Ovum

Reaching for the Cloud

Higher education's journey to leveraging the transformative power of cloud technology

Publication Date: 03 July 2019

Author: Richard Palmer, Joyce Kim

Summary

In brief

The journey to the cloud is about far more than better technology delivery. It should also transform how IT addresses student and staff needs for teaching and learning, research, and other campus initiatives. The benefits of cloud strategies are doubly effective: as well as providing a smorgasbord of secure, ready-to-use, pay-as-you-go technologies, they refocus IT cost and effort away from managing platforms and infrastructure and toward directly supporting business transformation and innovation.

Ovum view

Cloud strategies are no longer avant garde or a journey into the unknown. Many higher education institutions are a long way down the road, and the best ways of gaining value from the cloud are well established.

The cloud journey doesn't tend to be taken in a single leap but in several distinct stages: moving to more flexible infrastructure and platforms, expanding skills and capability, and leveraging leading-edge tools to solve new kinds of problems. Each stage contributes to achieving the goal of a modern IT organization, which is to support timely business innovation by delivering insight from data and creating smarter, more flexible systems.

In each stage, multiple benefits accrue: the time needed to deliver new services substantially decreases and cost scales with usage rather than with peak demand; pre-provisioned, idle infrastructure is eliminated; and the cost and effort of keeping platforms safe and up to date largely transfers to the supplier.

Notre Dame, the University of Queensland, and Arizona State University's experiences with Amazon Web Services (AWS) demonstrate the power of the cloud to enable institutional transformation. Institutions that are not taking advantage of basic and advanced cloud services are at risk of increasingly falling behind as they will need to continue to expend significant resources on running infrastructure and services instead of refocusing staff on leveraging those platforms to meet business needs.

Key messages

- Leveraging the cloud allows CIOs to focus more on delivering business needs and improving institutional services.
- Key benefits of cloud services include faster academic and administrative innovation, smarter and safer systems, data-driven insights, a refocusing of IT's mission to directly support business effectiveness, optimization of institutional spending, and improved user experience.
- Each stage of the cloud journey generates different value. The initial stage comprises several proof-point projects, which serve to highlight the benefits of cloud services as well as triggering revision of policy and process in areas such as IT governance, budgeting, and project and service management.

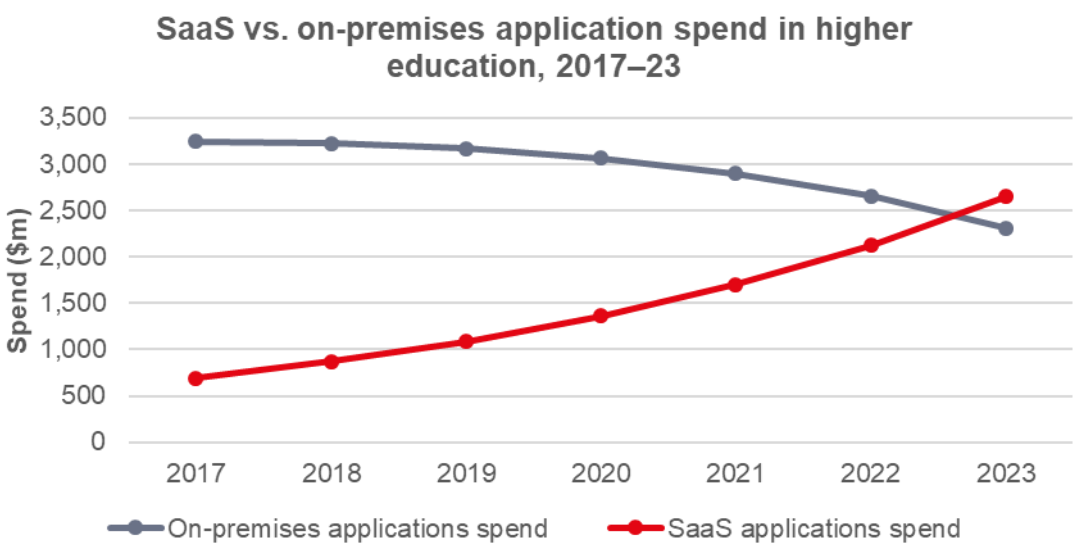
- In the second stage of the cloud journey, cloud-first becomes a reality and the IT organization's structure and culture transform to more fully embrace agile, business-aligned operations.
- The services in the cloud are rapidly evolving, continually providing new tools – such as big data analytics and artificial intelligence (AI) – to address business and academic problems that were previously intractable. Practical quantum computing promises to herald a new era.
- Without the cloud, IT will be hard-pressed to support the institution through change.
- Arizona State University, Notre Dame, and the University of Queensland's experiences with AWS can provide other institutions with useful insights as they embark upon their own cloud journeys.

