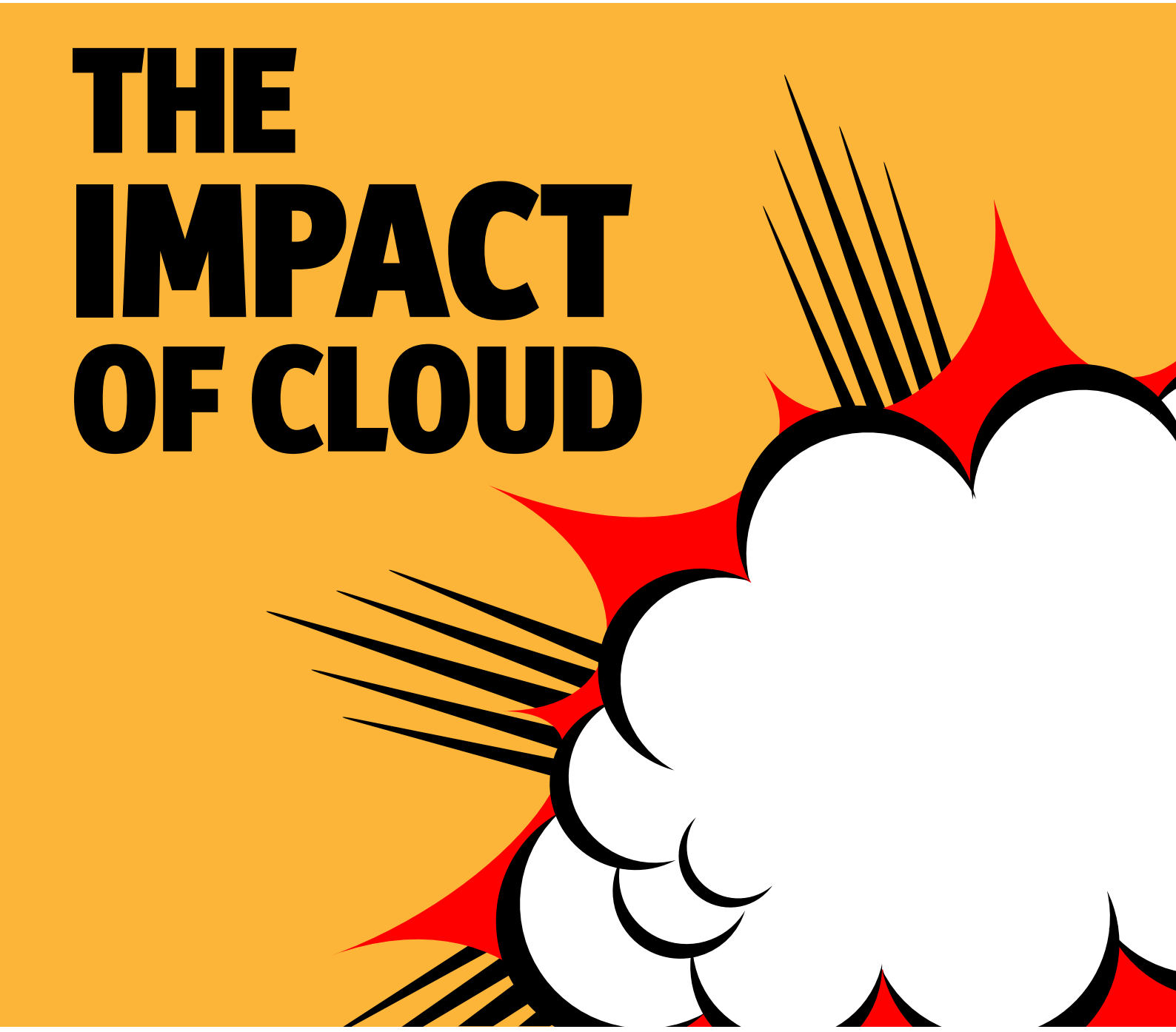
The Economist Intelligence Unit

A curated report by the Economist Intelligence Unit.

THE IMPACT OF CLOUD



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INTRODUCTION

The impact of cloud computing has barely begun , writes The Economist Intelligence Unit

Cloud computing has already made huge waves in the technology industry. Consumer cloud services such as iCloud, Google Drive and Dropbox have changed the way people think about digital content and how to use it. In the enterprise sector, cloud deployment is increasingly the preferred option, no longer the niche use case.

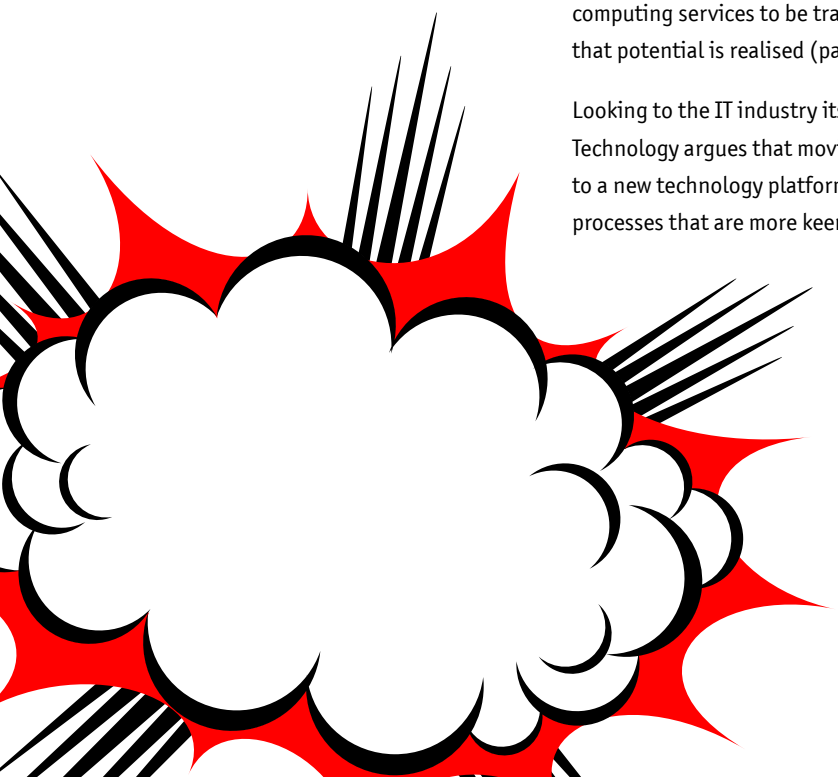
But this is barely the beginning. The rise of utility computing services, delivered over the Internet (or internally, in the case of private clouds), will continue to disrupt markets, spawn new business models and revolutionise information-sharing and business management for years to come.

