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The Strategic Value of the Cloud

A RECENT STUDY BY OXFORD ECONOMICS BASED ON A RESEARCH COLLABORATION WITH SAP IDENTIFIED THE TOP FIVE BENEFITS THAT EXECUTIVES EXPECT FROM CLOUD INVESTMENTS.[1] First, they expect significant gains in productivity—to do more with less. They also expect significant gains in innovation as well as in the speed and efficiency of processes. These executives believe that cloud investments should enable IT to be a better partner to the business, and IT to become a profit center. Only after these five top priorities did executives rank cost savings.

To be sure, the cloud has a variety of mechanisms that can help reduce costs. For example, a reduction in required physical servers achieved through virtualization or containers reduces total capital expenditures, leasing, or reserved or on-demand costs. Pay per use is a pricing mechanism that can reduce total costs when used with pure public or hybrid clouds, especially in the presence of variable demand.[2] The cloud can also improve performance, for example, by reducing latency for interactive tasks through geographic dispersion, and reducing total response time through parallelism.[2]

However, the Oxford Economics study illustrates that executives don't view cost reduction per se as a major driver for cloud. This is a wise assessment. After all, with IT budgets averaging a few percent of revenues, even a dramatic 25 percent cut in budgets would have a small impact on the finances of the overall corporation, especially compared to, say, increasing revenues by 10 percent, or even preserving existing revenues in the face of turbulence and competition. Such a strategic impact is becoming increasingly common: consider the battles between Borders Books and Amazon.com (the retail division of Amazon, not Amazon Web Services, the cloud provider), Netflix and Blockbuster, Uber and taxis, or WhatsApp and SMS services.

This, however, begs the question of exactly how the cloud can be strategic, and whether such strategies are repeatable. I've identified four major generic strategies, which I call *digital disciplines*, that exploit the cloud and related technologies such as big data, social, mobile, and the Internet of Things.[3] Here, I'll also describe the high-level architectural patterns that each strategy entails.

The digital disciplines update a two-decade-old framework, which articulates three strategies—called *value disciplines*—for achieving marketplace success by offering customers unparalleled value: *operational excellence* (that is, better processes), *product leadership* (that is, better products and services), and *customer intimacy* (that is, better customer relationships).[4]

Given today's technologies, however, physical operational excellence must be complemented by virtual *information excellence*. Standalone product (or service) leadership needs to evolve to smart, digital products and services connected to the cloud and from there onward to an ecosystem of services and partners. I call this *solution leadership*. Traditional face-to-face customer intimacy is now not only complemented by virtual customer intimacy through social networks and online communities, but is also being supplanted by *collective intimacy*, where de-

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FIGURE 1. Information excellence high-level architecture. Data is aggregated in the cloud, where it's processed, and the solution implemented through people and things.

tailed data from all individuals, such as movie-watching habits or genetic data, is processed to provide personalized, contextualized recommendations and services to every individual. Finally, a fourth metastrategy, *accelerated innovation*, enables companies to innovate not only faster, but with higher quality and at lower cost, through cloud-based approaches such as contests, idea markets, and innovation networks.

Information Excellence

Traditional operational excellence entailed static design of operational processes such as manufacturing, distribution, or service operations. For example, consider a manufacturer who might spend years designing a new automobile assembly plant, paper mill, or refinery. A model of the new paradigm is extreme flexibility coupled with dynamic optimization. A good example is a modern container port, with numerous trucks, ships, cranes, and containers. The objectives are to maximize throughput, minimize delay, and minimize cost in the face of congestion, ship delays, labor stoppages, and congested roads. Or consider changes in distribution. Rather than a fixed delivery route, a package delivery company wants to optimize deliveries by minimizing fuel and carbon footprint and labor costs and capital requirements while maximizing customer satisfaction through a combination of regularity (for example, deliveries to Acme, Inc. are usually at 10 a.m., after the daily status call) and meeting delivery deadlines and customer constraints.