Leveraging the cloud allows CIOs to focus more on delivering what the business needs

Ovum's *ICT Enterprise Insights 2018/19* survey reveals that 37% of institutions across the globe listed adopting cloud services as one of their top-three IT projects over the next 18 months. The journey to the cloud is about far more than better technology delivery; it offers a once-in-a-generation refocusing of IT away from the mechanics of technology delivery and toward more directly supporting the university's mission of excellence in teaching, research, and administration. The ever-expanding palette of cloud services can transform how IT addresses student and staff needs, teaching, and research. Low cost of entry combines with robust scalability to allow affordable proofs of concept to translate more seamlessly to full production.

As a result, institutions across the globe are slowly but surely moving to the cloud. For example, Figure 1 shows that by 2023, on-premises application spend will be overtaken by software-as-a-service (SaaS) applications spend in higher ed. Moreover, Ovum's higher ed technology forecast reveals that global spend across cloud-based infrastructure, platforms, and applications will increase from $1.75bn in 2019 to $4bn by 2023. IT spend on cloud infrastructure alone will increase from $419m in 2019 to $909m in 2023, at an annual growth rate of 21%.

Figure 1: Cloud momentum is on the rise for higher education



Source: Ovum, Global Higher Ed Technology Spending Forecast through 2023

Employing cloud services effectively can deliver benefits in six key ways: they lead to faster academic and administrative innovation, provide a springboard to smarter and safer systems, enable better insights from data, allow IT to refocus on directly supporting business effectiveness, optimize costs, and transform the user experience.

If your cloud journey isn't delivering across all these themes as it proceeds, a once-in-a-generation opportunity may be wasted.

Faster academic and administrative innovation

While cost is often suggested as the greatest benefit of the cloud, strategically speaking, the cloud's ability to enable more-rapid institutional innovation is possibly more significant. Traditionally, delivering new capability to the organization has been delayed by the need to purchase and commission platforms for development and pilot operation, and delayed again as the infrastructure is scaled up for wider use. Both of these delays, which can extend to weeks or months for larger systems, are virtually eliminated with cloud services.

The low entry barriers for cloud services mean that new technology can be trialed at relatively little cost and effort. And if the initial selection proves not to be optimal, switching costs are also low. These benefits are amplified when agile development practices are used: users get to see prototype systems in days or weeks rather than months, and incremental development reduces the quantum of business change and risk at each release. Project deliverables are business validated far more quickly, and learnings from using the new functionality can readily be incorporated into subsequent development cycles. Furthermore, the ability to try something new at relatively low cost encourages experimentation – a key element of innovation.

Arizona State University (ASU) is a public, research-intensive institution with around 72,000 students on its four physical campuses (and another 30,000 enrolled in its online learning programs) and 17,000 staff members. ASU is also the *US News and World Report*'s 2019 winner of its Most Innovative School category – an honor it has won four years in a row. Some of this reputation for

innovation can be directly tied to its use of technology/technology-driven initiatives, from voice-enabled services to its Internet of Things (IoT) project to supporting the student experience through a cloud-native mobile app. Cloud-enabled technologies and services allow ASU to push forth a "bias for action" principle – to experiment with new services and tools (such as virtual reality platforms or smart lighting), learning quickly from experiments and replacing or adding new services as needed, all with the ultimate goal of improving the campus experience.

Hackathons can test the feasibility of multiple innovative ideas in just a day or two and commonly involve students as well as staff. For example, ASU has hosted hackathons for its students to build their own Alexa skills. While no promises are made that the prototypes will go forward, many good ideas – such as Facebook's *Like* button – began their life at one of these events.

While administrative innovation is important, cloud services can also contribute on the academic front. New SaaS teaching and learning tools are continually appearing, and most clip seamlessly into major learning management system (LMS) platforms. Virtual teaching labs can be spun up as needed in the cloud, making them available to students anywhere, anytime. Academic programs, particularly in science, technology, engineering, and mathematics (STEM) disciplines, can be enhanced by the educational materials and partnerships offered by vendors to help students and faculty engage effectively with cloud technologies.

For research, cloud marketplaces can be created where research environments can be quickly and safely built from predeveloped templates that integrate capabilities from experimental data capture, curation, and e-notebooks, through analysis, visualization, and support for data archiving and publication. The flexibility of the cloud allows specialist applications to be readily incorporated into standard offerings. Cost can be managed effectively through usage tracking and alerting, and the application of standardized components for access management and cybersecurity can reduce the risks traditionally encountered when academics have built and deployed their own configurations from the ground up.