To provide a glimpse of the true impact of cloud, The Economist Intelligence Unit invited a number of experts from management, academia and the technology industry to explain what they believe will be one impact of the cloud in the medium to long term. The variety of responses presented in this curated report, sponsored by Fujitsu, is in itself proof of the cloud's far-reaching significance.

Mark Ridley, technology director at reed.co.uk, predicts that the ready availability of technology services the cloud enables will reshape the way businesses are organised (page 5). He believes that the notion of an "information technology department" distinct from the rest of the business will eventually give way to a network organisation of small teams with a mix of technical and non-technical skills.

Next, Dr James Mitchell, CEO of cloud broker Strategic Blue, explains the potential for cloud computing services to be traded as a commodity – but also why cloud pricing must change before that potential is realised (page 8).

Looking to the IT industry itself, Dr Tua Huomo of the European Institute of Innovation and Technology argues that moving to a cloud service model not only challenges suppliers to migrate to a new technology platform, but will also force them to adopt operational and developmental processes that are more keenly focused on customer value (page 11).



Paul Miller, an analyst and consultant at The Cloud of Data, contends that while the dangers of putting personal data in the cloud have been widely discussed, the cloud's potential to empower individuals to control their own data is far greater (page 14). That said, there are considerable challenges to be overcome before that happens.

In recent years data centre operators in general, and cloud providers in particular, have come under criticism for their undeniably significant energy consumption. However, Professor Ian Bitterlin of The Green Grid Association predicts that the unique technical qualities of cloud computing mean that it is likely to have far less of an environmental impact than preceding computing paradigms (page 17).

And finally, Dr Jonathan Liebenau, reader in technology management at the London School of Economics, explains why cloud computing will have a net positive impact on the economy – but not every country and industry will feel the benefits equally (page 20).

Put together, these expert views reveal the many frontiers on which cloud computing is driving change: from internal operations to the IT industry, from the economy to the environment. That diversity of change compels business and technology leaders not to think of cloud computing simply as a replacement for older computing platforms. It is a revolution in the way information is stored and shared that could prove as disruptive to business practices as the advent of computing itself.

Given that it is a computing paradigm that emerged during the gravest recession since the 1930s, it is unsurprising that cost – or, to be more precise, cost flexibility – has been the prime driver for cloud adoption. The essays that follow reveal that there are many more factors to consider.

To assess its real significance to their organisation, therefore, executives should also pay close attention to how cloud computing is enabling new business models, transforming business processes, changing market dynamics and, in some cases, creating new markets altogether. It is here that the true revolutionary impact lies.

HOW CLOUD COMPUTING WILL RESHAPE YOUR BUSINESS

The cloud is rendering the division between IT and business obsolete, and the hierarchical org chart with it, writes Mark Ridley, director of technology at recruitment website reed.co.uk

Technology has always shaped the organisations that use it. When business academics Harold Leavitt and Thomas Whisler coined the term "information technology" back in 1958, they predicted that it would cause large companies to "recentralise" and trigger "a radical reorganisation of middle management".

But information technology, when Leavitt and Whisler defined it, comprised three distinct themes: "techniques for processing", "the application of statistical and mathematical methods to decision-making", and "the simulation of higher-order thinking through computer programmes".

These themes may still be part of the modern IT department's remit, but the work that IT does today is far broader than Leavitt and Whisler could have imagined.

Unsurprisingly, the shape of IT departments has changed hugely since the 1950s. And today technology is changing the scope of "IT" again – so much so that the structure of entire organisations must and will change.

THE MODERN ROLE OF IT

The Information Technology Association of America (ITAA) has defined information technology as "the study, design, development, application, implementation, support or management of computer-based information systems". But even this definition falls short of the reality faced by most IT teams.

Today's IT departments undertake an enormous range of tasks, from buying and supplying desktops and printers to statistical analysis of data on a scale that could never have been imagined even 20 years ago. Those tasks require a broader range of complementary skills than ever before.

To name but a few: helpdesk staff support ever more demanding users; procurement teams negotiate deals; architects design IT infrastructure while security experts keep it safe; and business analysts write the specifications for software to be coded by developers, while designers and user experience (UX) researchers consider how best to deliver the experience to the end user.

Mark Ridley
reed.co.uk

The status of the IT department as 'the people who deal with technology' is no longer fit for purpose.

All the while, the ongoing evolution of technology demands that these experts are continually learning and challenging themselves. In the IT department of today there is no career for life, and no single specialism is a strong enough mast to lash your skills to while riding out the storm. Change is at the very core of what IT has become.

