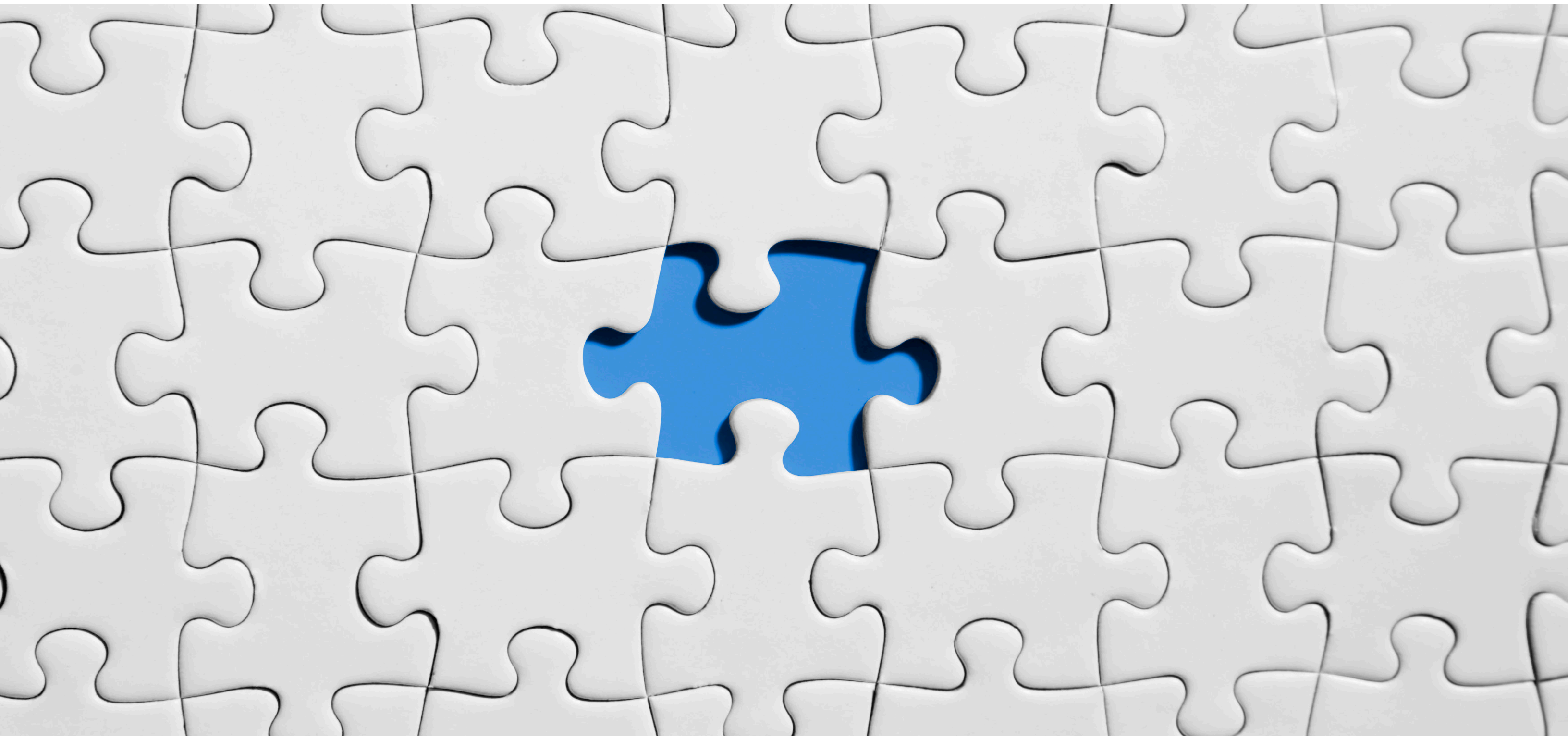
DELL Technologies

EVOLUTION OF 5G & ENGINEERING SLA FOR SCALABLE XAAS



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Introduction

Fifth generation mobile technology is known as 5G. Improvements in communication networks right from first generation 1G to 2G and from 3G to 5G has revolutionized the way wireless networks and operations are handled in every sphere of human life. Our social life has been completely transformed with each stage evolution of the networks. 5G networks, well known for very high-speed data packets at almost 1gigbit per second, enable cost-effective broadband wireless connectivity and is redefining the way future internet and tactile networks will be operated. Fifth generation technology solves the critical requirement of speed to deliver Xaas (Anything as a Service) through wireless access points for customers. The 5G mobile network allows the end-user not only to connect multiple wireless technologies but also switch between them at the same time. IPv6 and flat IP are well supported by 5G technology. This enables autonomous systems like drones for food delivery and support to electronic transactions services amongst machines. 5G will also open doors for next-generation artificial intelligence (AI) applications supporting Big Data and virtual reality in real-time. Resources can be elastically scaled in edge, fog and cloud by running deterministic algorithms based on proximity and available zones for mission critical latency-sensitive applications in all walks of life.

The main use-case was voice delivery, when mobile networks were initially designed and built for 1G and 2G networks. The development of the PSTN (public switched telephone network) based on analog to 3G resembles the fact of it. Packet-based data carried over circuit-switched networks was introduced to enable data services in 2.5G and later 3G networks. The main bottleneck for TCP/IP that caused 2.5G and 3G to behave poorly was its nascent connectivity with RF (Radio Frequency) links which suffered from fading, multi-path effects and retransmissions common in predominant internet protocol.

All IP network-driven data services have been achieved by 4G. The fourth-generation network has been optimized for high bandwidth streaming video. However, there are certain challenges on packet throughput performance and operation of the air-interface. Although data rates on Long Term Evolution (LTE) appear to be close to wired connections there is high latency that plummets the throughput altogether;

Table 1 compares generations of mobile networks in terms of data bandwidth, multiplexing, switching and core network.

1. In 1980s, the First Generation (1G) 1G emerged in Analog systems and was popularly known as cellphones. All voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties; In addition, 1G has poor voice links along with low-capacity and unreliable handoff with almost zero security. Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT) along with Frequency-Division Multiple Access (FDMA) which is used for voice modulation on analog radio signal which has a frequency 150 MHz were introduced in 1G.
2. Second Generation 2G emerged in late 1980s; For voice transmission at the speed of 64Kbps the digital signals were introduced, and it used 30 to 200 KHz frequency and provided SMS (Short Message Service). At the data-rate of 144kbps GPRS, CDMA were introduced in 2.5G systems along with circuit switched and packet switched domain solutions.
3. Wide Brand Wireless Network was introduced in 3G network, it increased clarity compared to 1G,2G and 2.5G altogether. Voice calls are interpreted through Circuit Switching and Data are

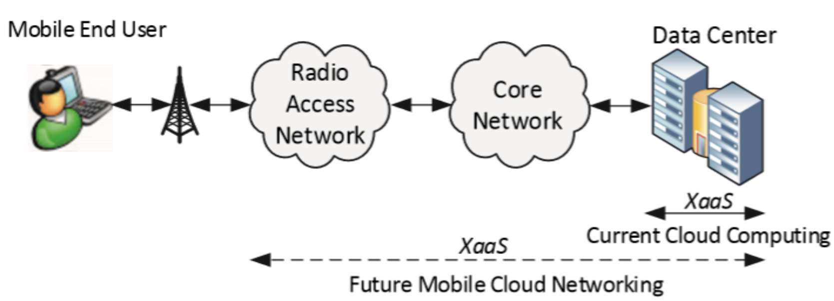
sent through the technology called Packet Switching. 3G is used for High-speed internet service, video chatting and it operates at a range of 2100MHz and has a bandwidth of 15-20MHz.
3G uses Wide Band Voice Channel which brought death to the distance and turned the world to global village by now a person can not only send messages with other person located in any part of the world but also contact other with live streaming-video on Skype, Zoom and WebEx.

4. A downloading speed of 100Mbps is offered in Fourth Generation(4G) 4G cellular networks. Although 3G provides same features as 4G, additional services like streaming video and Watch TV programs with more clarity and one can send data much faster rate than previous generations. In addition, the QoS and rate requirements were set by the industries in ICN/CCN solution vendors like Google GCN, Cisco, Netflix and Akamai who predominantly support applications like wireless broadband access, Digital Video Broadcasting (DVB). LTE (Long Term Evolution) is a part of 4G technology.

Table 1: Comparison of Generations.

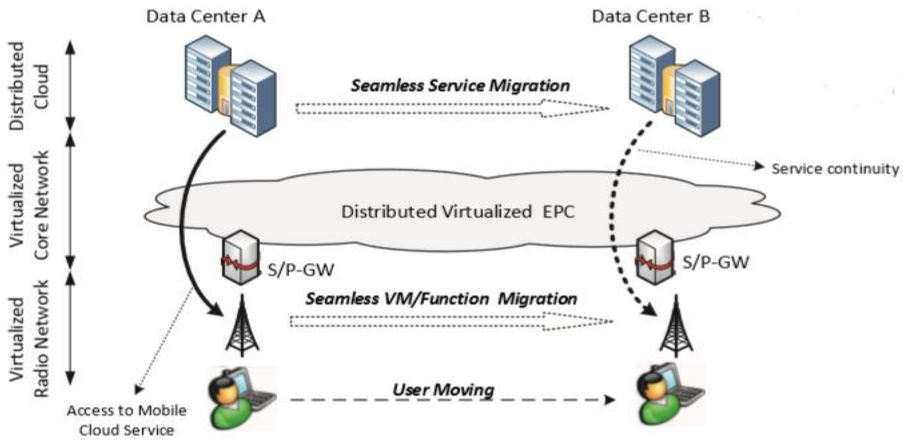
Contents	1G	2G	3G	4G	5G
START	1970	1990	2004	NOW	2020
DATA BW	2kbps	64kb ps	2Mbp s	1Gbps	>1Gpbs
MULTIP LEX	FDM A	TDM A	CDM A	CDMA	CDMA
SWITHC ING	CIRC UIT	CIR UIT	PACK ET	ALL PACKE T	ALL PACKE T
CORE NETWO RK	PSTN	PST N	PACK ET N/W	INTER NET	INTER NET

Reference:



A view of future LTE mobile cellular network

LTE brings in the concept of service continuity most commonly used in cellular networks. An on-going service should not be dropped or lose connectivity when a mobile user is moving from one network to another. The evolution of services hosted on Virtual Machines (VMs) that can be moved and migrated across multiple networks is achieved through cloud-based (virtualized) LTE systems in order to improve the quality of service (QoS) and user experiences to mobile users. It must happen in such a way that the disruption of an on-going service is minimized during the migration of VM and the services running on such VM.