Cloud platform services are a springboard to smarter and safer systems

While cloud infrastructure and technology platform services (infrastructure-as-a-service and platform-as-a-service, or IaaS and PaaS) deliver value in cost, flexibility, and IT team focus, cloud application platform services (application platform-as-a-service, or aPaaS) offer transformational possibilities for application development. aPaaS provides robust, high-functionality, modular components that can be combined and configured to create customized business processes with a minimum of code.

Time to market can be cut to a fraction of traditional development, leveraging modules with powerful and well-defined behavior. Testing is simplified, as unit testing of the modules is the responsibility of the vendor. The ability to prototype powerful applications in days or even hours, using the low-code development tools provided by major aPaaS vendors, challenges the idea that extensive up-front planning and design, before coding begins, is the only recipe for success. Major aPaaS platforms, such as Pega, Appian, Salesforce, and MS Dynamics, are all delivered on cloud infrastructure by top-tier providers, such as AWS, employing leading scalability and security practices to maximize availability and minimize risk.

SaaS is an excellent proposition when your organization has mainstream needs, and many leading SaaS vendors provide a platform on which to create extensions to the core system, allowing unique business needs to be satisfied.

While a quick web search of "security compliance programs" of any of the major cloud vendors will result in a long list of the global and national certifications they have achieved, universities will need to rethink some of their traditional security practices to fully leverage the advanced security features and services available in the cloud. A recent Ovum survey indicates that 55% of all enterprises intend to engage third-party services for both designing and executing cloud security. To assist developers and operators to use the platforms' security features to best advantage, the major cloud vendors offer a broad palette of cybersecurity training and consulting services.

Better, data-driven insights power a more effective organization

The old adage that data is the lifeblood of an organization has never been truer. Any data that is relevant to providing a better student experience, higher levels of retention and success, and a smarter, more sustainable campus should be actively curated and analyzed for the insights it contains. Ovum's 2018 digital maturity survey indicates that only 35% of higher education institutions are well advanced or complete in exploiting the value of data across the organization. This is well below the leading industry group, financial services, at 54%.

Several factors have hindered universities from taking full advantage of all the data they collect.

Firstly, only limited data is available in traditional business intelligence (BI) systems, primarily summaries sourced from enterprise resource planning (ERP) and other transactional systems. This transactional and structural data is of limited value in answering questions such as, "Is this student engaged and likely to succeed and, if not, what will improve the likely outcome?"

Making broader data – such as social media and engagement (e.g., customer relationship management, or CRM, and service management) information – available requires substantial effort and different skills and tools than institutional research and reporting. There is a rich variety of cloud data management and analysis tools available; however, these will need to be complemented by new staff competencies in big data analytics if value is to be generated.

Secondly, traditional BI systems use summarized data to identify trends and relationships. Many problems, such as locating at-risk students or finding fraudulent transactions, are more akin to finding needles in a haystack than summarizing data. AI methods, such as machine learning (ML), can effectively analyze much larger and more-complex datasets and deliver faster, more-accurate results than previous techniques. ML models need to be both trained and run on large quantities of well-prepared data – both of which require specialist skills and significant effort.

Finally, analysis, when it is available, is often delivered through applications separate from those used to conduct everyday activities. Specialist applications can have steep learning curves, access may be limited, and users need to make a conscious decision to move out of their line-of-business system to access the insights. Embedding the insights within line-of-business tools is an imperative if data insights are to change behavior, and is a practical endeavor with modern systems.

Higher education has been slow to adopt big data, with only 50% of higher education actively trialing or having deployed data lakes and big data tools, compared with the leading sector, banking, at 66%.

AI stands on its own as a source of innovation. From chatbots to advanced analytics, the cost and time to train and deploy are steadily decreasing as the power of the tools increases. These technologies are ready for mainstream use and should no longer be considered as suitable only for bleeding-edge adopters. Among higher education institutions, 43% are trialing or have deployed some form of AI, compared with the leading sector, telecommunications, at 64%.

Chatbots and natural language processing tools can create powerful, conversational user interfaces. These services are evolving very rapidly both in power and ease of use, and consuming them in the cloud removes the need for constant updating to keep up with advances.

A key caveat with AI is that it requires large quantities of high-quality data to generate meaningful outputs, so a parallel focus on data management is essential. Fortunately, the recent emergence of AI tools for data curation has automated some previously complex and time-consuming tasks, reducing the load on data professionals.

The University of Queensland (UQ) is a public, research-intensive university and a "Group of 8" member located in Queensland, Australia, with around 52,000 students and 6,600 staff members. While switching to cloud infrastructure has delivered better outcomes and experiences for students and staff, AWS has particularly enhanced research capabilities while lowering storage and compute costs.

