computing
research

Cloud & Infrastructure Review 2017

Hybrid, multi-cloud and serverless: how cloud models are informing strategy

September 2017

Contents

1 Executive summary

The *Computing Cloud & Infrastructure Review 2017* is the fifth review published by *Computing* on the subject of infrastructure and data centres, but only the second to focus on the growth of the market for cloud-based services. The types and varieties of cloud models available have increased significantly in the last two or three years. The concept of a hybrid cloud consisting of integrated public and private cloud services has been joined by newer approaches such as multi-cloud and serverless.

The review summarises the results of a comprehensive research programme undertaken by *Computing* during the third quarter of 2017. The review discusses how data centre strategies are evolving and the degree to which the cloud is informing those strategies. The level of understanding of the differing cloud models is discussed before we look at their respective adoption levels. In particular, the impact of serverless computing and its implications for other technologies within the data centre is covered at length.

The review then moves to the market place for cloud services and the implications of the skills shortages being experienced by many organisations on the growth of cloud services. It concludes with a discussion about the future of the cloud – and the role of AI in particular.

Along with our quantitative research, the review contains some unique insights from high-ranking IT decision makers into how and why cloud services are being adopted and what this means for the traditional data centre.

Key highlights from the research include:

- The cloud now plays a part in data centre strategy for the vast majority of organisations. The proportion using no cloud services has plummeted from 52 per cent in 2014 to eight per cent this year.

- The most prevalent arrangement is "partial cloud" or ad hoc adoption, with 70 per cent of respondents describing this as their current operational mode.

- Organisations employing between 1,000 and 4,999 individuals were found to be slightly more likely to feature no cloud services in their plans, while those numbering in excess of 5,000 are the most likely to be pushing ahead with "cloud-first" strategies.

- Seventy-one per cent of those we questioned expected their takeup of cloud services to increase in the year ahead.

- The progress of newer data centre virtualisation technologies such as software-defined infrastructure and hyperconvergence has been marked by an uptick this year from a low base.

- Industry definitions of hybrid cloud, multi-cloud and serverless computing are not widely shared among IT professionals.

- SaaS is the most common public cloud model with 58 per cent of respondents using it, followed by IaaS (31 per cent) and PaaS (13 per cent).

> "The concept of a hybrid cloud consisting of public and private cloud has been joined by newer approaches such as multi-cloud and serverless computing"

- Thirty-four per cent of organisations are pursuing a multi-cloud or best-of-breed strategy.
- Serverless computing has grown a great deal in a very short space of time when compared with other technologies.
- Forty-four per cent of strategic cloud platform decisions are made by IT directors or their equivalent.
- Microsoft Azure is the most widely used cloud ecosystem among those participating in our research.
- Sixty-nine per cent of organisations face a shortfall of technical skills as well as experience and qualifications in project management, communication and leadership. More than half have no training plan in place to facilitate a smooth transition to the cloud.
- AI-enabled "Analytics-as-a-Service" is likely to be a key development in cloud services.

2 Research overview

The key objective of the *Computing Cloud & Infrastructure Review 2017* was to understand how data centre strategies are changing and in particular, the degree to which cloud services are now informing those strategies. Where appropriate, findings are compared with research published every year since 2013 to establish trends.

Key areas of research included:

- The part played by the cloud in data centre strategy and whether that role is likely to increase.
- Whether newer technologies such as software-defined infrastructure and hyperconvergence are taking hold among those choosing to retain their own data centres.
- Whether the size of an organisation has any meaningful impact on data centre strategy.
- Understanding of concepts such as hybrid, multi-cloud and serverless computing.
- The longer term impact of serverless on container technology.
- How organisations are utilising the public cloud.
- The market place for public cloud services.
- Obstacles in the way of cloud adoption.
- Whether organisations have access to the right skills and how cloud projects are being affected by possible shortages.

2.1 Methodology

The research project was conducted in five phases, using a combination of qualitative and quantitative methods.

Phase 1 – In-depth interviews with business decision makers from industries including digital retailers, the NHS, venture capital and cloud integrators and consultancies.

Phase 2 – Focus group discussion comprised of senior technical employees from organisations all at differing positions with regards to their use of cloud services. Industries represented include media, broadcasting and NGOs.

Phase 3 – A nationwide, online quantitative study completed by in excess of 270 IT decision makers representing organisations ranging in size from a minimum of 50 employees to enterprises comprising many thousands. Numerous industries were represented including banking and finance, technology, retail, business services and manufacturing.