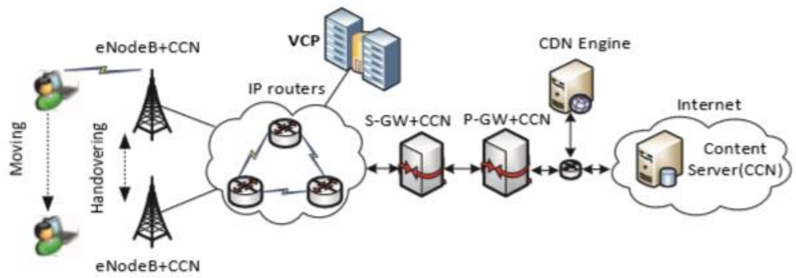


Service continuity in the virtualized LTE system

ICN/CCN (Information Centric Networking / Content Centric Networking) technology vendors and Online Gaming operators are looking out for technologies that can support live VM migrations without effecting user experience on mobile devices.

Solutions / Approaches	IP Address Continuity	Session Continuity	Content Continuity	Storage Continuity	Function Continuity
ICN	S	S	S	S	S
M-CDN	S	S	S	S	NS
SDN	S	S	S	S	S
HIP	S	NS	NS	NS	NS
SCTP	S	NS	NS	NS	NS
PMIPv6	S	NS	NS	NS	NS
ILNP	S	NS	NS	NS	NS

Voice traffic is simply another data service in LTE. There are certain complex challenges attached to traffic associated with voice service specifically on-air interface modulation types. Specifically, partitioning network traffic into low-latency forwarding schemes to segregate data traffic and to take evasive action during the time when RF quality drops below given thresholds by proactively monitoring radio performance**.** In addition, LTE requires deployment of dedicated core networks optimized for voice traffic models.



Integrating ICN/CCN in LTE system.

This forced operators to deploy 4G networks for data and continue to leverage existing 2G/3G networks for delivery of voice service. The under-utilized networks have given rise to Internet of Things (IoT) services and sensing networks for next generation internet services for consumers and business alike.

5G new demands

It took almost four years for ITU to establish and publish requirements of base-5G requirements. It would take two more years to complete the 5G Core standards. 3GPP (Third Generation Partnership Program) provided formal System Architecture in June 2017 with the latest versions of 23.501 and 23.502. For wireless and mobile network interoperability, the 5G mobile systems model is an all-IP based model. AIPN (All-IP Network) is a common platform for all radio access technologies. The AIPN is capable of fulfilling increasing demands of the cellular communications market with optimized performance and cost though continuous evolution in packet switching.

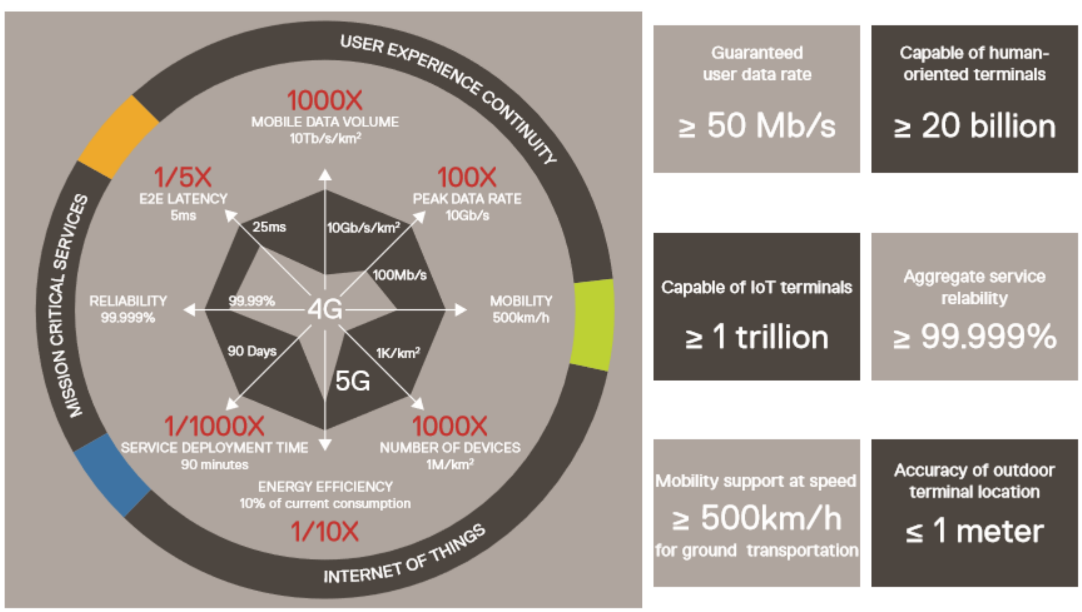


Figure 1: New Service Characteristics & Capabilities Enabled By 5G

There are several independent, autonomous radio access technologies (RAT) which play a crucial role in the new architecture of 5G. Cloud Computing Resources (CCR) augment 5G architecture. Figure 2 depicts the shift in Mobile Architecture and Value Chain. Cloud computing economics ensures convenient on-demand network access to configurable computing resources.

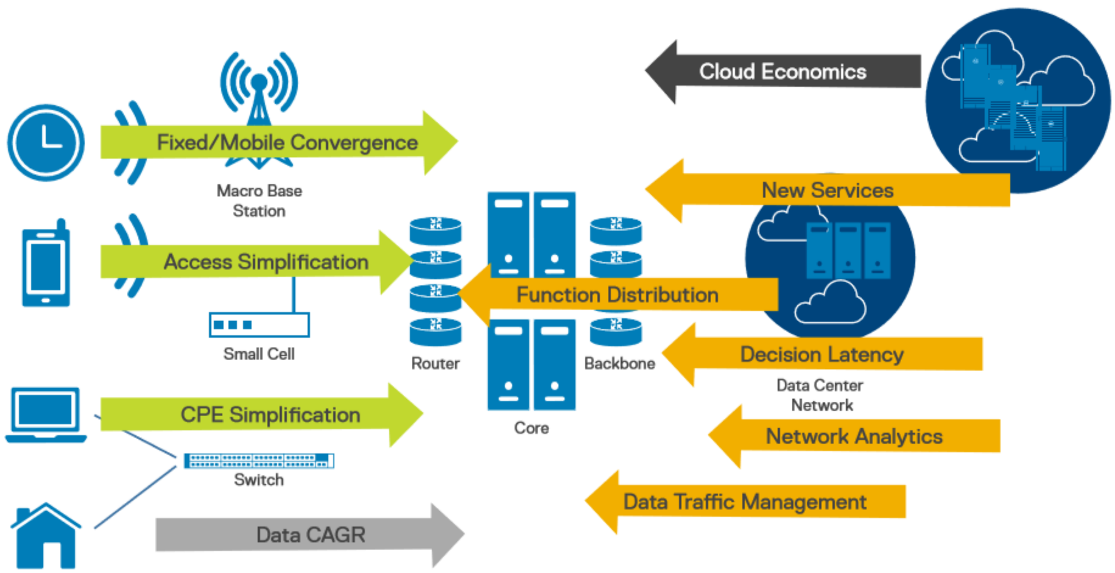


Figure 2: Shifts in the Mobile Architecture(s) and Value Chain

Allowing consumers to use applications without installation and providing ability to access their personal data from any computer with internet access is known as Cloud Computing. As shown in Figure 3 and Figure 4, to be able to deploy new processing and/or storage solutions around the network – not currently possible in 3G and 4G solutions. 5G will ensure to make this possible by not only introducing new technologies in packet-core, access and RF, but also by enabling some of the existing solutions to be re-worked into more dynamic, flexible deployments.