UQ's move to AWS has enabled its researchers to have near-instant access to sophisticated data and analytics tools, exponentially increasing the speed at which researchers are able to work and share massive datasets with collaborators across the globe. AWS records metadata automatically (which was previously a manual process for many researchers) and performs analysis of data pipelines in near-real time.

The UQ IT organization's own speed of service delivery in providing research support has increased exponentially with AWS. When one graduate student needed six compute nodes to conclude a project in a week, the IT team was able to equip/give her access to those resources in less than a day, and she was able to do her computational work before the deadline. UQ's experience demonstrates the ways in which cloud services can enable better and faster access to high-quality data, thus increasing the level of insights that result.

Cloud allows IT to refocus on directly supporting business effectiveness and transformation

While "lift and shift" for existing systems is a substantial initial project, often spanning several years, it is important to focus simultaneously on developing IT's new value proposition: brokering, orchestrating, and integrating the cloud-based application and data ecosystem that will support the university's future.

Moving away from directly managing infrastructure, platforms, and applications allows IT teams to refocus on, and expand capacity in, those roles that more directly support the evolving university: for example, designing and transforming the user experience, reforming business processes, and turning data into insight.

Managing cloud infrastructure, developing cloud-native applications, and working more closely with the business all require different skills. Engaging staff in the right professional development will be an important contributor to success.

Notre Dame, a private research-intensive university in South Bend, Indiana, has about 8,000 undergraduates and 4,000 graduate students, with a staff of 4,600. In 2011, its Office of IT (OIT) began to explore how moving to the cloud could enhance the flexibility and scalability of the services it provides for students and staff, all while staying within budget. It created an ambitious cloud-first strategy with the overall goal of having 80% of its academic and administrative workloads in the cloud within three years. It has exceeded its initial 80% goal, estimating that 84–85% of its workloads are now in the cloud; its efforts were awarded with the EDUCAUSE Cloud Leadership Award in 2017.

With their move to cloud infrastructure, Notre Dame's IT staff are happy that they can now devote less time to rote tasks, such as maintaining infrastructure, and can instead explore higher-value, innovative work. For example, the IT team has helped support and create an ingestion model that takes in data from different systems (such as its LMS and video-content data) and uses predictive analytics to identify at-risk students within their first month of enrollment. Being able to shorten the time to insight and provide interventions is a differentiating service that the university can now use to support foundational missions like student success and retention.

Cloud pricing models optimize institutional spending

On-premises infrastructure spending practices are sub-optimal at all stages of their lifecycle. Capacity is normally procured in substantial tranches, anticipating the type and quantity of infrastructure that will be needed in the future. A substantial proportion of new infrastructure will lie idle early in its lifetime, having been purchased to meet future needs. In mainstream use, traditional practices provision for peak load, resulting in low utilization rates for the rest of the time. At the end of the lifecycle, as applications are moved to the next generation of infrastructure, the original infrastructure again runs idle before decommissioning. Development, test, and standby disaster recovery environments consume resources, even when idle.

Long-term value can be increased by eliminating infrastructure capital costs and by scaling capacity up and down to match demand. Additionally, the cost and risk of evaluating, and then deploying, new technology at scale are reduced by using cloud services with well-known scaling characteristics and automation.

Historically, UQ researchers had found that calculating the funding, research capabilities, technology, and equipment when applying for grants had been essentially a guessing game. Researchers would find they'd overestimated compute and storage costs or, more frequently, that they were at risk of running out of funding before concluding their work. However, using AWS cloud infrastructure allows them far greater flexibility and cost savings while processing complex workloads. Its pay-as-you-go pricing means that researchers only have to pay for the storage and compute resources they consume, and the elasticity of the cloud allows them to scale their experiments up or down as needed.

Software and infrastructure upgrade projects and system patching are expensive and often unaccounted for in the overall lifetime system costing. Application upgrades may be substantially more expensive, or even prevented, where customization has occurred. In cloud services, particularly SaaS and aPaaS, the service core is protected from customization.

As cloud services are adopted, IT's financial needs move away from capital and toward operational costs. Capital infrastructure and perpetual software licensing largely disappear in cloud initiatives, along with the attendant allocations for depreciation. While this can initially disrupt university

budgeting for IT, it has the benefit of surfacing the ongoing cost of running new services at the project approval stage – something that has often been difficult to argue successfully for in university circles. In addition, the cost reduction on terminating a service is easier to calculate and is less deeply tied into IT staffing provisions and bulk infrastructure spending.

From a price perspective, Notre Dame is now able to do far more with the same IT budget. While migrating its various systems to AWS, the institution was able to retire around 90 services that were no longer necessary and thus allocate those resources to other initiatives. With the ability to use cloud services on demand, and with the elimination of the need to perpetually refresh its hardware, the school has been able to provide more services and to meet campus demands on a greater level without needing to increase its budget.