The most substantial driver of change is the fact that the IT department no longer has a monopoly on technology. On one hand, smart mobile devices – computers by another name – are pervading our personal lives and are infiltrating the workplace. Meanwhile, the ubiquity of services delivered via the Internet – cloud computing – means that the requirement for IT departments to host their own, customised systems is diminishing.

Among new employees joining a company there is an expectation that the services provided by their organisation will at least match the quality that they expect from their own personal devices.

If, as a Gmail or iCloud user, I can expect my phone to alert me to emails and chats, store all of my photos and documents and be aware of my availability and location, why should I not expect that from my work device? If I can use Facebook, Snapchat or Twitter without a training session, why should I need an induction to explain how my HR system works?

And it's not just end users who are experiencing this effect. Compare the job of administering SharePoint on an on-premise server with the experience of a Jive, Huddle or Google Apps admin. The knowledge and training required by the latter is vastly decreased because of the reduced opacity and complexity of the administration experience itself.

The "expert" and "user" roles are merging, which in turn blurs the line between business and technology functions. Deciding which department owns which task will only become harder.

In light of the simplicity and accessibility of cloud computing, the status of the IT department as "the people who deal with technology" is no longer fit for purpose.

NETWORKS, NOT DEPARTMENTS

One possible solution is to reorganise the business as a network, rather than a hierarchy.

Some modern management theorists, such as John Kotter and David C Aron, have suggested that adopting a network or cluster organisational structure can support the kind of agility that many businesses crave. But it could also be a better way to split the responsibility for assigning domain expertise between teams.

Rather than a typical organogram with department heads and lines of hierarchy, the network structure requires groups, or squads, of specialists and experts who are defined as much by their own skillsets as the relationships and contacts they have with other groups in the business.

This structure allows the business to grow and adapt to challenges more easily, by bringing cross-disciplinary teams together with specific unified objectives. Where previously IT might have inherited a project for the delivery of a finance system, within the network model a team would be pulled together to address the business objective, with no concern for disciplinary boundaries and a single-minded focus on the outcome.

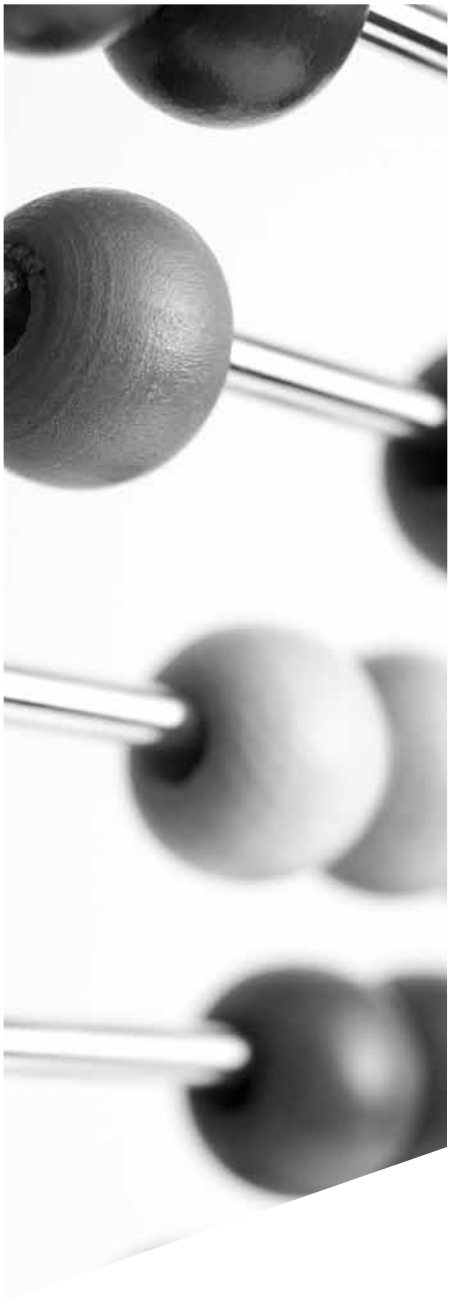
Squads, grouped by domain expertise, would no longer be bound by departmental responsibility. Tossing projects over the wall – "IT have let me down on this project again" – would no longer be possible, with teams committing to their own objectives and selecting their resources as needed. The network system is more organic, fluid and dynamic, with a greater sense of the value of individual contribution and less reliance on seniority and rank.

What is perhaps most notable is that in the best companies these lines are already blurred, and cross-team collaboration is common. The network model just makes this behaviour explicit and encouraged.

The greatest challenge with a network system will be at the strategic level. While squads will be able to deliver business value more immediately, the definition of the strategic direction of the company and the communication of the strategy to the teams will be critical.

At this level, perhaps the greatest change is how a board can assign responsibility, with traditional hierarchical responsibility no longer supporting the structure of the organisation beneath.

Not only will the roles of the chief information officer or chief technology officer no longer fit, but the roles of the chief finance officer and chief marketing officer, as well as any other vertically assigned executive roles, will also be challenged. The accountability of individuals to define the company strategy and take ownership of delivery will be undiminished, but the assignment of responsibility will, perhaps rightly, be more dynamic and demanding.



WHY CLOUD PRICING IS BROKEN

Commodity trading of cloud services would benefit both buyers and sellers, but the industry's current pricing models are standing in the way, writes Dr James Mitchell, CEO of Strategic Blue, a cloud broker

One of the more remarkable characteristics of cloud computing is that, in theory at least, it turns IT resources into tradeable commodities.