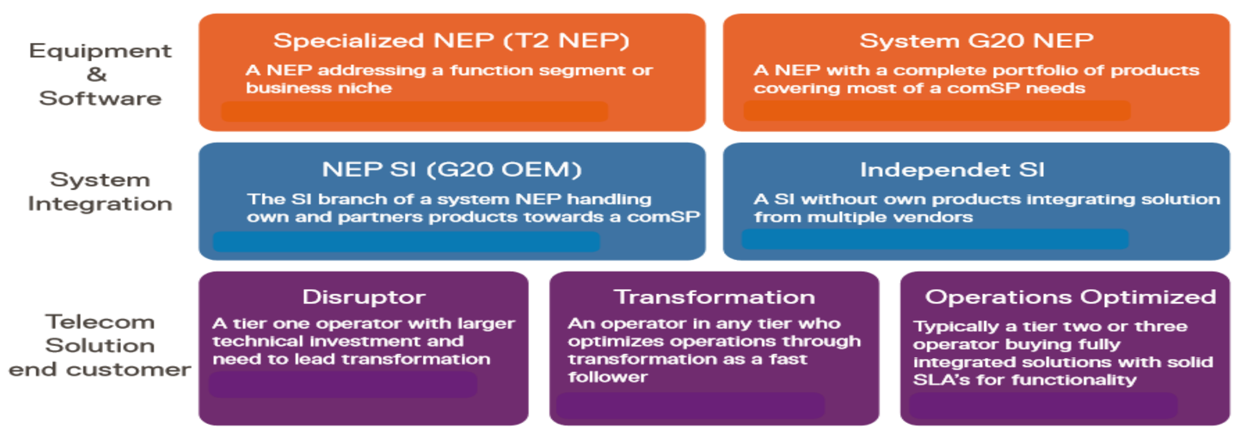


Figure 3: Shifting Roles Across the Mobile Supply Chain

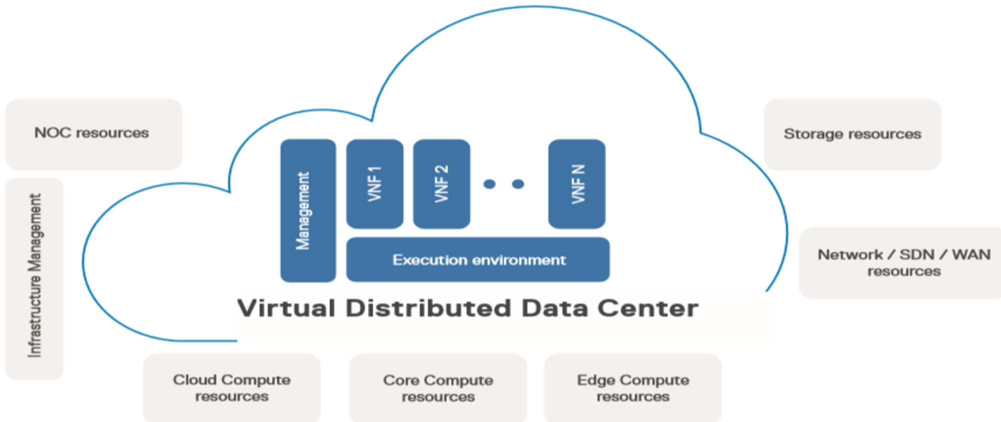


Figure 4: The Emergence of a New Mobile Cloud Blueprint

CCR are linked to Reconfigurable Multi Technology Core (RMTC) to Reconfiguration Data models (RDM) which are attached to remote reconfiguration data from RRD. Convergence of radio, cloud computing and nanotechnology are based on an All-IP Platform. Depending on the status of the network and/or user demands, communication functions are changed in the core. Several radio access technologies ranging from 2G/GERAN to 3G/UTRAN and 4G/EUTRAN on top of 802.11x WLAN and 802.16x WMAN are connected to RMTC. Other standards such as IS/95, EV- DO, CDMA2000, etc. are enabled through it. Interoperable process-criteria and mechanisms enable RMTC to choose from heterogeneous access systems.

Quality of Service

Controlling and managing network resources by setting priorities for specific types of data (video, audio, files) on the network are involved in Quality of Service (QoS). Functionalities of data transport to support latency, error rate and uptime to control transport is involved in Next Generation Network Services. QoS is exclusively applied to network traffic generated for video-on-demand, streaming media, video IP, videoconferencing and online gaming. Supporting low latency and improving loss characteristics are primary goals of QoS which is supposed to provide priority in network performance which includes dedicated bandwidth and controlled jitter. Future business applications in campus involves technologies that supply the elemental building blocks such as wide area networks (WAN) and service provider networks. There are three fundamental components for basic QoS implementation:

1) Coordinating QoS from end to end between network elements and service providers by identifying and matchmaking techniques using service brokers.
2) QoS within a single and heterogenous network using service level objectives (SLO) amongst the providers in Edge, Fog, Core and Cloud.
3) Accounting functions to control and administer end-to-end traffic across a network by maintaining QoS policy, management and IoT.

Why so much of excitement about 5G?

Low cost-per-bit along with very high speed, and high capacity achieved though 5G excites industries across the verticals on the speed, coverage, and responsiveness of wireless networks is driving new use cases such as social gaming, virtual and augmented reality (VR and AR), robotics, automated vehicles, advanced manufacturing, healthcare imaging, interactive television, high-definition and 3D video. Global access and service portability are offered by 5G technology. As shown in Figure 5, because it can handle high error tolerance it can offer high-quality services. By supporting almost 65,000 connections at a time, 5G can achieve broadcasting capacity up to Gigabit. Next Generation applications on future internet in combination with AI that are surrounded by artificial sensors communicating with mobile phones to save human life is no longer science fiction. 5G technology enables remote health management so that users can get better and faster solutions.

Downloading and uploading speed of 5G technology is very high.

- Bi-directional large bandwidth is offered to cell phone users through 5G technology.
- With unparalleled consistency, transporter class gateway is offered through 5G.

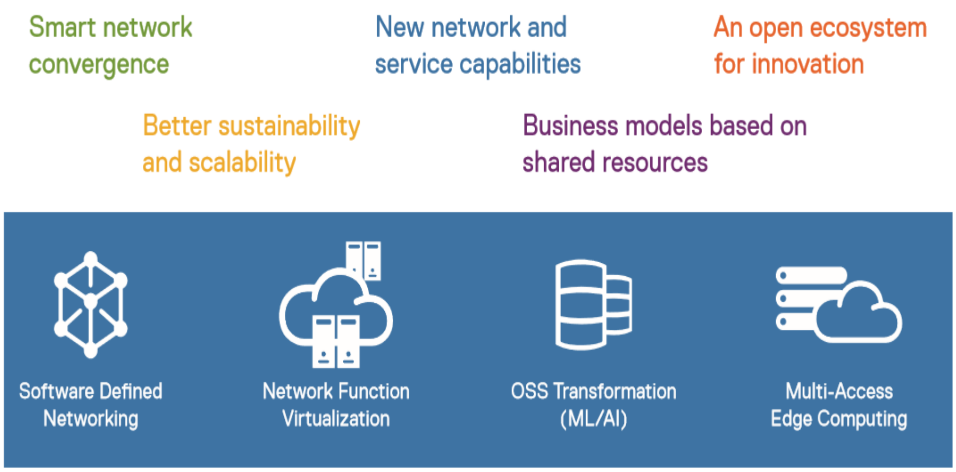
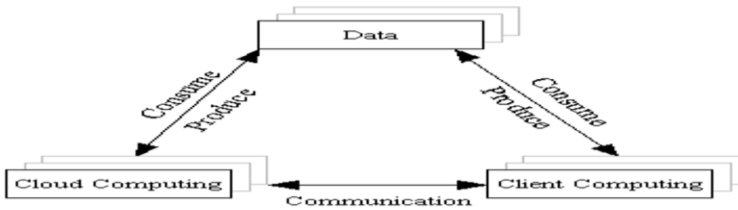


Figure 5: Technology Transformation Domains

Development of wireless networks and mobile cellular devices is moving toward an all-IP principle and higher data rates. With each passing year more processing power, higher memory on board, and longer battery life for the same applications is supported through Mobile terminals. The latest technologies such as cognitive radio, SDR, nanotechnology, and cloud computing is based on an All-IP Platform enabled through 5G. The future generation of mobile networks with implementation of 5G will keep the network as simple as possible, giving more functionalities to the end nodes while maintaining the initial Internet philosophy.

Dealing with Engineering Service Level Agreements for 5G at Edge, Core and Cloud

Internet Computing of Next Generation (5G) accommodates 10X faster data transfer than traditional 3G and 4G networks and it is expected to impact mobile network and associated ecosystems. Hence ensuring service quality and guarantees is important for Network functions and Network Services. Service level agreements can be used to ensure Network Services are provided in efficient manner.

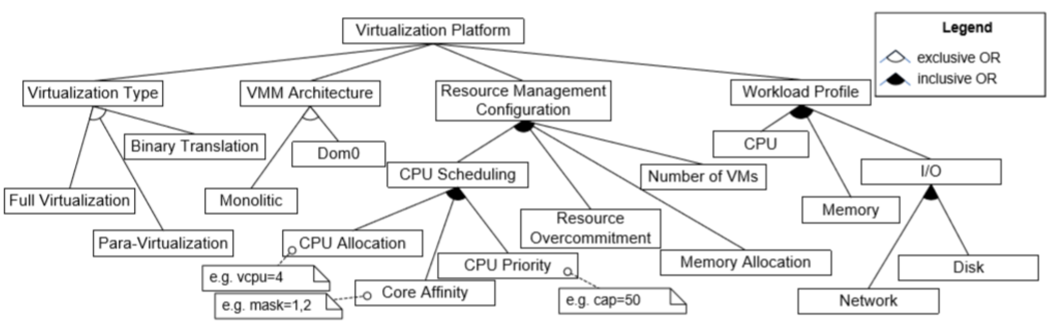


The triangle model of next-generation Internet Computing.

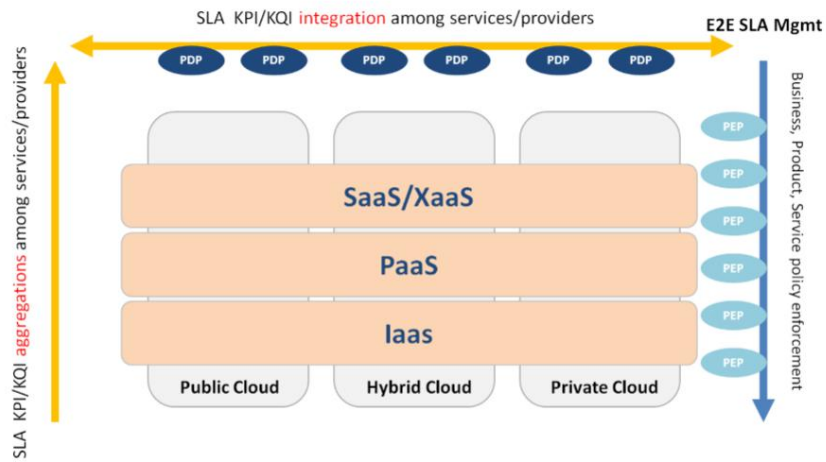
The SLO (Service Level Objectives) are a superset of SLA (Service Level Agreements) between Service Provider, Service Consumer and Service Broker. There are several projects funded by the EU and Telcom industry to enable end-to-end SLA management with respect to cloud, core and fog computing which can be taken as our reference guide to maintain SLO with key performance indicators for scalability and key quality identifiers for reliability as shown in the below figure for Iaas, PaaS, SaaS and Xaas (the delivery of anything as a service through internet, in general).

