MIDDLEWARE FOR MULTICLOUD

A Middleware for Mobile Edge Computing, p. 26

Authorization Policy Federation in Heterogeneous Multicloud Environments, p. 38

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THEME ARTICLES

22 Guest Editors’ Introduction: Middleware for Multicloud
Luiz F. Bittencourt, Rodrigo N. Calheiros, and Craig Lee

26 A Middleware for Mobile Edge Computing
A. Carrega, M. Repetto, P. Gouvas and A. Zafeiropoulos

38 Authorization Policy Federation in Heterogeneous Multicloud Environments
Ioram S. Sette, David W. Chadwick, and Carlos A. G. Ferraz

48 Cost-Aware Cloud Profiling, Prediction, and Provisioning as a Service
Ryan Chard, Kyle Chard, Rich Wolski, Ravi Madduri, Bryan Ng, Kris Bubendorfer, and Ian Foster

60 NoMISHAP: A Novel Middleware Support for High Availability in Multicloud PaaS
Luca Acquaviva, Paolo Bellavista, Filippo Bosi, Antonio Corradi, Luca Foschini, Stefano Monti, and Andrea Sabbioni

74 On the Design of Resilient Multicloud MapReduce
Pedro A. R. S. Costa, Fernando M. V. Ramos, and Miguel Correia
COLUMNS

4 From the Editor in Chief
Multiclouds in an Enterprise — a Love-Hate Relationship
Mazin Yousif

6 Cloud Economics
Real-World Experience with a Multicloud Exchange
Adam Zeck and Jack Bouroudjian

12 Cloud and the Law
Biometrics in the Cloud: Challenges and Research Opportunities
Aniello Castiglione, Kim-Kwang Raymond Choo, Michele Nappi, and Fabio Narducci

18 Cloud Tidbits
Are Cloud Service Brokers (CSBs) Still Relevant?
David S. Linthicum

84 Standards Now
Blockchain Standards for Compliance and Trust
Ashiq Anjum, Manu Sporny, and Alan Sill

92 Blue Skies
Software Defined Membrane: Policy-Driven Edge and Internet of Things Security
Massimo Villari, Maria Fazio, Schahram Dustdar, Omer Rana, Lydia Chen, and Rajiv Ranjan

25 IEEE CS Information

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Real-World Experience with a Multicloud Exchange

There are many different options available to implement information technology (IT) today: enterprise data center legacy approaches or private cloud, public cloud, hybrid cloud, fog, device, mobile edge, and multicloud. Although definitions vary, for a variety of reasons, many companies are using multicloud approaches in a variety of patterns, at various layers such as infrastructure as a service (IaaS) and software as a service (SaaS). In some cases, multiple SaaS or infrastructure public or private clouds are used to support an end-to-end process, sometimes called workflow enactment. For example, a purchase order might be sent via a (cloud-based SaaS) email service such as Gmail, processed in a private cloud application, and then billed via a (cloud-based SaaS) billing service such as Zuora. Other use cases involve multiple public infrastructure clouds. For example, Netflix famously uses Amazon Web Services (AWS) for digital movie transcoding and its entertainment recommendation engine, but it also backs up data to Google’s cloud in the event of an AWS outage.

The constellation of cloud providers, cloud users, intermediaries, and use cases has been evolving into a richer and richer ecosystem, as shown in Figure 1. At first (see Figure 1a), there was only one cloud provider. Then, (see Figure 1b) there were multiple providers, each with its own customers. Some customers began to use multiple providers (see Figure 1c), in some cases with the support of a multicloud orchestration platform or workflow enactment service. Some clouds began to federate (see Figure 1d), for example, for footprint augmentation or to act as resellers or virtual cloud providers. There are many roles for intermediaries. One important use case for multiple public infrastructure clouds is where an intermediary acts as a marketplace (also referred to as a cloud broker) for multiple clouds (see Figure 1e), where buyers can choose from multiple sellers in much the same way that Hotels.com does for hotels and Travelocity does for airline flights. A variation of this model (see Figure 1f) is an exchange, where traders can act as buyers or sellers, like the New York Stock Exchange (NYSE) for stocks or the Chicago Mercantile Exchange (CME) for commodities. One of
the greatest advantages of an exchange is that direct market competition and transparency lead to buyers and sellers determining the true price of the good being exchanged based on supply and demand and other external factors. This process is called central price discovery. As with stocks and commodities, brokers often help smaller customers interact with exchanges (see Figure 1g) and ultimately other participants can complete a vibrant ecosystem (see Figure 1h) through derivatives, such as futures and options, which support speculators and also enable hedging to minimize risk.