If cloud providers can deliver services – such as processing or storage – that can be measured against a benchmark quality, then it is theoretically possible to buy and sell those services as commodities in a futures market.

Futures markets can be used by companies to protect themselves from fluctuations in the price of commodities they buy or sell. Power stations use electricity futures markets to finance their construction projects at a lower cost, for example, as do major users of electricity such as aluminium smelters or bleach manufacturers.

A futures market for cloud computing, then, could benefit both users and suppliers. It would allow intermediaries to package up services and contracts to meet each buyer's precise needs at an optimal price. It would also mean that sellers are more likely to attract investment – vital for building their cloud platforms – as their services have a transparent value.

There are certain prerequisites for a commodity market to function, however. One is a vibrant ecosystem of providers, and this is already evident in the cloud computing market. Since the online retailer Amazon pioneered the delivery of scalable computing services under a utility, pay-as-you-go model back in 2006, it has dominated the Infrastructure as a Service (IaaS) market.

However, there have been plenty of entrants into the cloud market. Many of the large enterprise IT companies have cloud offerings, and a whole new generation of smaller, specialist providers has come into being. In short, competition is alive and kicking.

Another prerequisite for something to be traded as a commodity, in theory at least, is that it must be fungible. This means that units of that commodity can be exchanged for one another without any impact on the quality of service.

Anyone who has tried migrating from one cloud service to another will know that they are not precisely fungible. In fact, making the switch requires careful comparison of capabilities, performance, pricing and the accompanying legal documents.

Dr James Mitchell
Strategic Blue

By establishing a transparent value for commodity cloud services, businesses will be able to put a price on innovation.

That said, many of today's most widely traded commodities are not truly fungible either. Try telling a coffee connoisseur that all coffee beans are the same, or try putting diesel fuel in a petrol engine. Nevertheless, coffee futures and crude oil are two of the most important commodity markets. The fungibility issue is side-stepped by creating a benchmark product that is fungible by definition and pricing "real" products by reference to the benchmark, making pricing adjustments for any difference in quality.

But there is one major hurdle to the commoditisation of cloud computing that has yet to be addressed: the pricing model.

In my opinion, cloud pricing is broken, at least from the customer's perspective, because cloud providers design their pricing to suit themselves, not the customer.

PAY AS THEY GROW

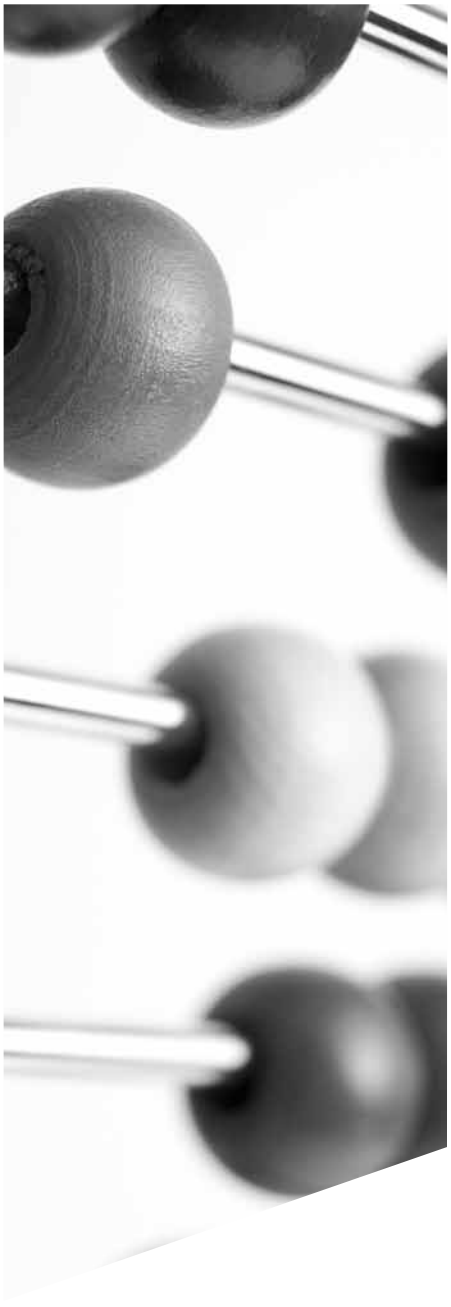
Take a new entrant to the IaaS market. The company has just reserved a small area in a data centre and has bought its first rack of servers and other infrastructure. Now all it needs are some customers to get the equipment used and to have a few user logos to put on their website. The provider therefore offers an "on-demand" or "pay-as-you-go" tariff to minimise the barriers to adoption and takes payment by credit card to keep customers' overheads down.

This is where almost all cloud providers begin their journey. The lucky ones have been able to maintain their on-demand prices, as customers have tended to be sticky and less sensitive to price in test and development environments, where cloud services are often used.

This has led to a situation in which customers, when they move their cloud-based systems from test and development to production, are paying for flexibility they do not need. This makes in-house, "private clouds" look cheap in comparison, impeding the move to a true utility or public-cloud delivery model.

But things are starting to change. Amazon, the market leader, has a business model that values market share over profit margin – the company has kept its profits to a bare minimum while growing exponentially in the last decade. And, like any business, it would frankly appreciate its customers providing a forecast for at least some of their future usage.

In 2009 the company launched "reserved instances" as a new pricing structure for on-demand instances. The new structure allows cloud buyers to make an advance payment in return for the option to use on-demand instances at a really low price in future, a little like buying a book of discount vouchers. Amazon later introduced another type of reserved instance, where a larger advance payment secures an even lower price, but without the option to turn the instances off and not pay for them.