Virtualization Overview

Virtualization applies across the cloud computing industry and telecom industry alike for storage, compute and network.



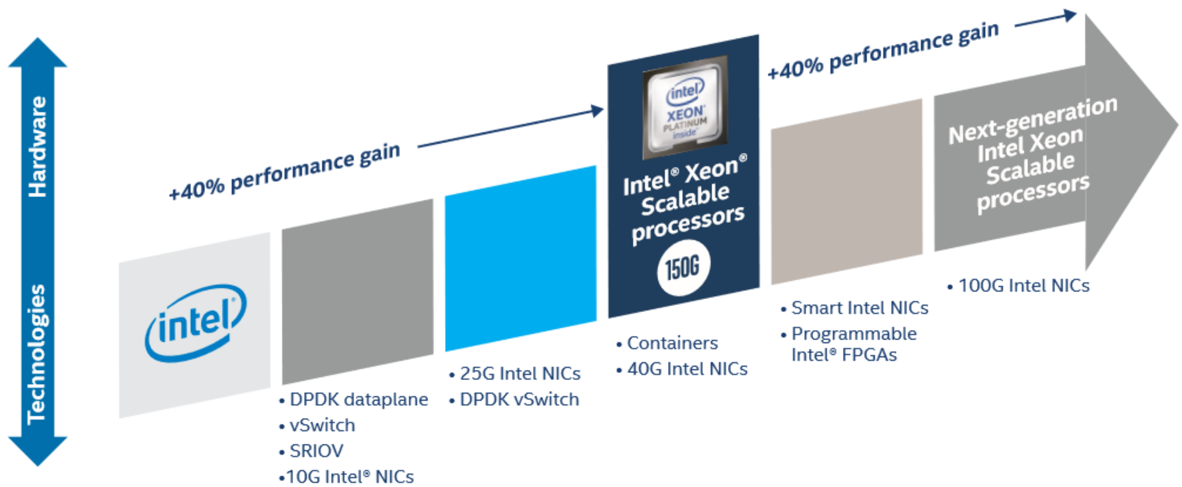
Major performance-influencing factors of virtualization platforms.



SLA Continuum for the Cloud Ecosystem

Moving from SOA to ROA Architectures

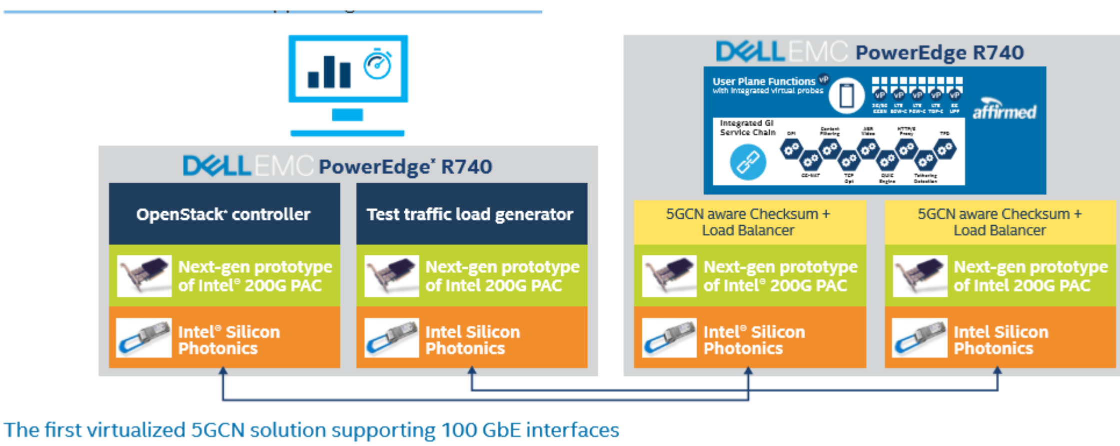
- Introduction of REST and state transfer of Resources on Cloud/ On-Premise/ On-Fog for Serverless Computing.
- Provisioning, Decommissioning Resources made easy on Heterogenous Clouds, Cloudlets and Fog Computing Servers and Micro Data Centers.
- Moving from QoD (Quality of Data) to QoS; Service offering based on SLA amongst different stakeholders for data, storage and network in a distributed environment.



Intel, Dell EMC, and Affirmed Networks are delivering high performance and low cost per bit[2]

The first cloud-native solution supporting 100 GbE interfaces (shown below) was developed in collaboration with Intel, Dell EMC, and Affirmed Networks for 5GCN/EPC. This solution pushes boundaries and presents true 100 Gbps/CPU socket using a single Intel Network Interface Card (NIC).

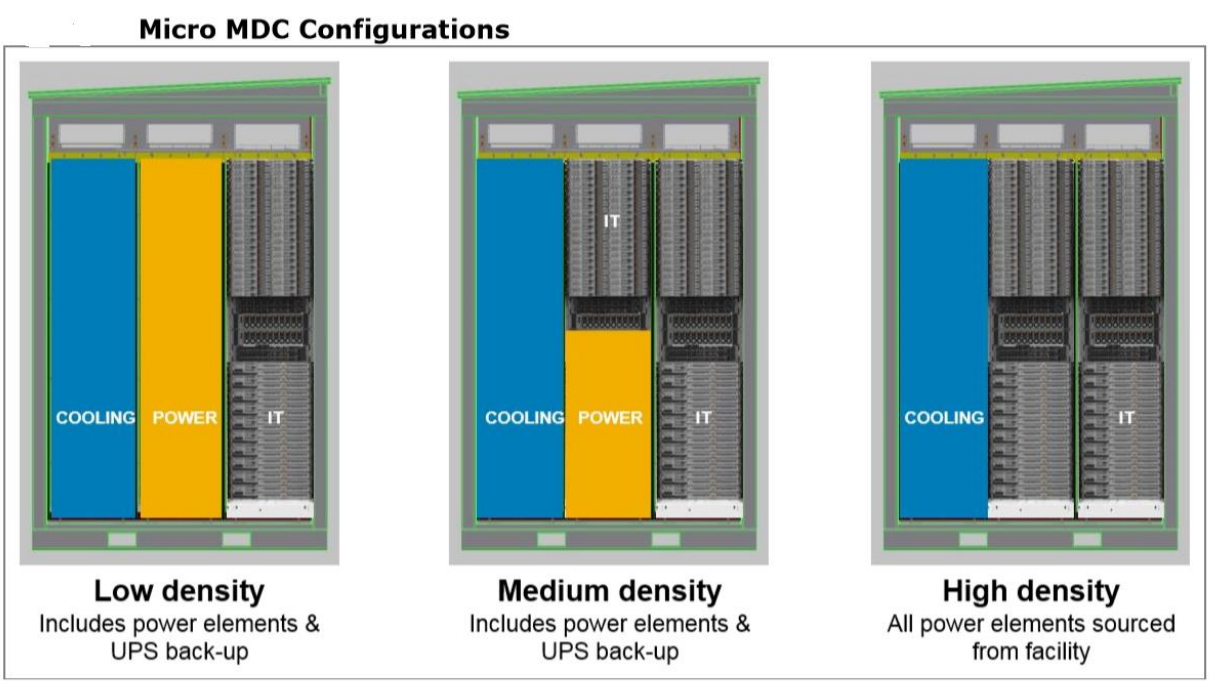
Note: The interface is running on a Dell EMC PowerEdge* R740 server powered by Intel Xeon Scalable processors and realized in a 5G data plane UPF from Affirmed Networks.



White Paper: Intel, Dell EMC, and Affirmed Networks are delivering high performance and low cost per bit

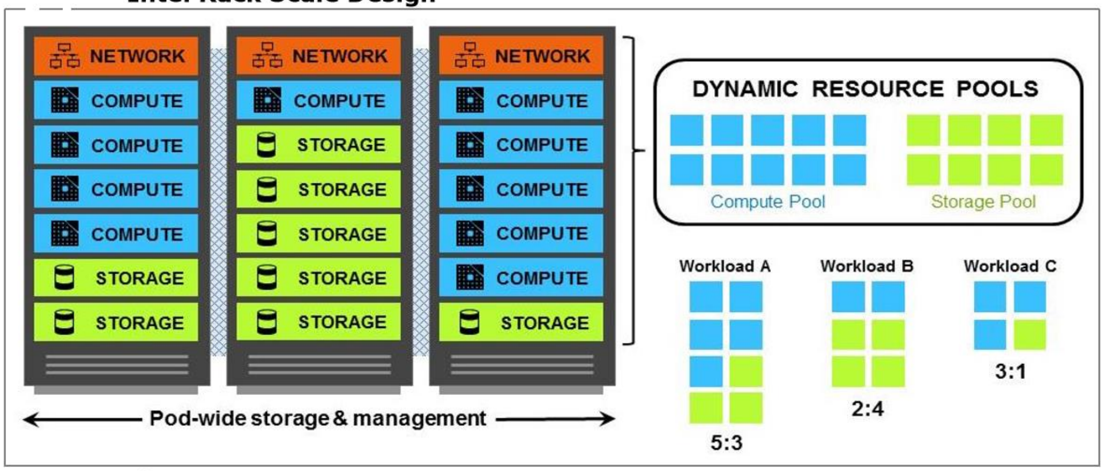
Micro Data Centers

To support IoT and next-level Sensing Semantic Networks and latency-sensitive, mission-critical applications for Smart Cities, Micro Data Centers were introduced to cater compute, network and storage needs to locate in the proximity where the data is generated and analyzed.