Cloud can transform the user experience

If you're not delivering something that directly improves the experience of your students and other stakeholders, you're not getting the full benefit of the cloud. Thinking "customer inward" may uncover pain points and new opportunities that can be addressed in unique ways by cloud services. With ever-reducing barriers to entry, CIOs should have a constant stream of low-cost trials underway to assess the value and application of new technology, bringing the successful ones online with minimum delay.

Benefits enabled by cloud services include the following:

- Robotic process automation may be able to remove unnecessary steps and wait times from your business processes, substantially improving staff and student satisfaction.
- A chatbot might be able to answer many student and staff queries, at any time of the day or night, reducing labor costs and raising satisfaction.
- Operational and IoT data that could improve the campus experience might be lying dormant in your facilities and network departments.
- Social and engagement (CRM) data can provide valuable insights to enable student success and improve the university's public profile.
- Augmented and virtual reality have many applications, from student wayfinding to teaching anatomy and astrophysics.
- New cloud services, such as AI, offer the opportunity for greater insights into, and personalization of, the administrative and learning experience.

The main goal of ASU's University Technology Office (UTO) is to put student success – increased engagement, an improved campus experience, and more – at the heart of its initiatives. One major project was to improve ASU's mobile app, which was first released in 2011 and was relaunched in April 2018, built on AWS cloud technologies. The new app gives students a much more personalized way to interact with the campus and its other constituents (with integrated schedule data, campus maps with wayfinding capabilities, virtual tickets for sports events, and real-time transit information on campus shuttles).

The relaunch was very successful, with over 91,000 unique downloads, including 92% of the freshmen class, in the past year. ASU is highly focused on increasing retention and completion rates, and initial data (while not 100% correlative) has indicated that freshmen who have downloaded the app have a much higher retention rate than those who did not. Future plans include a voice-enabled component as well as chatbot services.

ASU is also a pioneer among higher ed institutions in the usage of voice-enabled services to enhance student engagement and learning. In 2017, the institution released an ASU-specific application or Alexa skill, called "Ask ASU," in which Alexa will answer questions such as academic calendar dates, the business hours of campus buildings, facts and features about the university, and other frequently asked questions. The UTO is also currently exploring the addition of more-personalized features in the Alexa skill, in which a student, after authenticating their identity, can ask Alexa for information about their grades, deadlines, and financial aid information.

Cloud education enables students and staff to gain new skills

As cloud technology affects all industries, gaining competencies in the cloud can be an important way for students and staff to help them succeed in the changing world of work. Gaining access to cloud training and tools (such as AWS Educate, Amazon's global initiative for cloud-related learning), either from an institution or from a vendor, can give students a valuable skillset that will serve as a competitive advantage when searching for employment.

While the move to the cloud might initially be a source of trepidation for those in the IT organization, who might fear the loss of their job or a dramatic shift in their daily responsibilities, institutional leadership should look at this as an opportunity to help IT gain new and relevant skills.

Notre Dame's IT leadership emphasized that the AWS migration was not about reducing headcount but was an opportunity for staff to learn modern and relevant skills; many OIT members are now trained in AWS architecture, analytics, and cloud computing skills. Moreover, as a way to impart these increasingly in-demand skills to their students, Notre Dame's Mendoza School of Business has created a robust cloud-computing educational curriculum, with courses that offer cloud-computing competencies and training in AWS. (Its online training provider, A Cloud Guru, is hosted on AWS and uses AWS Lambda serverless computing, so classes are delivered to students via a web browser.)

Similarly, ASU's students can enroll in courses on a voice-enabled interface and other cloud technologies (and some students in specific dorms or programs are even given their own Echo Dot to use and program on). In doing so, these students can experience and directly participate in the intersection of technology and education while gaining voice-technology skills that will be very attractive to prospective employers. In addition, over 5,000 ASU students are participating in the AWS Educate program, learning about the fundamentals of cloud technology.

Each stage of the cloud journey generates different value

Most educational institutions have begun the journey to the cloud, one that has several distinct stages. At each phase, issues of quality, cost, governance, pace of change, and IT skills present differently.

The initial stage: One foot in the cloud

The initial stage of the cloud journey is often driven by the need to escape the infrastructure renewal cycle (IaaS) or an interest in adopting a single SaaS offering. Whichever need triggers the journey, the impact inevitably spans the IT organization and beyond. Along with beginning to realize the

benefits of the cloud, there are several issues that need to be addressed if the cloud journey is to proceed smoothly.