The company we founded, the Universal Compute Xchange (UCX), a technology partner of the CME, is both a cloud marketplace that facilitates multicloud use cases, similar to Travelocity, and an on-demand spot exchange for compute resources, like the CME, that facilitates both intercloud and multicloud use cases. The CME facilitates trading of pork bellies, barrels of oil, frozen orange juice, and corn among buyers, sellers, speculators, and risk managers. The UCX facilitates the trading of compute, storage, and networks among those same roles: IT buyers, cloud and network service providers, speculators, and risk managers. As with hotel stays and flights, a customer with a set of computing requirements is offered multiple selections, and they can then make knowledge-based choices based on optimizing a variety of trade-offs such as cost, reliability, and performance. Envisioned as early as 2007, such brokers are now becoming a critical part of the fabric of the overall cloud and IT ecosystem, and we now have enough experience to share insights. This experience has been gained through nearly 100 million contract hours traded across scores of cloud service buyers and cloud service providers ranging from very small to the very largest providers who are either

FIGURE 1. The evolving cloud ecosystem. (a) Single provider. (b) Multiple providers. (c) Multiclou. (d) Reseller/federated cloud/virtual cloud provider. (e) Market. (f) Exchange. (g) Exchange with brokers. (h) Ecosystem.
participants in the UCX exchange or are represented by brokers.

The current state of the computing industry represents the inexorable maturation of the cloud ecosystem, in a context where IT spending is no longer optional, but a necessity for survival in an increasing digital world; one where applications are not just for internal processes, but fundamental to the delivery of customer value. As more enterprise organizations migrated both critical and noncritical assets to the cloud, spending began to grow exponentially due to increased use but also, in some cases, inefficient use, and so new technologies and intermediaries were developed to help provide visibility, analytics, optimization, and efficiency around these costs. End users and executives with financial responsibility wanted to understand the growing spend on providers such as AWS, which gave way to entities such a Cloudyn, which helped with the pressing need for full financial transparency. This then opened the door for a wave of Cloud Management Platforms from companies such as DXC (the merger of CSC and HPE software) and IBM Brokerage Services, which facilitated the use of multiple clouds via a single “pane of glass”, i.e., a multicloud management application. Emerging technologies, such as containers, also facilitated seamless workload migration from one provider to another using a single platform. These developments are significant because they enable greater flexibility across multiple public and private clouds, cost optimization, a level playing field, customer choice, security, and governance, and a base for further technological advancements.

Necessary Conditions for Cloud Market and Exchange Viability

Markets and brokers are found in virtually every industry, and exchanges broadly exist as well. There are several necessary conditions for such roles to be viable in industry ecosystems:

Multiple participants: In early 2006, there was arguably only one public cloud IaaS provider—AWS. Since then, a number of public cloud providers have entered the market, such as Microsoft, Google, IBM, Alibaba, Tencent, and NTT. But beyond the well-known names, there are hundreds of smaller players. Moreover, because of data sovereignty laws and because many applications are latency-sensitive, physical footprint/geolocation matters. In any given location, small providers may offer advantages over a large global provider with a limited presence in that area.

Differing offers: Although to most car owners, oil is oil, there are numerous different variations of crude: West Texas Intermediate, Saudi Sweet, Nigerian Light, Canadian Heavy, etc. Similarly, there are different offers from and across cloud providers, e.g., an AWS t2.medium instance versus an AWS m4.10xlarge versus a Google Cloud n1-standard-32 versus a Microsoft Azure Standard_F16s. Besides the underlying service itself, there are variations in the total offer. While the larger providers compete on breadth of portfolio, enterprise account relationships, pace of innovation, synergies with other noncloud portfolio elements, and so forth, smaller players also compete based on geographic focus, support services, customer intimacy (including possibly customer part-ownership), unique technology, price, and dependability.

Varying prices: Even if we were to ignore nonprice differentiators, the fact is that prices vary between competitors for identical or nearly-identical service offerings. Moreover, beyond price variations between competitors, prices vary over time. Prices vary due to cloud price reductions, although it’s been argued that Moore’s Law-based price decreases are, paradoxically, becoming victims of their own success. They also vary due to dynamic pricing of some services, for example, AWS spot instances. Dynamic pricing is a natural result when there is perishable fixed capacity and variable demand—as with airline seats, hotel rooms, or cloud infrastructure. This so-called “yield management” can help service providers maximize revenue and simultaneously enable customers to minimize cost, especially when there is demand elasticity. Subject to conditions such as prices varying in a similar range and in an uncorrelated fashion, cloud brokers can generate compelling benefits with as little as two participants in the market, as shown in Figure 2.