Phase 4 – In order to verify the quantitative results and gain further insights, several interviews were conducted with key thought leaders from companies with varying policies on cloud infrastructure. Industries represented included transport and technology.

Phase 5 – An additional quantitative survey was carried out to drill down into cloud strategies and to find out more about the remaining obstacles to cloud adoption (see section 5). This survey was completed by 130 IT professionals.

3 Data centre strategy

The first task of this years' research was to establish the data centre strategies being pursued, and whether the picture has changed in any meaningful way from that discovered in previous years. The obvious starting point is the cloud. Figure 1 illustrates answers to the straightforward question: "What best defines your cloud strategy?"

## FIG. 1 What best defines your cloud strategy?
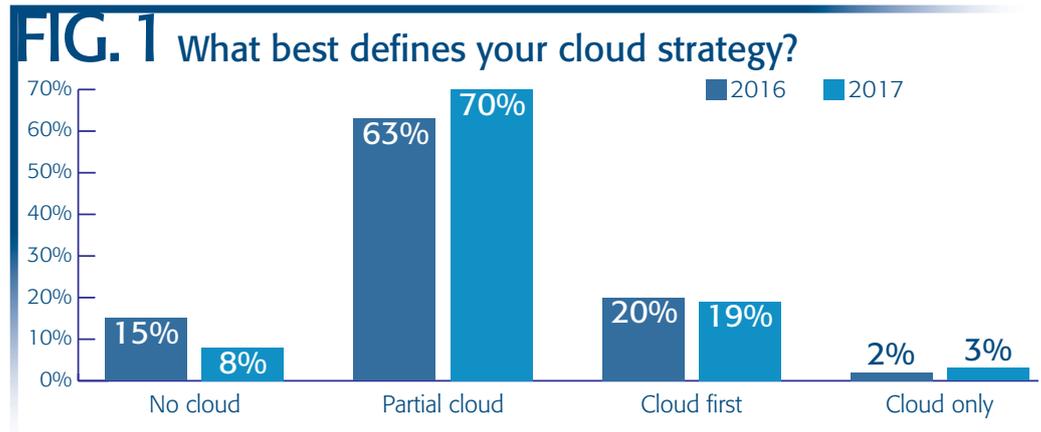
The answers to this question when compared with responses to similar questions in previous years track the growth and growing maturity of cloud infrastructure services. First, the proportion answering simply "no cloud" reached a low of eight per cent this year. In 2016, 15 per cent of respondents gave this answer. To give some scale here, note that exactly three years ago, 52 per cent of those responding to our survey had no experience of outsourcing any aspect of their infrastructure to the cloud.

The sharp reduction in the proportion of our respondents not utilising cloud services in any form is the standout finding here. When it comes to the way in which organisations are using the cloud, the proportions only vary slightly from last year to this one. Those defining their strategy as "partial cloud" (meaning ad hoc adoption where cloud makes sense) have grown from 63 per cent to 70 per cent – the most prevalent way of adopting cloud by a huge margin. The proportion opting for "cloud first" (signifying that cloud is the first port of call when introducing a new service) remains almost unchanged at 19 per cent. Those ploughing a "cloud only" furrow have increased only marginally in number – from two to three per cent.

The degree to which our survey reflects a greater acceptance of cloud across the board is worthy of some discussion. The growth of cloud service provider revenues in the last several years has certainly been impressive. One analyst has stated that across six key cloud services and infrastructure market segments, operator and vendor revenues for the year ending in September 2016 grew 25 per cent on an annualised basis, with IaaS and PaaS enjoying the highest growth rate of 53 per cent.

2016 was also a landmark year because spending on cloud services for the first time overtook spending on the infrastructure providing them.[1]

How sustainable is this rise? Some analysts believe that the market for public cloud services is entering a period of stabilisation with the growth in revenues tapering off in the years to 2020.[2] However, different segments of the overall market are moving at very different speeds.