Source: Dell EMC

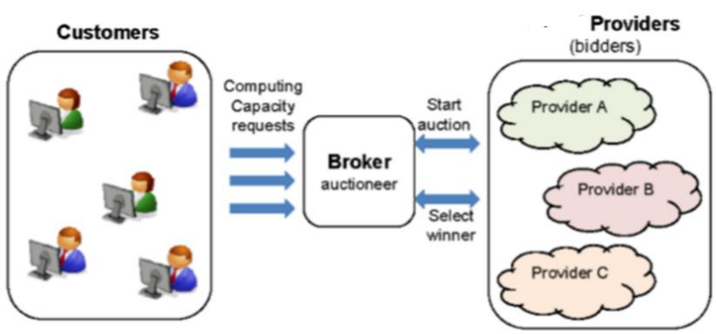
Intel Rack Scale Design



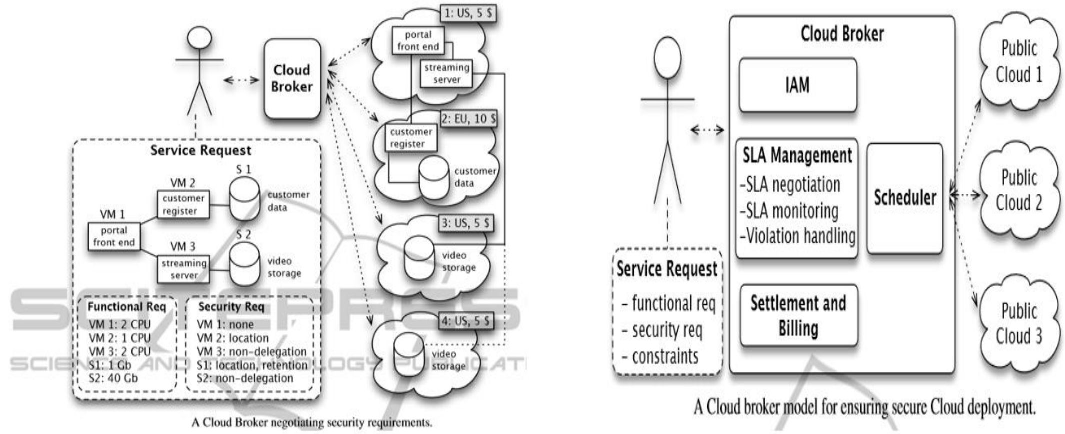
Source: Dell EMC

Brokers play an important role in in managing SLA in heterogenous environments enabled by 5G for providers of Cloud Computing, Core, Fog and Edge. Brokers help achieve maximum efficiency and catering costs to Service Consumers by taking into consideration Privacy Laws based on regional government and industry specific requirements for healthcare remote data management.

Marketplace



Cloud Broker

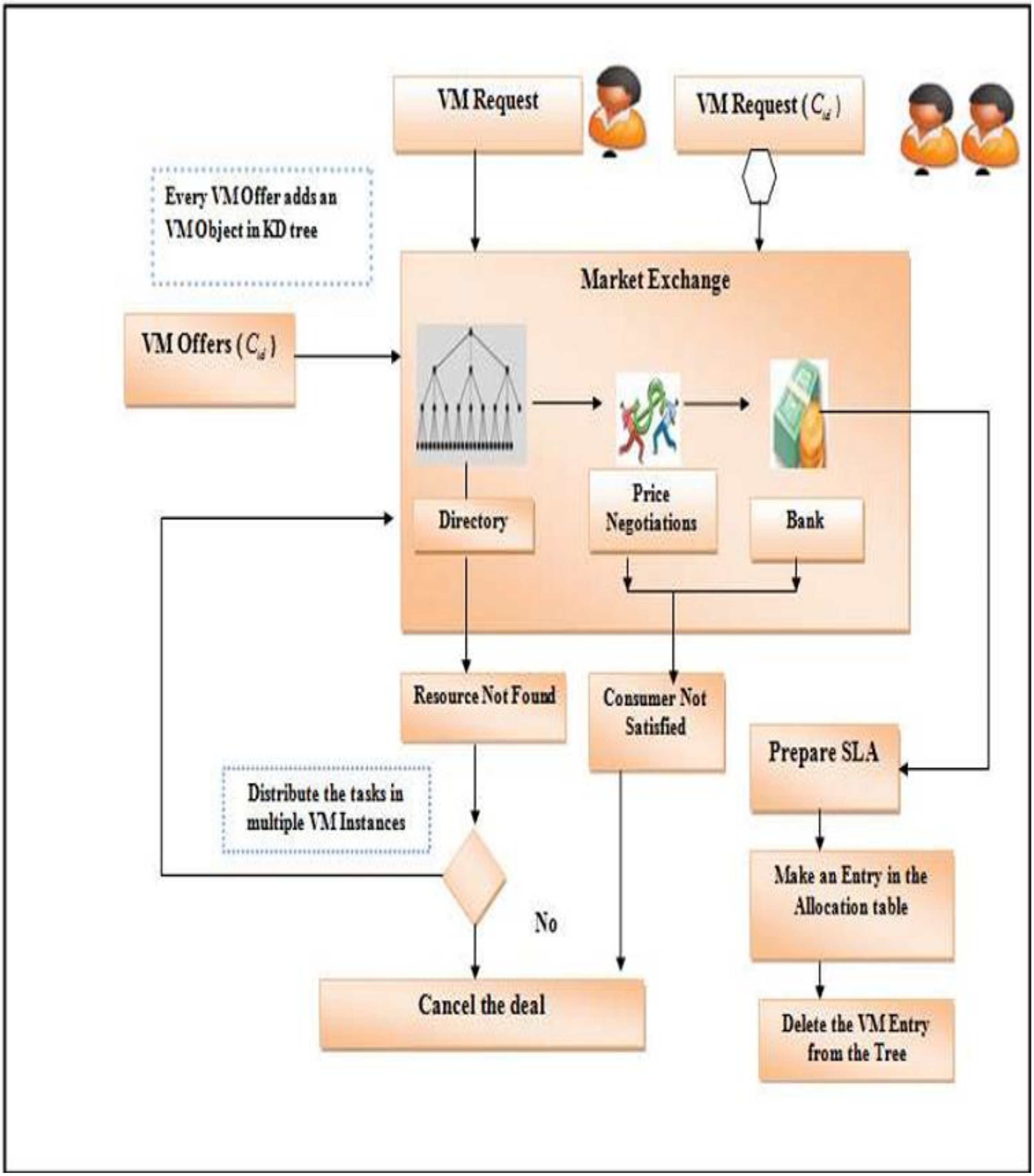


A Cloud Broker negotiating security requirements.

A Cloud broker model for ensuring secure Cloud deployment.

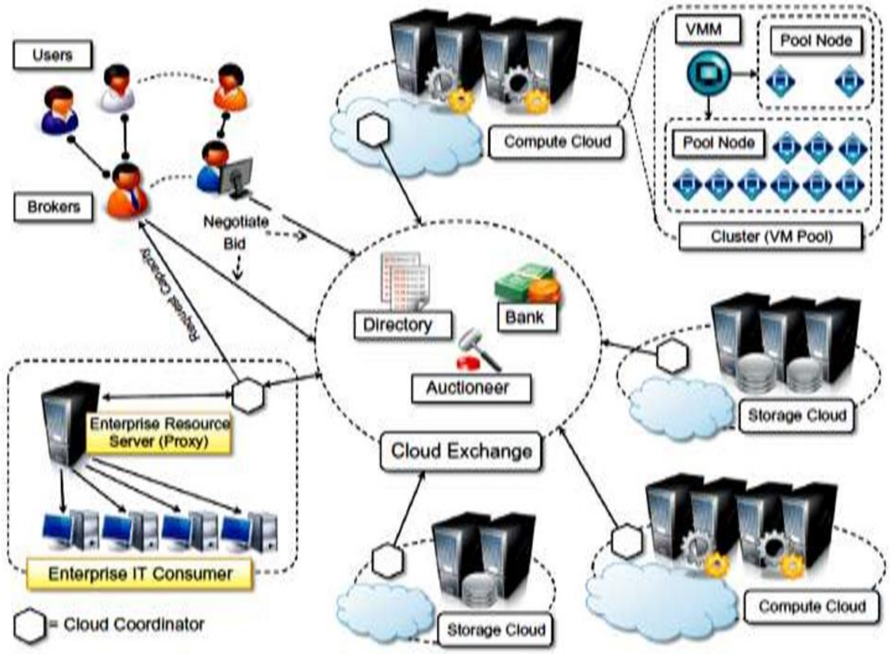
Source: SCITEPRESS (taking care of privacy and cost management rules before migrating VM and applications running into Public Cloud)