Cloud service providers (CSPs) are trying to maintain their current retail pricing while simultaneously trying to
deal with their current customer load, current customer load capacity, projected load and load capacity, potential new customer acquisition, and current customer loss, while also dealing with external factors, electricity costs, government regulation and unrest, interest rates, and more. We have seen prices fluctuate wildly on a day-by-day basis due to any one of these factors. In such an environment, both providers and customers benefit in a “free market” system subject to supply and demand.

**A uniform basis for resource comparison:** All of these differences, however, can be a challenge for customers or traders looking to compare offers. In the case of oil, West Texas Intermediate is the benchmark price, from which lower or higher quality oil gets a percentage discount or premium. UCX licensed the only patented algorithm that normalizes compute-processing power into a standard unit of measure—the Workload Allocation Cube (WAC)—from 6fusion.7 The WAC is the industry’s first patented metric for measuring IT infrastructure usage. It integrates six compute resource metrics, spanning the central processing unit, memory, storage, disk I/O, LAN I/O, and wide area network. It thereby normalizes consumption metering, enabling an “apples-to-apples” comparison regardless of the underlying hardware or software technology, resources, infrastructure, vendor, or provider.

**A uniform basis for comparison of other factors in the total offer:** However, there is more to consider than just technology. UCX combines detailed contract specifications and service level agreement requirements with the WAC to create a WAC Financial Product. Think of it this way: when you lease a car, it’s not only the make and model that matters, but the residual, down payment, interest rate, whether routine maintenance is included, roadside assistance programs, the scope and duration of the warranty, etc.

**Centralized price discovery and marketplace efficiency:** An intermediary offers the advantage of a single location for price discovery, i.e., determining the “true price” based on what the market is willing to pay. It also offers efficiencies similar to going to Expedia.com to determine flight alternatives between New York and London for next Tuesday, as opposed to visiting the websites of hundreds of different airlines. In addition, exchange functionality offers a number of improvements to market efficiency. One is Intercloud functionality, where providers can sell excess compute capacity to each other. Another is a centralized source for price information. Yet another is that such brokers/exchanges act as channels, helping providers sell otherwise unused perishable capacity.

**Optimizing consumers:** Another key driver for a marketplace such as this involves customer awareness, intent, adoption, and prioritization—IT customers must want or need to optimize their procurement of IT products and services. This is good economic practice, but also often involves fiduciary responsibility to shareholders and is a necessity due to frequently found IT budget constraints. However, it is also safe to say that, as with many human decisions, rational economic behavior is not always the basis.

**Customers as providers:** Ordinary people can buy stocks from corporations, but in addition, companies can buy stocks from corporations and people can sell stocks to each other through an exchange. Similarly, UCX enables enterprise customers of all sizes to buy compute resources from cloud service providers; however, enterprises can also sell resources to cloud service providers or to each other.

**Viable switching mechanisms and portability:** If there were no way to transfer ownership of a stock, the NYSE wouldn’t be very helpful. Similarly, if a customer is locked in to a given cloud service provider, all of the above conditions don’t count for very much. For example, long term contractual commitments, monopoly industry structure, or regulatory barriers may prevent a switch. This has typically been found with utilities, where the location of your residence defines who your cable, water, or electricity provider may be, regardless of better offers from other competitors.

In the case of cloud computing, most of these barriers don’t exist, although some do, e.g., a limited set of suppliers due to regulatory compliance concerns and industry standards such as the Health Insurance Portability and Accountability Act in healthcare or the Payment Card Industry in payments. One barrier which has traditionally existed is lack of compatibility between clouds. However, the last few years have seen a great easing in this, as technologies such as containers and the Open Cloud Computing Interface effort of the Open Grid Forum have made it easy to migrate applications and microservices from one cloud to another, and as portfolios available from various providers increasingly mirror each other’s capabilities. There are also initiatives underway such as PaaSage for cross-cloud development and deployment.8 There are still issues, as Spotify discovered when moving 1.5 billion files from AWS S3 to Google Cloud Storage, such as provider-dependent object names, hardcoded Internet Protocol addresses causing latency issues, service integration, portfolio or footprint limitations, and transfer failures.9 However, these issues are being mitigated by both cloud provider efforts and increasing customer knowledge regarding designing
cloud portability into applications and architecture.