Budgets and procurement

The pay-as-you-go nature of the cloud requires a different approach to budgeting for projects and ongoing operations. The first hurdle often encountered is in project and annual IT budgeting, where there is a distinct shift from capital (and depreciation) to operational budgeting, and from staff to external services. In order to avoid roadblocks with every cloud-related initiative, it will often be necessary to present a budget-related paper to the senior executive that outlines how these changes will impact project and operational budgets into the future. Presenting a total cost of ownership (TCO) or total value of ownership (TVO) analysis at the application level can be useful in arguing the overall proposition of moving to cloud infrastructure and services.

Once a cloud account is created, new capacity can be enabled by a developer or engineer simply clicking an on-screen button, and costs begin to accrue immediately. This ability to authorize spending is previously unlikely to have been in frontline hands, and new disciplines will need to be established to ensure cost control, replacing traditional procurement and the purchase order. Self-discipline, training, automation, and regular audits are preferred to establishing complex bureaucratic approval processes, as these high-process overheads erode the significant cloud benefit of being able to stand up new capacity (or to scale and decommission it) quickly.

Finally, the IT budget will have to support legacy skills and invest in those needed for the future during the transition to the cloud, which will consume a portion of the cloud's financial benefits during the transition phase.

Data governance

An extensive discussion should ensue as the first significant data set is tagged to move to the cloud in order to ensure security, privacy, and legislative compliance are maintained. Once this initial discussion has occurred, it is important for the outcomes to be incorporated into policy as soon as is practicable to avoid inconsistent outcomes and unnecessary delays in subsequent initiatives.

Architecture

During this first stage, new development may be cloud hosted but is most likely to be traditionally architected. Adopting the tools and techniques of the cloud too rapidly for mission-critical applications can be as problematic as trying to fit old ways of thinking into the new "as-a-service" world. Leveraging business-project proofs of concept to validate new architectures and then purposefully reusing proven, cloud-native patterns can help to safely and rapidly scale cloud practice.

Operations

The shift to externalized mission-critical applications will be challenging to security and incident management. Security and operational monitoring arrangements will need to be adapted to provide alerts on external events and trigger remediation processes that include external parties. To facilitate fast and effective action when something does go wrong, it will be necessary to build robust service management relationships with cloud providers, based on solid contractual arrangements.

As mentioned above, unsafe or budget-draining configurations can be created at the click of a button if effective operational controls are not in place.

Moving to the cloud, despite the high levels of availability, does not absolve CIOs of the responsibility for good disaster recovery and provisioning for business continuity. As most SaaS vendors take advantage of the multiple data centers provided by top-tier cloud infrastructure vendors within each logical location, the risk of system unavailability is reduced to being almost negligible. However, loss of connectivity to campus, and data loss or corruption still need to be provisioned for. So, backups must still be made and kept separately from working systems, and alternate, business-continuity processes need to be maintained in case of loss of local access to business-critical systems.

From robust developer to agile orchestrator

A new shift in perspective is necessary before advancing to the next cloud stage. With a shallower technology stack needing to be delivered directly by IT, it is possible to start thinking about IT sharing responsibility for the business outcomes of the initiative, not just the technology outputs. This is paramount if IT is to become a transformation-enabling business partner rather than simply a technology supplier.

The shift from supplier to partner is unlikely to occur until IT begins to apply significant resources to engage in co-design of the future business environment and supporting business change. In order to get enterprise-wide support, Notre Dame's OIT collaborated with at least one staff member from every department to create and execute its cloud migration plan.

At this stage, most IT organizations need to maintain both traditional and agile/DevOps project and service governance regimes. While issues of cost and complexity are largely unavoidable, negative impacts can be minimized by triaging initiatives into one or the other stream at inception, and not attempting to create unified processes that can seamlessly handle both modes. For instance, a traditional gated project and change processes, where programs submit extensive documentation to boards that meet on a fixed calendar, will unduly impede low-documentation, fast-moving, agile initiatives.

With less work to do in-house, and the shorter commissioning times for cloud infrastructure and services, greater agility is possible for IT and the business. Platform (aPaaS) services, low-code tools, and agile development become attractive, and their adoption often triggers the second phase.

The move to the cloud won't happen by itself. Throughout the journey, it is useful to have a team who can develop and evolve cloud strategy and orchestrate all the aspects of cloud implementation, providing timely and effective communication with the IT team and beyond about the benefits and means of employing the cloud to best effect. For example, Queensland's IT department has created a designated cloud-centric team to provide guidance, oversee architectural design, and manage cloud governance across the campus. One way in which this team has proved to be instrumental is in creating and implementing an enterprise-wide strategy for tagging (self-created metadata for labelling cloud resources). Tagging is critical for understanding and tracking how cloud resources are being utilized for governance, reporting, and cost management purposes.

