had taken this journey and business has grown did not go alone and have done it on their own. Cloud providers were there every step away and they are in this business for decades, they have a wealth of knowledge and expertise because there is no compression algorithm for experience.

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