A secure, trusted third party: Customers generally recognize issues associated with buying from providers through unknown third parties with no financial recourse. The issues are well known: consider scalpers selling fake tickets to sporting and entertainment events. UCX offers a centralized, legitimate, secure marketplace that benefits from both third party auditing of all participants—UCX and cloud service providers—and its association with the CME.

All these drivers together create a compelling need for and the conditions supporting a centralized intermediary for cloud computing. This is very much like other industries, such as travel, where online brokers enable a traveler to 1) discover who the relevant service providers are and their prices, 2) compare prices and other criteria (say, flight departure time, airport or hotel distance to city center, and room type), and 3) complete the purchase.

**Trends, Lessons, and Surprises**

At UCX, we have been in the cloud broker business since 2015. In that time, we have learned as our business has grown, and have developed a number of insights:

**Meter usage, not allocation:** The electricity and water you pay for at your home is not charged for based on the amperage rating of the wire or diameter of the pipe coming into your house, but on how many kilowatt hours or gallons you actually use. This seems obvious, yet cloud computing has, since its inception, been charged for based on compute resource allocation, not use. Cloud functions such as AWS Lambda represent a step in the right direction, since they are billed for mostly based on usage, although the devil is in the details, and in some cases, such as most reserved instance pricing, a discount is the quid pro quo for a commitment. In general, however, it’s important to meter, analyze, and optimize actual usage of classic cloud resources such as instances, compute, memory, and storage, preferably on a per container basis.

**Evolution to a commodity/utility:** Everything we have seen and experienced over the last decade leads us to the conclusion that the cloud is and should be priced as a utility. After all, different cloud IaaS providers may call their compute services by different names and have different instance sizes, but at their heart they may be using exactly the same Intel Xeon 2650 processor with 32 GB of random access memory. The same applies to storage services, where solid-state drives, once exotic, have now become a commodity.

**Cloud adoption maturity is multifaceted:** Enterprises are at different points in the cloud adoption lifecycle. This includes not only architecture issues such as legacy systems or organization structure, and operations changes such as DevOps, but also the business elements of cloud adoption such as spend management. For example, especially as business units directly procure cloud, IT may not know the true spending on cloud, and even if they do, may shield that info from executive management. The historic isolation of IT departments has made it difficult for many organizations to understand the budgetary needs of the department. The walls of separation must be torn down for a corporation to survive in the present day, and everyone in the decision-making process, from IT engineer to board member, must understand the growing capital expenditures and operating expenses for computing. As companies become increasingly digital, compute expenses are the key line item to be managed. For example, in 2016, Snap, Inc.’s (Snapchat’s) cost of revenue was $452 million, greatly exceeding its revenues over the same period of $404 million. These costs increased $269 million over a year earlier, of which $191 million was for “increased hosting costs.”

**Customers increasingly appreciate the value in diversification:** All the major cloud providers have experienced outages, which can have a significant impact on customer satisfaction and revenue. For example, the four-hour AWS US-EAST-1 S3 outage of February 2017 reportedly cost customers, such as financial services firms, well over $100 million dollars. One of the most famous is perhaps the Netflix Christmas Eve outage, which is one of the reasons that Netflix not only operates in multiple availability zones/regions, but also backs up data from AWS to Google. In addition, although unlikely for a major provider such as AWS or Microsoft, smaller ones such as Nirvanix have declared bankruptcy and provided customers limited time to migrate. Customers face strategic procurement tradeoffs here: a strong relationship with a single provider can offer benefits, where the customer can influence the evolution of the provider’s services over time, but diversification also offers pricing and risk mitigation benefits. Diversification among cloud providers reduces risk similarly to the way that mutual funds reduce risk compared to a single stock.

**Summary**

In the past decade, cloud service provider offerings and customer awareness of how to use them have evolved significantly. One of the major developments has been the evolution of customers from using a single service from a
single provider to using multiple clouds in a true, integrated multicloud. Due to industry characteristics such as differential and dynamic pricing, emerging technologies such as containers and standards that facilitate workload migration, and the needs of customers to minimize spend yet maximize performance and availability, cloud brokers such as UCX are becoming an essential element of the entire ecosystem.

References


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