Other cloud providers have followed suit, offering similar savings to customers who commit to future usage, although there are some big brand names that have so far resisted. However, even with new variations on the reserved instance on offer, cloud providers keep on skewing the terms in their direction. The insistence on advance payments is the most obvious example of this, and this is likely to persist, so that cloud providers can offer discounts for future usage commitments without worrying about the creditworthiness of their customers.

This is why I argue that cloud pricing is broken. Hopefully, it won't stay that way for long, however. The market price is becoming more transparent, and this is a good thing for cloud buyers, cloud providers and the rapidly developing resale chain in between. Cloud providers will be happy, because as soon as they are really regarded as a utility, they will be valued more highly by investment analysts.

There are some who believe that commodity trading will damage innovation in cloud computing, by encouraging providers to offer homogeneous services. This is not the case. Instead, by establishing a transparent value for commodity cloud services, businesses will be able to put a price on that innovation. The ultimate version of this is an exchange-traded benchmark cloud-computing index price.

In the same way as you can pay a little extra for high-octane petrol to improve the performance of your car, you should be able to pay a little extra for a higher-specification cloud service. Equally, you may wish to pay less for a cloud service without the bells and whistles.

That will help to attract investment to the largest number of providers with the most valuable services and ensure that cloud computing's potential as an engine of innovation in IT is realised.

WHY CLOUD WILL FORCE THE IT INDUSTRY TO FOCUS ON VALUE

For ICT providers, moving to the cloud is not just about adopting a new technology platform but also about transforming the way they deliver value to their customers, writes Dr Tua Huomo, FUTURE CLOUD action line leader at the European Institute of Innovation and Technology (EIT) ICT Labs

There is no escaping the cloud in today's technology landscape. And yet, the concept of the cloud which has caught on in the minds of the public at large is a much simplified version of the real thing.

Ask a layman, and their answer will probably try to convey the idea of moving files and services from a physical computer into the Internet. Most business executives by now appreciate that it is more complicated than that: they know that the cloud is a powerful combination of technologies including networking, storage and applications, as well as an ecosystem of services and providers.

But while these executives may have a better understanding of the cloud than the man on the street, they still often fail to grasp the extent of its potential impact on their organisation.

Take ICT companies, for example. Many executives from the ICT industry will have looked at cloud and thought of all the new revenue streams it could support. But they also need to consider how moving their products and services to the cloud might affect their existing business, their product portfolios, and even the way they think about themselves as an organisation.

If a company has traditionally offered its customers specially developed and tailored systems, these need to be adapted for use by a wider range of customers once they are moved to the cloud. The overarching business model therefore changes from one based on project and maintenance contracts to a licensing model – the more of the same product a business can sell, the more money it is going to make. By making this shift, businesses run the risk that existing customers, who had previously paid for the more tailored service, may look elsewhere following the move to the cloud.

Companies must also consider how the cloud will change the way in which they interact with customers. For example, the cloud has created a more global market for IT services, which requires a different attitude towards understanding customers. Also, in the cloud customers and consumers are faced with a wider range of services than ever before, and in the case of business customers, they are able to buy cloud services with less involvement from their IT departments. That, in turn, means companies must take the user experience more seriously.

Bearing all this in mind, the wider point begins to emerge – when you go into the cloud, whether you are a customer-focused business or an ICT service provider, it's really just the starting point in fundamentally changing your business from operational processes to organisational structures, from business models to partner networks.

Tua Huomo
EIT ICT Labs

Cloud computing requires a new understanding of how to create and deliver value to customers

LESSONS FROM THE FRONTLINE

Many companies have already spent a lot of time and money thinking about how they need to structure their organisations, the types of new competences they need, and the different business models they need to capture the opportunities presented by the cloud.

In short, it comes down to being more agile. When companies start providing services in the cloud, they also need to change their processes to be far more agile as real-time value delivery becomes increasingly important.

This is especially true in the consumer market: if you don't provide something new, something exciting, on a regular basis, you'll probably be left just looking on as your customers switch to a competitor who does. This is already interwoven into the DNA of gaming companies, for example, but not into that of more traditional ICT service businesses. Yet the pressure to produce new features and new product capabilities faster than ever to keep up with the cloud now applies to business-to-business providers as well, and brings with it an acceleration of the pace of business.

But while many acknowledge how the cloud both demands and enables greater agility, not all of them understand that it requires new tools and methods and a new understanding of how to create and deliver value to customers.

So, having established the need to improve the underlying framework of a company in order for it to succeed in the cloud, how can it actually be achieved?

Before joining EIT ICT Labs, I worked on an industry-driven collaborative research and development (R&D) programme called Cloud Software Finland. With a budget of €62m (US$86m) from the Finnish government and more than 30 organisations involved, it ran from 2010 to 2013. The project used applied research methods to develop lean and agile techniques and tools to support cloud businesses.

The methods we applied, such as Kanban and "value stream mapping", remove needless intermediate phases and bottlenecks and help businesses to create and implement systematic change that makes their businesses leaner. We learnt that many people think that being lean only means efficiency – that to be lean you need to cut costs. This is important, but lean is also about focusing on creating new value.

For example, companies need to provide new features as quickly and efficiently as possible, but you also need to be valuable to your customers. In order to keep your customers happy, you need to concentrate on the areas or segments that really bring value not only to your company, but to your customers as well. This needs to be done in a very systematic and comprehensive way. That equates to a strategy change for many companies.