Today's dynamic optimization problems are computationally complex, that is, intractable. But that's only part of the story. Abstractly they're NP-complete, but that assumes that the problem data can be collected and then a solution attempted. In real life, additional problems include acquiring valid data in real time, updating it as conditions change (a delayed ship, a congested traffic route, a truck with a flat tire) then solving it, at least through heuristics and approximation methods, and then implementing the solution (for example, routing trucks, ships, cranes, and so on). Moreover, global policies might need to be implemented. For example, delivery companies such as UPS have long avoided left turns in their route construction to improve productivity, but recently, New York City has requested that Google help reduce left turns for Google Maps users to enhance pedestrian safety.[5] Solving these types of problems requires collecting big data in real time from things and people, processing it in near real time through an optimal combination of edge and cloud, and then enacting the solution through people and things, as shown in Figure 1.

Solution Leadership

Products like the Rolex Daytona or Aston-Martin DB9 have traditionally been emblematic of product leadership, as have services such as those from Nordstrom or the Four Seasons. However, today, standalone products and services are evolving into smart, digital ones, with embedded CPUs, sensors, and power. Moreover, they're being connected over mobile and wireline networks to the cloud, which can aggregate and process data from multiple endpoints. Sometimes data aggregation is across multiple similar endpoints, as when smart meters collect usage data for demand response in smart grids, or when wind turbines tune themselves based on the performance of nearby turbines. Sometimes data can be aggregated across heterogeneous endpoints from multiple vendors in an authorized or emergent partner product ecosystem, as when

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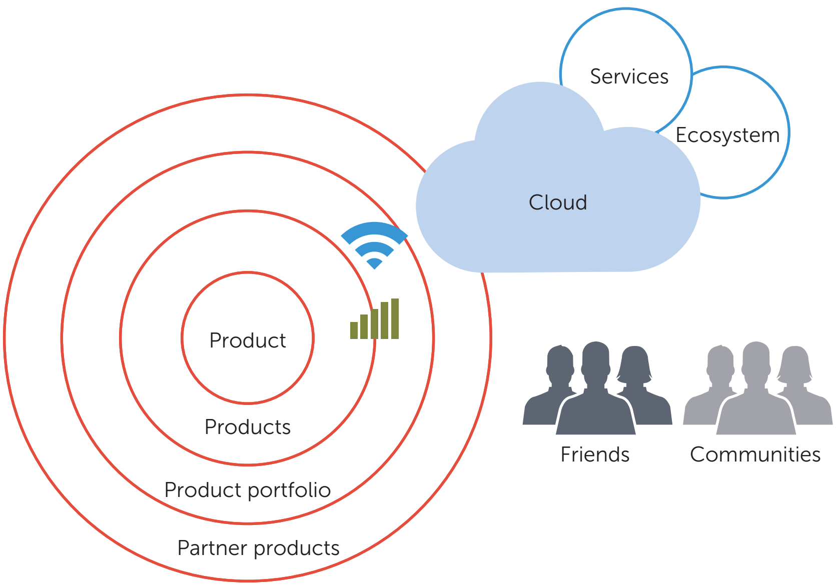

FIGURE 2. Solution leadership high-level architecture. The cloud ties together products, services, consumers, providers, and an extensible partner ecosystem.

activity trackers, footwear, smartphones, and connected scales can interoperate to aid in achieving fitness goals.

Not only products get connected as the Internet of Things connects to the cloud, services do as well. Healthcare services can leverage data from DNA sequencers and CT scanners and connected pacemakers to deliver higher quality services. Fast food restaurants can enable order configuration over the Web, with food deliveries tracked and reported to customers in real time via connected vehicles.

Smart, digital, connected product and service solutions enable ongoing customer relationships, encouraging stickiness and transforming one-time transactions focused on sales to ongoing subscription relationships focused on customer outcomes. The cloud becomes the nexus of data aggregation in real time, the development of and control point for actionable intelligence, and the gateway to social networks, communities, and extensible ecosystems, as Figure 2 illustrates.