VM Selection Framework for Market-Based Federated Cloud

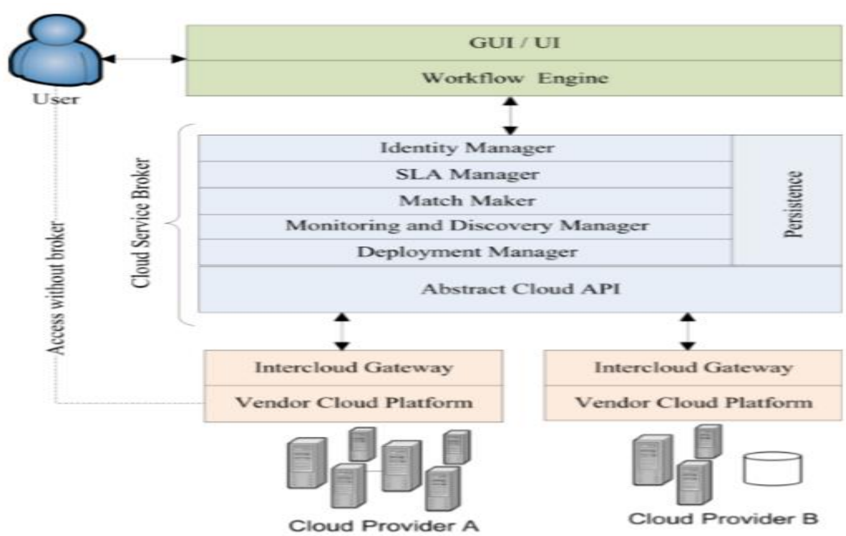


High Level View of Market-Oriented Cloud Architecture

Source: SCITEPRESS (Cloud Market Exchange)



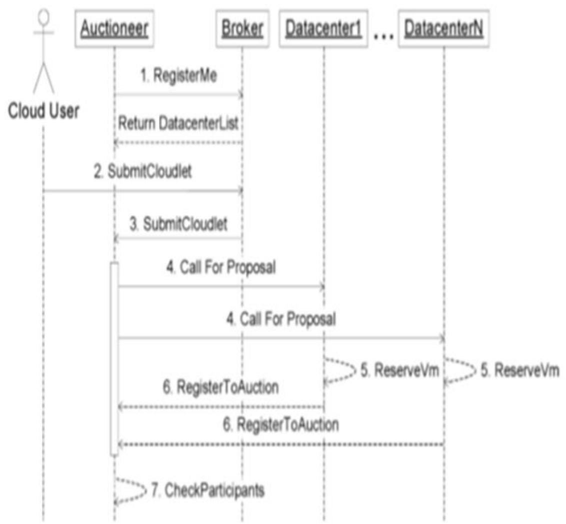
Architecture: Cloud Brokers importance in a Federated Hybrid Cloud



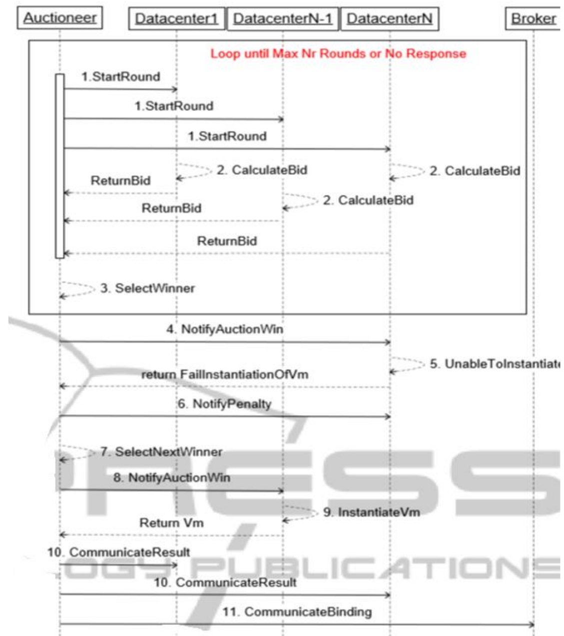
Cloud service broker architecture.

In Federated Hybrid Cloud, all the Cloud vendors are known stakeholders before participating. Research on algorithms which would choose the best provider of the service in real-time is an on-going effort.

Cloud user invoking CloudbrokerAPI

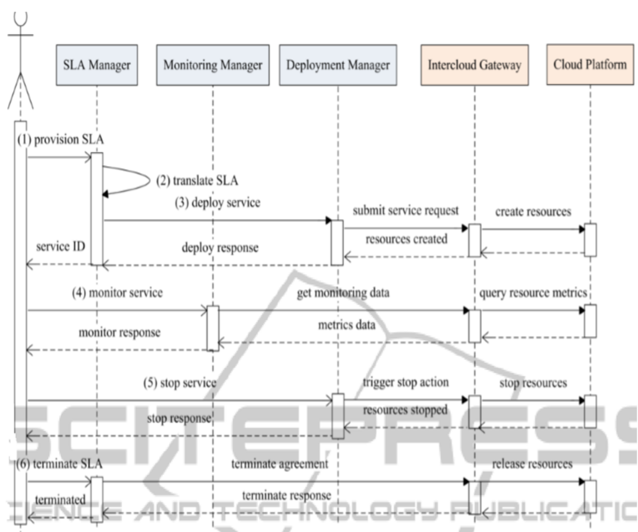


Auction preparation phase.

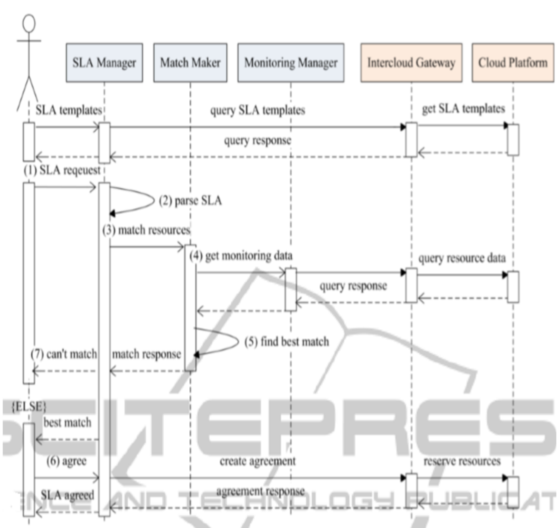


Auction running phase.

Negotiation and Provisioning Flow through Cloud Brokers



The SLA provisioning and monitoring flow.



The SLA negotiation flow.

Source: SCITEPRESS (Cloud Brokers in Public Cloud)

SLA Languages presently used by Cloud Brokers

WS-Agreement is widely used SLA language; the next most popular is XACML.

A WS-Agreement service level objective that uses P3P to put restrictions on data retention.

```
<wsag:GuaranteeTerm
  wsag:Name=
        SecurityRequirements
  wsag:Obligated=  Provider  >
  <wsag:ServiceScope
   ServiceName=
        StoreConsumerData  >
  </wsag:ServiceScope>*
  <wsag:ServiceLevelObjective>
   <wsag:CustomServiceLevel>
     <RETENTION><stated purpose/></
        RETENTION>
   </wsag:CustomServiceLevel>
  </wsag:ServiceLevelObjective>
 </wsag:GuaranteeTerm>
```

Expressing non-delegation in PPL.

```
<DataHandlingPreferences>
 <ObligationsSet> .. </
     ObligationsSet>
 <AuthorizationsSet>
  ..
 <AuthzDownstreamUsage allowed="
     false">
 </AuthzDownstreamUsage>
 </AuthorizationsSet>
```

Listing 6: A data retention requirement expressed in BCL.

```
Policy:  DataRetention
  Role:  Provider
  Modality:  Obligation
  Trigger:  StoreConsumerData
  Behaviour:  DeleteConsumerData
      after  StoreConsumerData.date +
    21
```

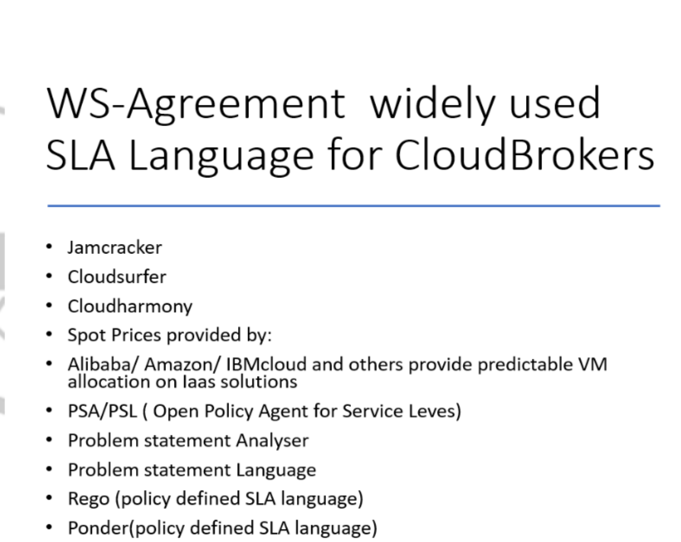
Source: SCITEPRESS, In Proceedings of the 2nd International Conference on Cloud Computing and Services Science (CloudSecGov-2012), pages 638-646 ISBN: 978-989-8565-05-1

Comparing the specification languages in Section 4.