These methods are today helping technology companies to deliver greater value to their customers. One example is Tieto, a large Finnish service software company for which the programme's pilot projects alone achieved savings worth several million euros.

Ericsson Finland, meanwhile, has seen a significant reduction in the length of its product cycle. Whereas once delivery capacity was twice a year, it is now measured in weeks. With new practices, Ericsson has also improved the quality of its products and reduced costs caused by malfunctions; the total amount of savings was estimated at around €100,000 a month.

At EIT ICT Labs, the Europe IT research institution where I now work, we recently changed the name of our cloud action line from "Cloud Computing" to "Future Cloud". That is because switching to the cloud is not just about the technology – it's about seeing the bigger picture: new products and services, new processes, new business models and new potential. This is not about business growth, but business transformation. ■

HOW CLOUD COMPUTING MAY REVOLUTIONISE PERSONAL DATA

Giving individuals control over their own data in the cloud offers benefits to businesses and consumers, writes Paul Miller, analyst and consultant at The Cloud of Data

So far, much of the debate around personal data moving into the cloud has been negative. It is coloured by revelations about snooping spooks, high-profile data breaches at large retail companies such as the US retailer Target, and the nagging doubt that Facebook, Google and the like are building a picture of us that is just a little too detailed for comfort. These risks are subject to frequent media attention even though they are, in fact, relatively infrequent occurrences.

More significant, in my view, are the potentially pervasive advantages of sharing information about ourselves via the cloud. But these are far less clearly conveyed, making it difficult for individuals and businesses to effectively weigh risks against benefits.

THE STATE OF DATA IN THE CLOUD

Information about us as individuals exists in many forms online, such as our purchase history with Amazon, Tesco, eBay or iTunes; the flights we searched for; and the trips we eventually booked with Expedia, Kayak, British Airways or EasyJet.

Meanwhile, near-ubiquitous "cookies" are deposited on our computers as we move around the web. Visit British Airways, Virgin Atlantic or some other brand, and you may very well find adverts from them – or their competitors – the next time you visit a wholly unrelated ad-bearing site such as The Guardian or Facebook. The information stored in customer accounts at sites such as Amazon is used by those sites to recommend further products we might like to buy, and advertising networks use the information from cookies to place adverts that their brand clients want us to see.

Today, individuals have very little control over the way these data are acquired, shared or used, and almost no incentive to take an active role in making the data a better reflection of our interests or ourselves.

There have been some attempts to change this. Back in the middle of the last decade an organisation called the Attention Trust Consortium set about building tools that would allow individuals to track their own browsing behaviour. It proposed that they should then be able to offer companies access to those behavioural data in return for some tangible benefits, such as discounted prices, demonstrably more interesting recommendations, or even cash.

Paul Miller
The Cloud of Data

Today, individuals have very little control over the way their data are acquired, shared or used.

An individual's purchase history with Amazon, they argued, should belong to the individual, who should be able to offer it to Amazon's competitors in return for better recommendations, discounts, etc. The Attention Trust model failed to gain traction, but the broader idea that browsers should own, control and potentially profit from data about themselves and their online activity refuses to die. A number of new, cloud-based services are now hoping to finally make that idea a reality.

US start-up Haggle, for example, collects information about an individual's preferences, past behaviour and online influence to offer discounts at restaurants keen to attract a particular type of customer. DataCoup describes itself as "the first personal data marketplace" and offers users money in return for access to their history on social media and even the transaction history from their bank accounts and credit cards.

Enliken, meanwhile, offers tools that make it easier for marketing companies to show consumers the information they already hold about them. This begins a dialogue which – in theory at least – leads to better data and an increased consumer perception that these brands are "trustworthy", and therefore deserving of more business.

Marketing is an obvious place to start giving consumers power over their own data. Marketers are already beginning to recognise how a trusted relationship can improve the quality of data they can collect from customers. Consumers stand to benefit, too, from a direct financial return or simply by improving the relevance and timeliness of the marketing material they receive.

However, there is a broader vision of personal responsibility for and control over data beyond this marketing context. This vision is evident in the world of so-called "personal data lockers".

The idea of a personal data locker is based on the view that individuals should have one "place" – a cloud-based vault or locker – in which to store any data that are of value to them: documents, photographs, personal contact information, financial data and more. Some data are simply placed in the vault for safekeeping – the online equivalent of the wills, deeds and personal effects stored in a safety deposit box at your bank.

More interesting, though, is the potential for the data stored in the locker to be used automatically. So, rather than asking you to enter your address, provide your bank details or prove that your car is insured, participating companies could simply ask for permission to access the relevant information in your locker.

One argument put forward by personal data locker providers, such as the Netherlands' Qiy, London's MyDex or Washington, DC's Personal, is that individuals will be able to give away far less information about themselves. A company requesting proof of age, for example, only needs to know whether or not the individual is over 18 or 21 – not their precise age or date of birth. A personal data locker could quickly return a "yes" or "no" answer without revealing more information than necessary.

RAISING AWARENESS

This example gives only a hint of the potential of personal data stores. However, these services have yet to attract the attention they will need if they are to become sustainable.

For one thing, they need more partner organisations that accept and integrate their services. "Get your address from MyDex", for example, would need to appear on the websites of Amazon, the Driver and Vehicle Licensing Agency (DVLA) or the company selling your summer holiday. "Prove you're insured with Personal" or "Enter your bank details from Qiy" would need to appear prominently when you rent or buy a car online. And as of today, they don't.