Collective Intimacy

The traditional model of customer intimacy is represented by relationships between consumers and their hairstylists, bartenders, butchers, tailors, or physicians, or businesses and the account teams that service them. Such pairwise intimate relationships have moved online to contexts such as social media.

However, there are deeper forces at work, enabled by big data processed by near-infinite cloud resources. Rather than dozens or millions of pairwise intimate relationships, comprehensive data from all customers is collectively analyzed to provide better services to each customer. For example, Netflix collects data on customer *characteristics* (such as demographics and personas) streaming video viewing *behaviors* (rewind, pause, fast forward, watch again, never watch), and *contexts* (device type, time of day, geolocation) from each of their tens of millions of customers.[6] This is combined with external metadata (name, release date, director, locations, and so on) and human-generated tags that assess such elements as the emotional content of the movie (happy, sad, romantic, and so on). All this data is processed to generate personalized recommendations to each viewer. Similarly, the Mayo Clinic processes collective genomic, epigenetic, microbiomic, and pharmacological efficacy data to generate personalized recommendations: personalized medicine and patient-specific therapies.

Here the role of the cloud is to collect, aggregate, and process data, determine personalized services and recommendations, and deliver them to customers, as Figure 3 shows. In addition to behaviors, contexts, tags, and external metadata, social elements can be incorporated as well. For example, Netflix can alter recommendations based on friends' viewing preferences.

Accelerated Innovation

The cloud can also be the means for firms with problems to connect with solvers, through idea markets, challenges, and innovation networks. Traditionally, companies would solve technical challenges internally through R&D labs. The "open innovation" approach espoused by Henry Chesbrough advocates looking beyond the firm boundaries to partners with either technologies or distribution capabilities.7 However, such open innovation is no longer based on intellectual property licensing and static agreements, but can be conducted in a highly dynamic, ad hoc fashion.

One way to do this is through challenges and contests such as the Netflix Prize or GE Flight Quest. Problems or needs are posted for any solver anywhere in the world to solve. Sometimes the problem can be simply stated (such as "prove Fermat's last theorem") but often they're accompanied by big datasets. For example, GE Flight Quest published data on scheduled and actual flight departure and arrival times as well as external data such as weather. A variety of techniques, ranging from 3D visualization to latent Dirichlet allocation, are then employed by solvers in an attempt to achieve the best result, typically but not always measured quantitatively.

Such innovation is typically accelerated. For example, the molecular structure of the Mason-Pfizer monkey virus retroviral protease hadn't been solved, even after 15 years of study by researchers using advanced computer models. It was solved in less than three weeks by contestants who were "ordinary people, not molecular biologists" via an open challenge conducted through an online, gamified site called Foldit.[8,9] Innovation via such mechanisms is also often of higher quality, due to simple math: there are more technical experts in any given area outside of a given company than within it. It can also often be less expensive, because a prize or licensing arrangement is typically only awarded for results, typically meeting specific thresholds, unlike employees or contractors, who are paid for effort, regardless of whether there are any practicable results. As Figure 4 shows, the cloud again plays a central role. As Jeff Weedman of P&G put it in describing the transformation from traditional innovation to the new model, "the new communication systems meant that we . . . could reach all the people that had [technical] capabilities."[10]