Language	Feasibility	Complexity	Extensibility	Maturity	Support	Adoption
P3P	Medium	Low	Medium	High	Medium	Medium
RFC4745	Low	Low	High	Low	Low	Medium
XACML	Low	Medium	High	High	High	High
WS-Agreement	High	Low	High	High	High	High
PPL	Medium	Medium	High	Low	Low	Low
BCL	High	Medium	Medium	Medium	Low	Low
ConSpec	High	Medium	Medium	Medium	Low	Medium
LegalXML	Low	Low	High	High	Low	Low

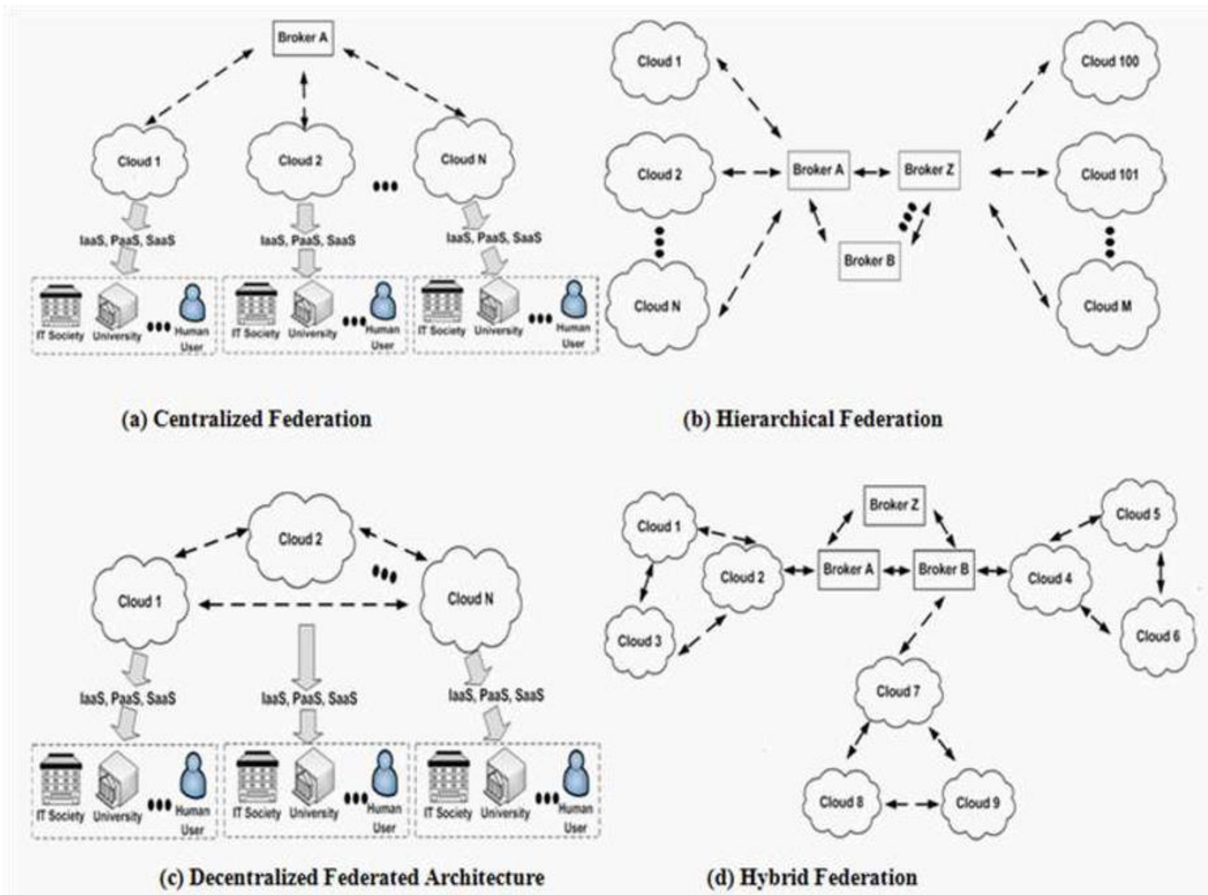
Source: SCITEPRESS, In Proceedings of the 2nd International Conference on Cloud Computing and Services Science (CloudSecGov-2012), pages 638-646 ISBN: 978-989-8565-05-1

```
<wsag:Location>qos:ResponseTime</wsag:Location>
      </wsag:Variable>
       </wsag:Variables>
</wsag:ServiceProperties>

 <wsag:GuaranteeTerm
       Name="FastReaction"
Obligated="ServiceProvider">
....
<wsag:ServiceLevelObjective>
 <wsag:KPITarget>

<wsag:KPIName>FastResponseTime</wsag:KPIName>
    <wsag:Target>
    //Variable/@Name="ResponseTime"  LOWERTHAN
800 ms
    </wsag:Target>
   </wsag:KPITarget>
 </wsag:ServiceLevelObjective>

 <wsag:BusinessValueList>
  <wsag:Importance>3</wsag:Importance>
  <wsag:Penalty>
   <wsag:AssesmentInterval>
    <wsag:TimeInterval>1 month</wsag:TimeInterval>
```



Example of WS-agreement SLA language and most popularly Policy-defined SLA language, Rego and Ponder

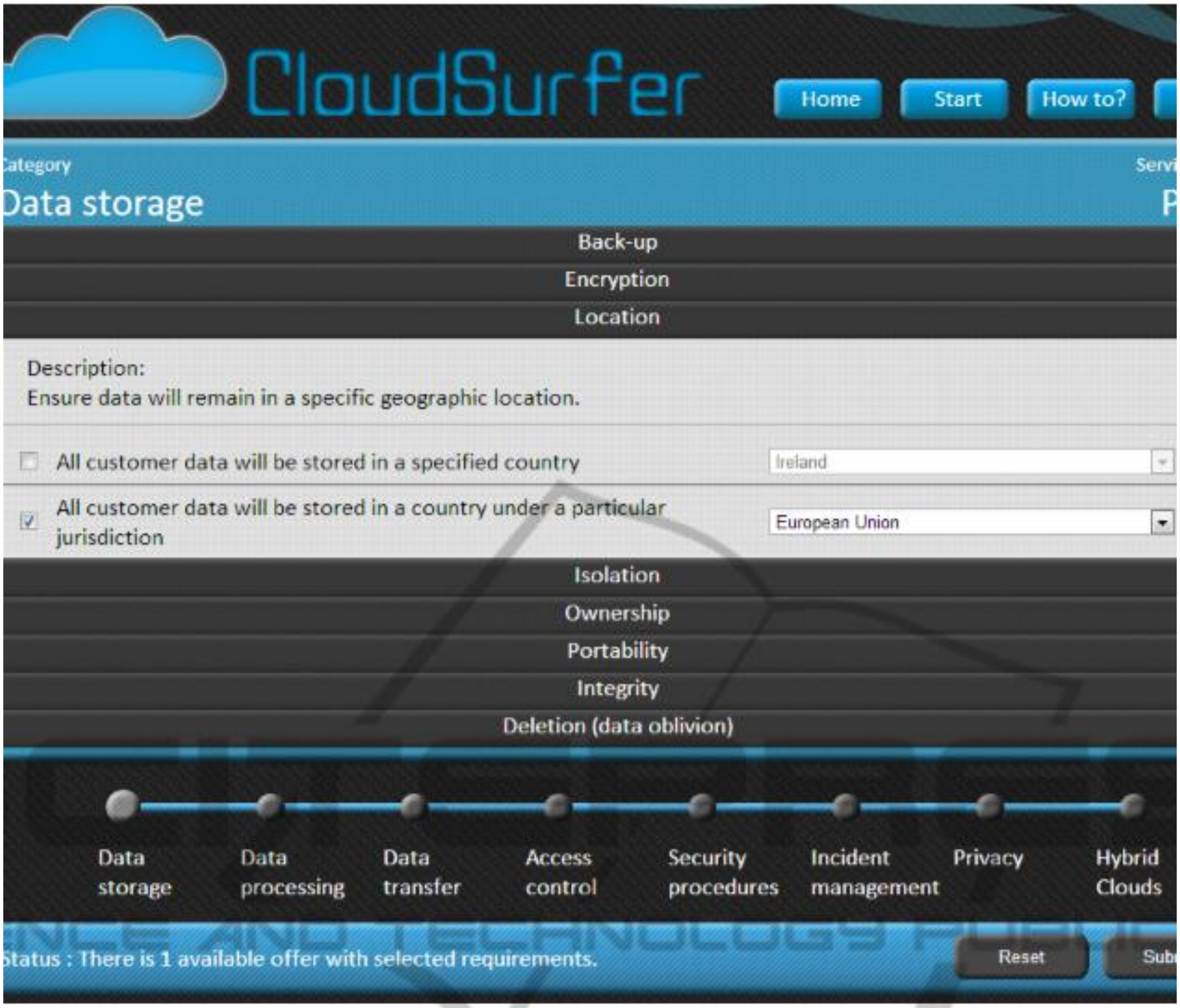
Future internet applications will need more than one broker and mediation might be required amongst the brokers. The situation will become more complex when brokers for Edge and Fog computing devices and Micro-Datacenters are involved for Smart Cities. 5G would enable them to on-board and off-board services at unprecedented speed which was not attainable with 3G and 4G generation networks.