An even bigger problem for these companies is attracting and empowering consumers. We all think that we should own and control our own data, but do many of us really care enough to do something about it? A few dollars a month or the promise of better targeted advertising are unlikely to be sufficient incentive to change our behaviour. And when it comes to data lockers, the size of the data management task becomes daunting. How many of us would willingly invest the time in storing bank details, insurance policies, personal preferences and more in one of these services when the benefits they promise remain intangible?

The move towards greater individual control over data has real momentum. New privacy legislation from Europe, as well as initiatives such as the UK government's midata project, recognise the rights of the individual. Research by the World Economic Forum on personal data has shown that traditional models around the use and reuse of data are increasingly breaking down, that more and more individuals believe data about themselves to be of value, and that they think more of that value should accrue to themselves.

But the gap between this perception and the reality of today's systems is still wide. A number of start-ups are exploring the opportunity, but real transformation will require engagement with both data buyers and data owners on a far larger scale. And that will necessitate better tools for acquiring and maintaining data, and managing requests for their use.

Ultimately, organisations with which we already have some form of trust relationship – the government, perhaps, or our bank – may be best placed to carry this idea forward. ■

WHY THE CLOUD IS GOOD FOR THE ENVIRONMENT

The energy footprint of the world's data centres is growing, but cloud computing means those data centres are growing in efficiency, writes Professor Ian Bitterlin, EMEA technical work group chair at The Green Grid Association, a non-profit industry consortium

Data centres have become essential infrastructure in almost every part of Western society. Whether storing data for businesses, delivering entertainment for consumers, supporting services such as telephony and banking or transacting commerce, the storage and processing of data enables much of society to function, and data centres are where most of it happens.

The continued adoption of cloud computing, in both the consumer and the business sector, will only see more of the world's computing resources consolidated into data centres. Research from the Cloud Industry Forum, a trade body, has found that seven out of ten organisations used some form of cloud service in 2013, up from just under half that number in 2010.

And with networking equipment vendor Cisco predicting that by 2020 the number of individual devices connected to the Internet will have swollen to more than 50 billion, demand for ubiquitous computing looks set to continue unabated.

Unsurprisingly, energy use by the data centre sector is growing rapidly. A study by Jonathan Koomey of Stanford University estimates this growth at approximately 56% between 2005 and 2010, while the results of an industry census conducted by Datacenter Dynamics Intelligence, published in early 2014, suggests a 19% increase in electricity consumption by global data centres between 2011 and 2012 alone.

Insofar as the electricity used by data centres comes from fossil fuels, this represents a substantial increase in atmospheric carbon dioxide. In fact, it is believed that global carbon dioxide emissions from the data centre industry are equivalent to those of the personal air travel sector.

This has rightly attracted the attention of environmental groups, including climate activists Greenpeace, which have called on the data centre industry to increase its energy efficiency.

Both private- and public-cloud data centres receive significant, if sporadic, attention because of the amount of energy they consume and their environmental impact as a result of this consumption. Less frequently mentioned, however, are the tremendous efficiency advantages inherent in cloud data centres.

FOUR PILLARS OF EFFICIENCY

Cloud computing derives its energy efficiency gains from four key elements: reduced carbon generation, improved infrastructure, efficient computing, and resource management. Not all of these are universally adopted within the data centre industry, but their efficacy has been demonstrated on a large scale by several leading data centre companies.

Ian Bitterlin
The Green Grid Association

The achievable amount easily to a tenfold efficiency improvement compared with conventional data centres.

Efficiency starts with electricity generation itself. Because cloud computing data centres consume upwards of 20 megawatts (mw) of power, they are often situated in close proximity to the electricity-generating facilities that power them. This co-location makes perfect sense: while it is easy to transmit data via fibre optics, there are large losses in the transmission of electrical energy over long distances. Google's data centres in The Dalles, Oregon, for instance, or Microsoft's data centres in Quincy, Washington, are located within a few kilometres of the hydroelectric dams from which they draw their energy.

In Europe, meanwhile, Google has converted a former paper mill in Hamina, Finland, for use as a data centre, repurposing disused seawater tunnels as a cooling system; Facebook has located its new Swedish data centre near a 120-mw hydroelectricity station.

Alternatively, energy-generating facilities can be built right next to the data centre. Apple recently built a 20-mw solar facility near its data centre in North Carolina, and eBay has installed fuel cells at a facility in Utah. This co-location can yield savings of between 5% and 20% of generating capacity by eliminating transmission losses.

Another major efficiency improvement stems from the rapid pace of transformation and innovation in the cooling and electrical infrastructure of cloud computing data centres. Traditional data centres typically consume between one and two watts of power to provide the back-up power and cooling necessary to maintain one watt of server computer power. State-of-the-art cloud data centres, however, use only one- to two-tenths of a watt for the same purpose.

Computers themselves have also become more efficient. Winston Saunders of Intel Corporation recently analysed trends in server efficiency as measured by SPECPower, an accepted industry computing energy efficiency metric. The energy efficiency of volume servers – the kind most prominently used in data centres – has increased at a rate of about 70% per year since the creation of the benchmark in 2008. Analyses going back to the 1940s show similar trends.

This is important, because the computing hardware in cloud data centres tends to be "refreshed" – that is, upgraded or replaced – on a more frequent basis than that in traditional data centres. This shorter refresh cycle, typically reduced from five years to about two, results in tremendous gains in the energy efficiency of the computing hardware in cloud data centres – typically between two and four times better, as newer equipment is far more energy-efficient and is increasingly designed with "green" credentials in mind.