The intermediate stage: Cloud-first is a transformational choice within and beyond IT

As the first agile, cloud-native project begins to deliver its unique combination of fast/incremental business transformation, the writing is on the wall for IT. With the rate of business and marketplace

change steadily increasing, traditional waterfall project approaches for anything but the most static of requirements will rapidly be viewed as non-viable.

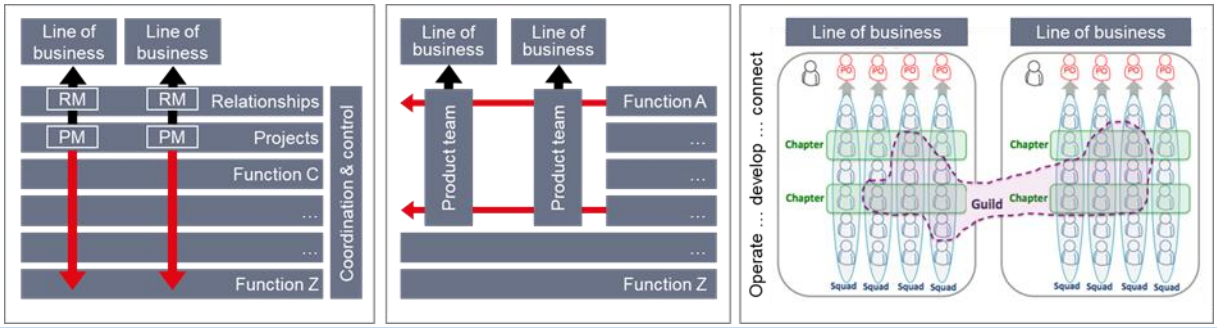
At this point, IT needs to shift from relying mostly on traditional services and agile at the edges, to being agile (but still robust) and cloud-native at the core.

IT's role and structure transforms

Once several agile, business-intimate projects have validated the new approach within IT and beyond, more business leaders will be willing to engage. The increased cadence of the sense-select-solve-employ-review cycle of agile change is very different from the plan-once-build-deploy models of the past, and requires far more intimate partnerships, at every organizational level, between IT and functional staff – all focused on successful, incremental business change and the achievement of business outcomes, rather than just high-quality technology delivery.

The benefits of retaining a deeply functionally aligned IT organizational structure (left-hand side of Figure 2) erode as the agile/cloud transformation proceeds. To increase their capacity to be business-responsive, many organizations have realigned their system development and operations groups around lines of business and managing functional (e.g., business analysis, programming, and systems administration) and technical governance tasks by coordination across the business streams. This transformation often occurs in several stages, generally beginning with activities closest to the business. Infrastructure and operations activity often remains integrated across business streams until the predominance of this activity is cloud-delivered.

Figure 2: Evolution of the IT organization



Source: Ovum

During the transformation it is tempting to continue to maintain the two-speed process and governance environment that supported the first stage. This an expensive and effort-absorbing option. Instead, it is recommended that organizations go back to the basic principles of managing risk, and rework policy, procedure, and governance with fundamentally agile operations in mind. There are mature, integrated frameworks such as Scaled Agile (SAFE) that are ready for adoption.

Leveraging the power and speed of the cloud

Designs in this second phase more effectively leverage the ability to deliver unique business needs using modular cloud components. aPaaS also provides a highly functional base for building new services. Traditional integration models and tools are less effective for cloud-native services, and a cloud-based integration suite is a fundamental component of the second stage alongside a modern, federated identity management system.

Automated, dynamic scaling becomes a key mechanism for cost control and satisfying variable business demand, as well as minimizing standing costs for development, test, and disaster recovery environments.

As the speed of delivery increases, end-to-end automated testing becomes increasingly important. Detecting code errors as soon as possible after their creation significantly reduces the time and cost of remedy. Automated testing allows any human contributions to be focused on resolving rather than locating issues. Adding automation to deployment, and automated verification post deployment, nearly eliminates errors introduced during manual deployment steps and vastly reduces calls to the service desk related to post-deployment issues.

The innovation stage: Peering into the fog of the future

Cloud-based components, such as AI, data lakes, streaming analytics, augmented reality and virtual reality (AR & VR), and collaboration, can be combined into completely new classes of business solution, and the transition from proof of concept to enterprise-scale deployment is simplified through the low cost of setting up a small-scale environment that can then be seamlessly scaled.

Immersive teaching and revolutionary research environments will be enabled by the combination of more powerful ways to collect, analyze, and visualize data, and the use of multisensory interactions through haptic, natural language, AR, and VR interfaces.

Quantum computing will herald a new era

Just as AI is rapidly changing the way we manage and process data and interact with machines in ways that were impractical only a few years ago, quantum computing will change the landscape of the kinds of problems technology can address. AI is already helping resolve the Sisyphean task of managing and leveraging today's avalanche of data, and quantum promises orders-of-magnitude greater power in data analytics.