FIG. 2 What best defines your cloud strategy?
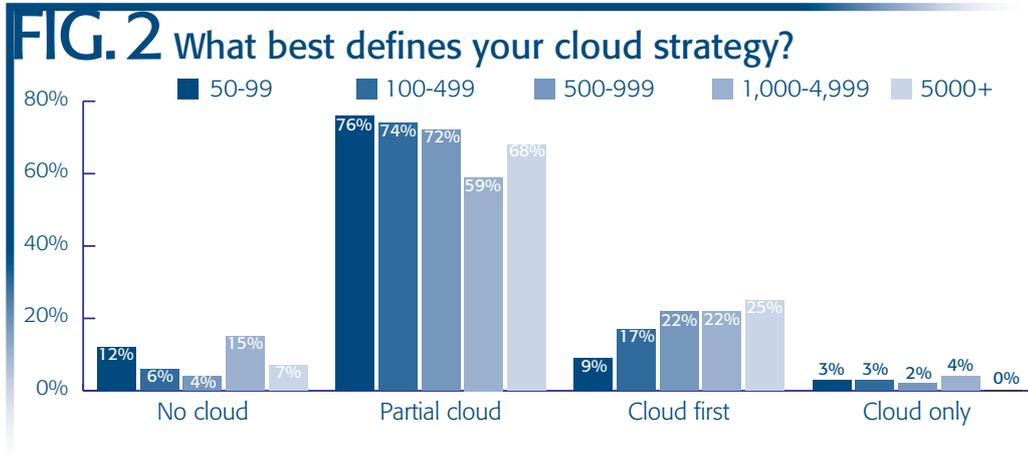
When results to the question above are analysed by the size of the organisation involved, a more nuanced picture emerges (Fig. 2). The size of business most likely to be avoiding the cloud completely is in the 1,000-4,999 employee bracket. This is not an entirely counter-intuitive finding. Businesses of this size are more likely to be able to afford to employ the necessary resources to make on-premise infrastructure more cost effective. They are also more likely to have a complicated, legacy infrastructure. This makes it harder to utilise the cloud on a partial basis for reasons of integration, customisation and compliance.

> **The tool set is much more assured for on-premise, so managing an exchange is a lot better on-premise than it is managing it online.**
> IT director, Media

Many of the barriers are cultural ones.

> **I'm consciously just focusing on 'prove these systems will bloody run on the cloud'. That's my highest priority. It's getting better but still there's so much discomfort with just even the concept of not having your own lump of tin and a data centre on-premise…** CIO, Healthcare

Other sticking points emerge around sunk costs. Businesses are reluctant to move to cloud when they have recently upgraded their infrastructure.
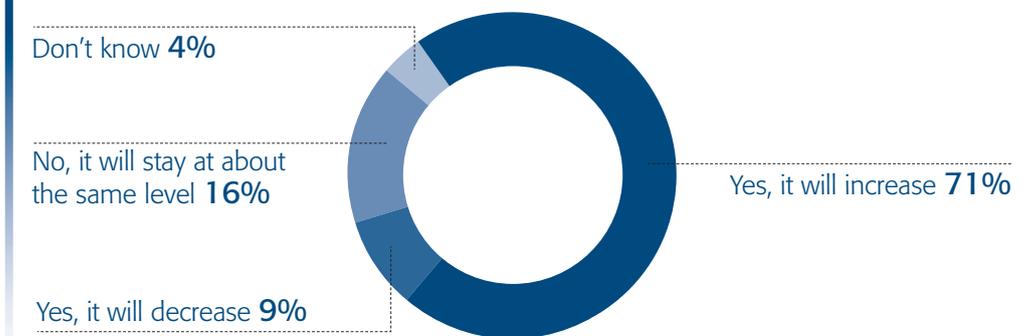
> **My previous employer was anti-cloud. I was at an accountancy firm and they said 'well, we bought this; we'll get 10 years out of it and why do we want to waste money on the cloud?'.** Head of IT, Charity

[1] www.srgresearch.com/articles/2016-review-shows-148-billion-cloud-market-growing-25-annually

[2] www.gartner.com/newsroom/id/3616417

Organisations employing more than 5,000 individuals are by far the most likely to have a "cloud first" strategy. Why are these businesses which are more likely to enjoy generous IT budgets and be able to employ the necessary skills in-house more likely to embrace the cloud? The chances are that the speed and agility offered by cloud infrastructure services are the motivating factor. The cloud means that large organisations, or at least teams or subsidiaries within them, can move at a speed equivalent to their smaller competitors. Whether this is good for the "creative destruction" so beloved of the proponents of economic liberalism is highly debatable but it's certainly good for cloud service revenues. What is clear is that the cloud will be playing an increasing role as time progresses.

FIG. 3 Do you expect your use of cloud services to change over the next 12 months?