Cloud Federation Broking Schemes

Use cases for Cloud Brokers

- Privacy requirements for EU GDPR law
- Data laws for US Banking Big Data workload execution
- Telco proximity workload for real-time services
- CDN networks provisioning cloudlets for temporary cold, warm and hot storage for video streaming



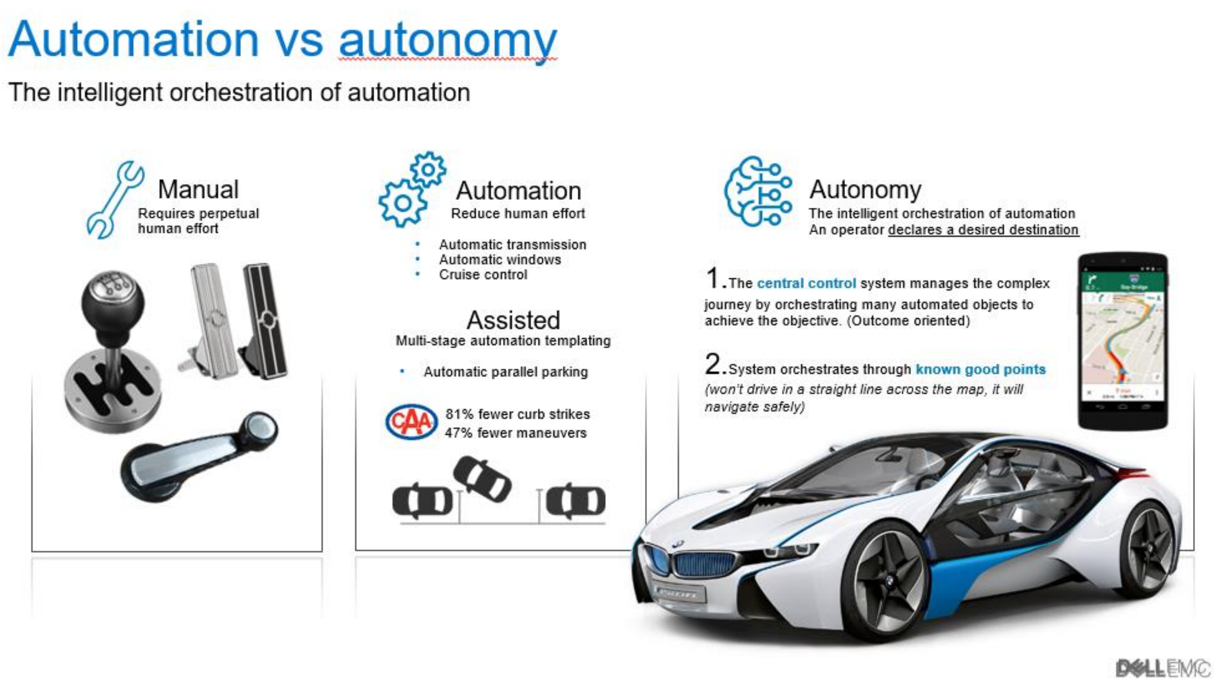
Requirements are selected and detailed.

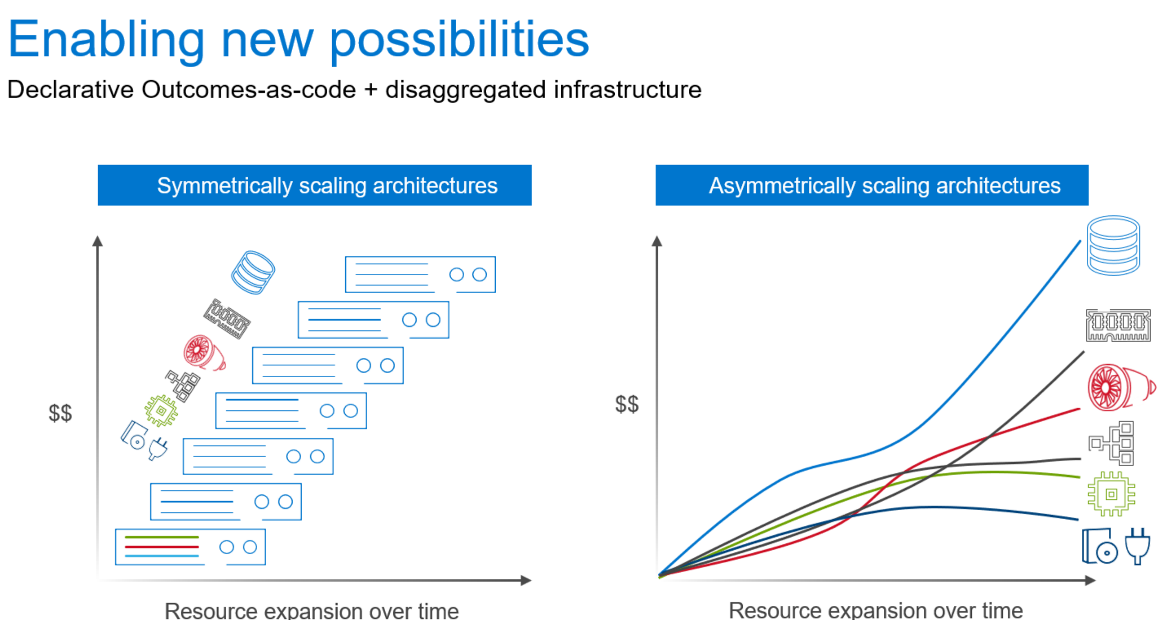
Example from Academic System Literature Review based on Cloud-Surfer

Source: SCITEPRESS (Cloud Brokers)

Rise of Autonomous Hardware

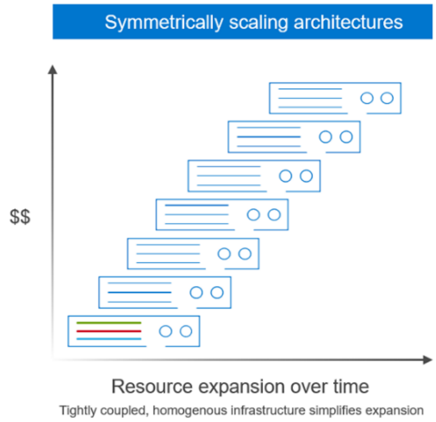
As opposed to asymmetric hardware solutions in the market, Dell EMC PowerOne autonomous hardware symmetrically scales Automation, AI and Hardware requirements.

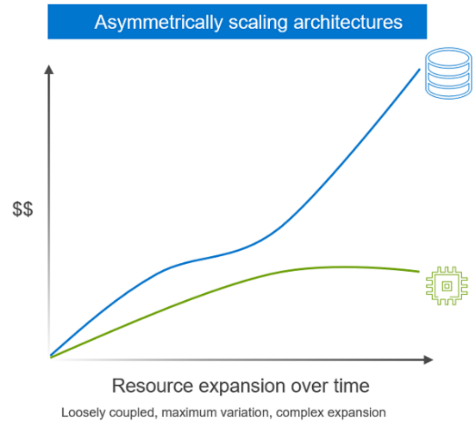




Enabling new possibilities

Declarative Outcomes-as-code + disaggregated infrastructure





Blending the benefits

The simplicity of a symmetrically scaling system" with the flexibility of an asymmetrically scaling architecture

Symmetrically scaling	Asymmetrically scaling
Lower OPEX Higher CAPEX (Potentially)	Lower CAPEX Higher OPEX (Potentially)
• Simplicity of expansion • Simplicity of management Agility & speed	• Scale resources independently • Cost avoidance (unnecessary HW & Lic) • Multi-technology choice

To realize this vision, we need more than just automation, we need...

Autonomous infrastructure

Dell EMC PowerOne Autonomous Hardware

Developing new and diverse sources of income by using the information developed by data analytics research is an on-going process in a most organizations. Based on processes that use data analytics to reduce costs by eliminating waste, optimize schedules, and efficiently using resources brings complex options. Organizations are continuously introduced to both opportunity and uncertainty among a wide range of use cases, coupled with the rapid development of new techniques.

What they need is a platform for data analytics that:

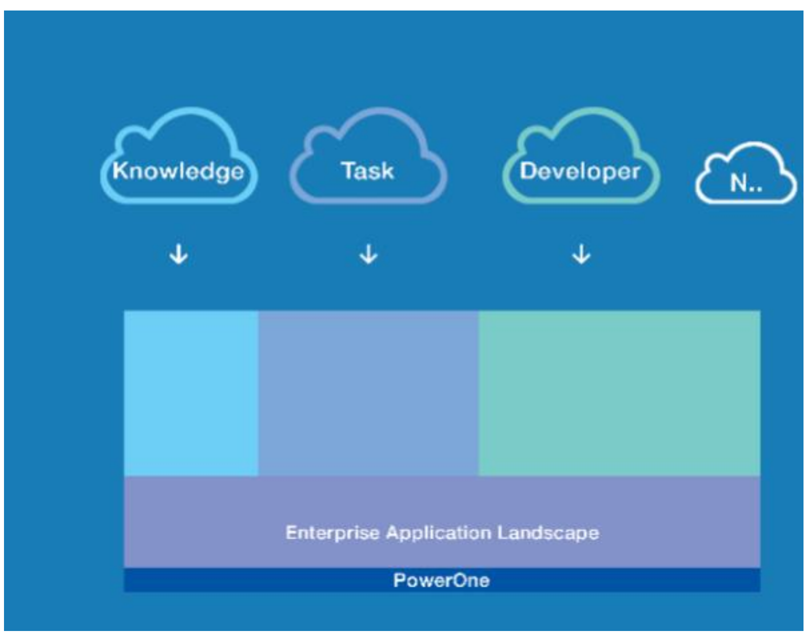
- Is easy to acquire and set up
- Scales storage and compute independently
- Reduces the need for internal resources that do not provide high strategic value
- Easily expands

The PowerOne System addresses all these challenges. Though not unique to data analytics, one can often encounter these challenges with greater time-criticality and potential impact to the business.

PowerOne's asymmetrical scaling capabilities make it the perfect choice for consolidating data center workloads and for hosting the most resource-demanding business-critical workloads.

PowerOne's PowerMax storage arrays, MX7000 servers, and PowerSwitch networking are ideally suited for hosting virtualized or bare-metal SAP, SAP HANA, or Oracle deployments, and for building high-performance SQL or Exchange clusters.

PowerOne is designed to satisfy the demands of memory-intensive, low-latency, and high-bandwidth workloads.



Varying Resource Requirements

• Performance & Experience

• Size & Scale

• Location & Endpoint

• Security & Availability

Cohabitation of Enterprise services and end user experiences:

• Wire-Speed Performance

• Enterprise HA and Security

Single System platform

Conclusion

We envision Cloud brokers to have a role in translating customer requirements into deontic contract language to choose the most suitable Cloud providers in a more automated and dynamic way. Seldom are security requirements addressed in current cloud SLAs as they are written in natural language and this is hindering the uptake of Cloud Computing. While many contract specification languages exist today there is no clear dominant language. Cloud SLA brokering needs further work based on specification and reasoning of security requirements. Overall, the industry needs a common ontology that represents contractual security concepts.

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