On a more pragmatic note, current cryptographic methods, which rely on requiring impossibly high amounts of traditional processing to crack their codes, may be rendered worthless as practical quantum computing emerges. Blockchain applications are similarly at risk.

In preparing ourselves for this revolution, it is likely that quantum-emulating hardware will become widely available in the cloud, just as GPU- and AI-enhanced server chipsets are currently proliferating.

Sensing, cognitive computing, and IoT will bridge the gap between the real and virtual worlds

Driverless cars, robotics, AR, and all kinds of other autonomous, real-world intimate systems will emerge that will need to sense and respond to the environment around them in real time – with delays measured in microseconds and milliseconds – as well as maintaining contact with the broader picture. The need for edge computing power to sense and respond quickly will continue to increase. We are already seeing serverless computing languages moving beyond the data center, allowing low-latency computing close to the device to seamlessly integrate with the cloud-computing core, and we expect implementations, such as AWS' Greengrass, to become ubiquitous.

Sense and respond capability will leverage parallel advances in gathering and processing of sensory data such as audio, image, and touch using copious quantities of increasingly powerful AI. The

primary interface to future systems is likely to be via natural language and AR rather than keyboard, mouse, and screen.

One of the benefits of these technologies is their ability to positively affect and address real-world issues. Arizona State launched the ASU Smart City Cloud Innovation Center (CIC) in March 2019. Powered by the AWS Cloud, the center focuses on using AI and ML and other emerging technologies supported by cloud computing to build smart communities and increase economic and workforce development. The CIC will work with the 22 municipalities within the Phoenix metropolitan area to reduce costs and optimize usage of IoT and other emerging technologies to address community issues (e.g., reducing homelessness, pedestrian fatalities, and water consumption rates).

Digital tools will increasingly be applied to managing digital risk

As technology proliferates, new forms of risk flourish. However, technology can also help manage risk.

Continuous and real-time, rather than periodic and historic, processing of risk-related data is becoming a necessity as the velocity of business, and risks, rises. Streaming analytics tools, long used in network and infrastructure operations, are a good fit for this. ML, one of the many faces of AI, can assist in finding the needles of aberrant behavior in a haystack of data. Blockchain has strong potential to be the future technology of choice in establishing an irrefutable and accessible record of events and their outcomes.

While technology provides the tools of digital risk management, it is important to remember that cultural and other human factors will make or break any initiative that transforms decision-making or operational processes, particularly if it appears to threaten personal autonomy or job security. Transparency and communication about the benefits and value of a technology initiative are important to facilitate buy-in.

Failing to apply the tools of the digital era to risk management will leave enterprises continually fighting rearguard actions against events that could have been addressed earlier in their lifecycle at lower cost and with less negative impact.

Without the cloud, IT will be hard-pressed to support the institution through change

Leading-edge cloud software and services open up new ways to address issues and opportunities for higher ed institutions, from providing better support for teaching, learning, and research, to meeting modern student expectations, to accelerating the speed at which experimentation and innovation can take place. By using the proper strategic processes and transparent, cross-enterprise communication, schools will be able to forge their own path forward to achieving institutional transformation.

Appendix

Author

Richard Palmer, Practice Leader, Public Sector

richard.palmer@ovum.com

Joyce Kim, Analyst, Education Technology

joyce.kim@ovum.com

Ovum Consulting

Ovum is a market-leading data, research, and consulting business focused on helping digital service providers, technology companies, and enterprise decision-makers thrive in the connected digital economy.

Through our 150 analysts worldwide, we offer expert analysis and strategic insight across the IT, telecoms, and media industries.

We create business advantage for our customers by providing actionable insight to support business planning, product development, and go-to-market initiatives.

Our unique combination of authoritative data, market analysis, and vertical industry expertise is designed to empower decision-making, helping our clients to profit from new technologies and capitalize on evolving business models.

Ovum is part of Informa Tech, a B2B information services business serving the technology, media, and telecoms sector. The Informa group is listed on the London Stock Exchange.

We hope that this analysis will help you make informed and imaginative business decisions. If you have further requirements, Ovum's consulting team may be able to help your company identify future trends and opportunities, please contact us on

https://ovum.informa.com/contact/contact-us

consulting@ovum.com

Copyright notice and disclaimer

CONTACT US

ovum.informa.com

askananalyst@ovum.com

INTERNATIONAL OFFICES

Beijing

Boston

Chicago

Dubai

Hong Kong

Hyderabad

Johannesburg

London

Melbourne

New York

Paris

San Francisco

Sao Paulo

Shanghai

Singapore

Sydney

Tokyo