Don't know **4%**

No, it will stay at about the same level **16%**

Yes, it will increase **71%**

Yes, it will decrease **9%**

When asked whether they expected their firm's use of cloud services to change over the next 12 months, 71 per cent of respondents said it would increase, with that number rising to the mid-eighties among 5,000+ organisations. Those at the opposite end of the size scale – businesses with 50 to 99 employees were almost as likely to report expecations of increased cloud usage.

In order to gain a more detailed understanding of the evolution of the infrastructure underpinning the UK economy, we asked: "Which best describes your current data centre set up?" This is a question we have asked consistently throughout our years of research, and Figure 4 illustrates a slow and steady progression away from the traditional data centre toward external hosting and/or cloud services. However, there remains a core of between 28 and 30 per cent of respondents who seem markedly reluctant to move away from the more traditionally configured on-premise data centre. Our qualitative research indicated that compliance and control are strong motivators behind the retention of the traditional model. These issues remain pertinent and (particularly given the impending EU GDPR data protection legislation) are likely to become even more so and therefore this figure seems unlikely to change.

Some firms are unlikely to make changes until their current infrastructure reaches end of life.

> **Eighteen months ago, we put a brand-new Cisco network in; we're not about to get rid of that. The last time we spent as much money as we spent on Cisco it ran for about 10 years.** Head of technology, Charity

Just because it's in the cloud does not mean it's cheaper.

> **We looked at what it would cost to use our ERP in AWS versus doing it in-house… and actually the costs are comparable. So unless there's another compelling reason then it's going to stay where it is for the time being.** Head of technology, NGO

Meanwhile, others were concerned about the complexity of moving applications to new architectures.

> **If you have an application that doesn't benefit at all from the flexibility of the system, or if you've got concerns that you're just going to lift and shift… I think you could potentially get into a lot of trouble…** CIO, Healthcare

Of course, the cloud is not the exclusive home of innovation, and recent developments such as the falling cost of fast storage and the rise of containers and software defined infrastructure – to name a few – may favour the on-premise or hybrid alternatives over moving certain data and applications to the cloud. This is in addition to the security and compliance concerns that remain.

While traditional server virtualisation may be approaching saturation point, these newer technologies can allow data centre managers to do more with less and to sweat their existing assets.

The *Computing Data Centre Audit 2015* contained a discussion on whether the transition to virtualisation had peaked and concluded that many organisations, having virtualised all that they feasibly could, were at the point of assessing virtualisaton as part of a broader strategy encompassing leading-edge (as of 2015) technologies such as software-defined infrastructure, hyperconvergence and the use of private and hybrid clouds. This process of assessment now seems to be over and the proportion moving to these technologies has increased from a very low base of four per cent to 10 per cent of respondents this year. It is therefore likely that those who retain on-premise data centres will continue to do so but will gradually begin to transition to these newer technologies while also farming out commodity services to cloud.

Our focus group participants and interviewees added some weight to this assertion.

> **We're just in the middle of a migration programme to basic cloud. Software-defined networking makes sense for us longer term but not within the next 12 months… I just don't think we're at the scale for where this is an actual fit for us but it might be 18 months down the line**
> Head of technology, Charity

Definitions

Software-defined networking (SDN) Networking where control is decoupled from the physical infrastructure.

Software-defined data centre (SDDC) IT infrastructure that extends virtualisation concepts to all of the data centre's resources and services to achieve IT-as-a-Service.

Software-defined storage (SDS) Storage infrastructure that is managed and automated by intelligent software as opposed to by the storage hardware itself.

OpenStack Open-source software cloud computing platform.

Converged/hyperconverged infrastructure Compute, storage and networking components grouped into a single, optimised solution.

Docker Container management, open virtualisation.

While software-defined networking (SDN) once only made sense for telecoms and cloud providers, the changing nature of the traffic flowing through organisations and the advent of microservices makes it more relevant to a wider range of businesses. Put simply, when there are hundreds of applications running on each virtual server, ensuring the required quality of service to each of them gets complicated in the absence of the sort of granular controls that SDN can offer.