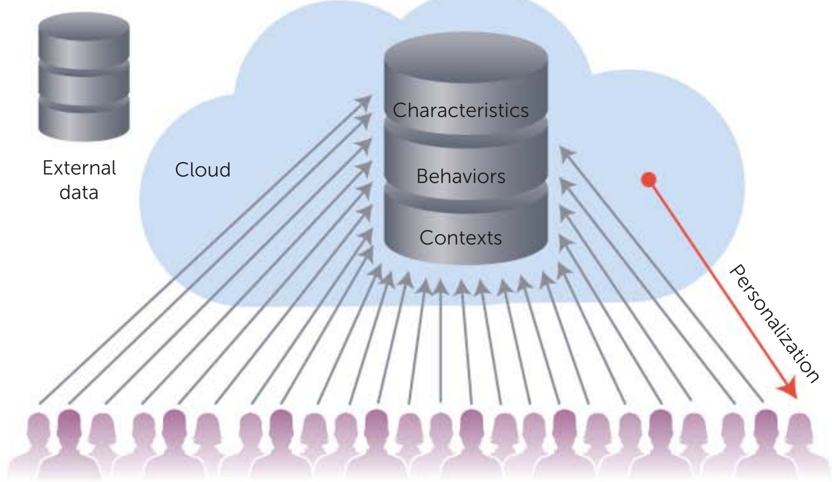

FIGURE 3. Collective intimacy high-level architecture. The cloud supports customer intimacy by aggregating data from customers to personalize and deliver services and recommendations.

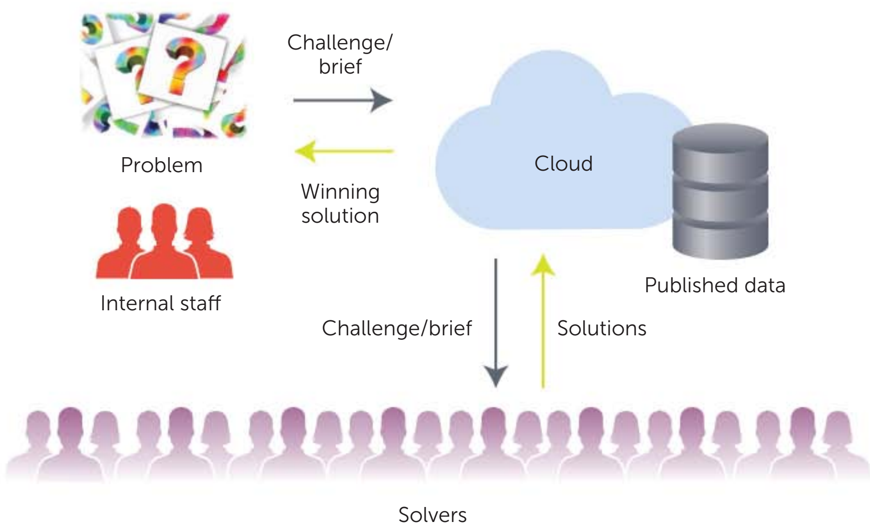

FIGURE 4. Accelerated innovation high-level architecture. The cloud allows firms to connect with experts outside of the organizational boundaries to produce novel solutions to problems.

In addition, the cloud and related information technologies can help accelerate innovation, for example, by offering speedy, cost-effective resources for conducting Monte Carlo simulations, enabling synchronous and asynchronous collaboration between researchers, or accelerating the digital portion of next-generation products through platform services and microservices or physical component prototyping through 3D printing.

Not Just Business, but Government

A companion piece in this issue of *IEEE Cloud Computing* delves into the role of cloud computing for governments.[11] The parallels are clear. For example, the California Natural Resources Agency leveraged cloud computing in an information excellence strategy to accelerate data acquisition and improve real-time response to rapidly changing natural disasters. Singapore has pursued solution leadership, connecting everything from driverless buggies to elderly patients to the cloud. Estonia pursued a customer (that is, citizen) engagement approach using individual cryptographic keys to better identify and thus engage with citizens across a broad range of government services. And governments can use the cloud to accelerate mission innovation.

THE CLOUD CAN PLAY A ROLE IN COST REDUCTION, PERFORMANCE OPTIMIZATION, FLEXIBILITY, AND USER EXPERIENCE. At its best though, it's the nexus of strategic competitive differentiation through the use of information excellence to optimize processes against any of a variety of goals such as cost, time, quality, or sustainability; solution leadership to tie physical endpoints to cloud-based services, social networks, and communities; collective intimacy to offer personalized services based on big data algorithms; and accelerated innovation through cloud-mediated contests, challenges, innovation networks, and idea markets.

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