The final distinguishing attribute of cloud data centres is the way in which computing workloads are assigned to individual machines. In a virtualised cloud data centre a single server may run between 10 and 40 individual "virtual" machines that can each be assigned for ad hoc computing needs. During working hours the virtual machines might support time-sensitive business transactions, for example, while at night new virtual machines, running on the same hardware, might support movie streaming.

This balancing of workloads ensures that data centre resources are more fully utilised. Highly utilised cloud infrastructure can be two to four times more efficient than under-utilised conventional computing resources: in much the same way as cars that spend a lot of time sitting idle in traffic tend to have poor fuel efficiency, idle data centre hardware is bad for the overall efficiency and environmental impact of the facility as a whole.

Taken in aggregate, the achievable efficiencies outlined above amount easily to a tenfold efficiency improvement compared with conventional data centres. While it would be a misrepresentation to say that all cloud data centres achieve this level of optimisation, it is remarkable that there are many large-scale data centres which achieve these benefits for little or no additional cost. Indeed, many of these improvements can actually bring about cost savings.

Thus, while the growth of ubiquitous computing has led, and will continue to lead, to the rapid expansion of data centres, the industry has aggressively adopted technologies that dramatically improve the efficiency of cloud computing. Through the broader adoption of technologies and more open disclosure of efficiency metrics, we can expect continued improvements in the energy efficiency of this essential infrastructure. ■

HOW CLOUD COMPUTING WILL AFFECT JOBS AND THE ECONOMY

Cloud computing will create jobs and new business opportunities, but which countries and sectors see the most benefits depends in part on policy, writes Dr Jonathan Liebenau, reader in technology management at the London School of Economics

Cloud computing has the potential to be economically transformative. By giving everyone—from individuals to enterprises—access to expensive computing power, software, data storage and analysis as well as other services, cloud computing could deliver increases in productivity and the genesis of entirely new kinds of businesses.

But will the cloud live up to its potential? So far, measuring the economic impact of cloud computing has been a major challenge. Without the means to assess the likely effects of this new way of using information technology, we cannot really know the scale of any likely transformation, or even whether the aggregate effect on trade and labour markets will be positive or negative.

There have been many industry reports, opinion surveys and even government-sponsored studies about the transition to cloud services, but so far very few rigorous analysts have addressed the problem.

As a result, some of the key economic features of cloud computing have not been given enough consideration. For example, the opportunity to move from capital expenditure to operating expenditure has considerable implications for accounting and investment practices, taxation, and the practices used to manage assets. The shift of work within firms from systems maintenance to higher-level tasks has implications for the labour market both in terms of displaced employees and skills demands. And the opportunity to exploit services worldwide to achieve low prices poses serious challenges to current data protection laws and practices.

One of the most revealing studies of the economics of cloud computing so far is by Federico Etro, professor of economics at Ca'Foscari University in Venice, whose approach is to interpret the utility of cloud services for a large number of sectors in Europe.

He views cloud computing as a general-purpose technology and estimates its possible impact on industry structure, labour markets and productivity. But while this top-down approach structures the problem in a valuable way, it produces hugely variable results. Looking at cloud computing from such a "big picture" perspective prevents us from analysing in detail the precise impact of cloud computing on specific jobs, tasks and investment trends.

An alternative approach is to consider the problem from the bottom up. This means looking at which particular tasks will be affected by cloud computing, which jobs will be displaced as firms divest their capital equipment, and which new jobs will be created by shifted responsibilities and new opportunities for spending.

Jonathan Liebenau
London School of Economics

The employment outcomes are likely to be positive, creating more jobs than are destroyed and accelerating the creation of new businesses.

In 2012 my colleagues and I produced the first effort to construct a dynamic model that accounts, in detail, for the likely impact of cloud computing in major industrial and services sectors.

Our bottom-up model allows us to take into consideration how the economic effects are likely to differ between countries and sectors. It also allows us to show how regulatory interventions, market trends or legal constraints might alter cloud usage.

What we found is that the microeconomic characteristics of cloud computing create a dynamic effect that will, when effectively implemented, improve company productivity, enhance new business development, and shift the character of work in many firms in the coming years.

While the effects fall short of being dramatic, they do confirm that the employment outcomes are likely to be positive, creating more jobs than are destroyed and accelerating the creation of new businesses.

But our findings also showed that the economic impact of cloud computing will vary significantly by country and by sector.

They revealed, for example, that most of the short-term economic benefits of cloud computing will be enjoyed by the IT sector, thanks to data centre construction and hardware investment.

One important consideration is the growth rate of a given sector. In Germany, between 2010 and 2014 cloud-related jobs in the fast-growing smartphone services sector more than doubled, but they grew by just one-third in the relatively static aerospace industry.

Another important factor is the policy environment in which a sector operates. Two areas are especially significant. First, energy policy is a major determinant of the economic impact of the cloud, as the cost of energy impacts data centre location.

The second area is the legislative environment governing data handling. Data transfer regulations can have significant effects on the economic dimensions of cloud computing, effects that can be directly translated into job creation.

An important question for Europe is whether the economic benefits of the cloud will be disproportionately enjoyed by companies in the US. According to our model, the growth in cloud jobs in the US need not be at the expense of European companies—as long as Europe can become more attractive than it currently is for public cloud investment.

The impact of cloud computing in Europe will ultimately depend on how services providers, governments and managers adapt. European cloud services providers need to offer competitive prices and guarantee safe and reliable technology. Governments need to ensure an appropriate legal environment, procurement practices and energy prices. It will also depend on the willingness of managers to adopt the new practices necessary to exploit the technical and economic advantages of cloud computing. ■