> **With the advent of SDN and hyperconvergence and the rest, you can segment those applications and make sure they get the quality of services at a fine grained level, and I think that's where industry is going…** Principal consultant, IT consultancy

FIG.4 How aware are you of the following data centre solutions?

a) Unaware or vaguely aware

Legend: 2015 | 2016 | 2017

	SDN	SDDC	SDS	OpenStack	Converged/hyper-converged infrastructure	Docker
2015	30%	37%	42%	30%	39%	58%
2016	32%	30%	25%	30%	43%	56%
2017	28%	30%	31%	32%	43%	41%
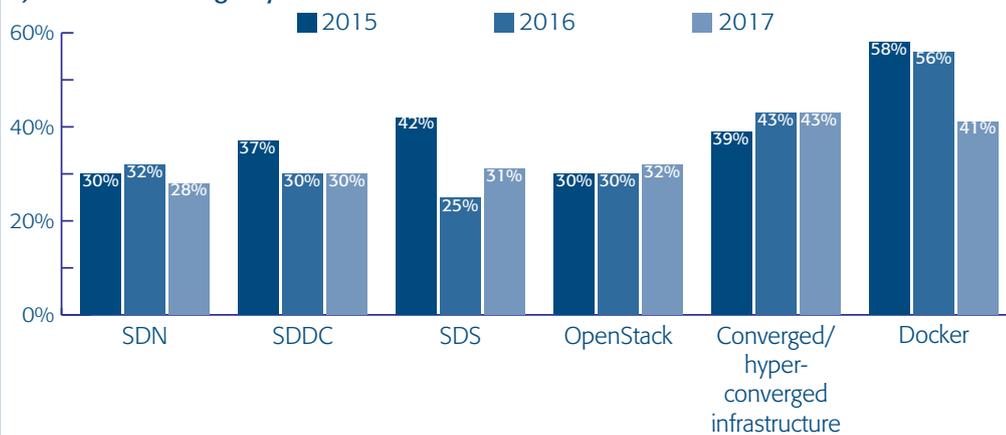
b) Testing or in production

Legend: 2015 | 2016 | 2017

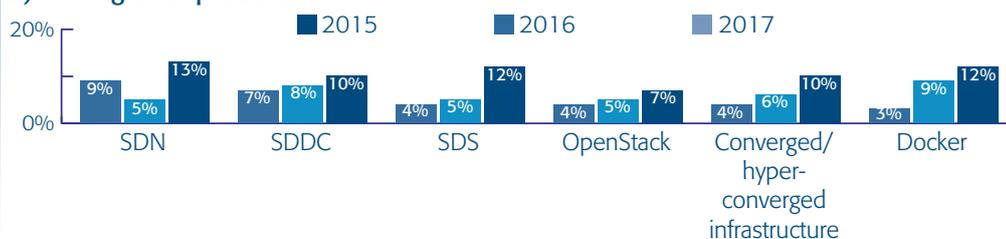|	SDN	SDDC	SDS	OpenStack	Converged/hyper-converged infrastructure	Docker
2015	9%	7%	4%	4%	4%	3%
2016	5%	8%	5%	5%	6%	9%
2017	13%	10%	12%	7%	10%	12%

Figure 4 illustrates answers to a question on the awareness and use of these newer data centre solutions. The trends are fairly clear, although the graph does once again underline the slow pace of change in the data centre. The march of Docker stands out. The proportion of respondents who were either unaware or only vaguely aware of Docker has dropped from 58 per cent in 2015 to 41 per cent. At the other end of the spectrum, 12 per cent have deployed it or are testing, whereas in 2015 only three per cent had done so (Fig 4).

Awareness of software-defined data centres (and software-defined as whole taking in storage, data centre and networking) has also increased and the proportion of respondents who had actually deployed SDDC had increased from two to four per cent, with a further six per cent trialling. However, when asked about how promising these technologies might be in meeting their needs over the next several years, 16 per cent of respondents thought SDDC was at the very promising end of the spectrum.

4 The journey to the cloud

So far we have ascertained that the vast majority of organisations are making some use of cloud services and are likely to increase deployments. *Computing* asked a series of supplementary questions to 130 respondents in a quantitative survey to discover more about the motivations and the hurdles encountered on this journey to the cloud. Their answers are examined in this section.

There are few areas of business in which cloud is not being actively considered, although finance and security are still no-go areas for about 20 per cent of those surveyed. However, a third of the respondents said that there are now no domains in which cloud will not play a part.

A similar proportion (35 per cent) said that there is nothing preventing them from transitioning to the cloud as quickly as they'd like and that they are adopting at their own pace. Only five per cent said they had no interest in cloud (Fig. 5).
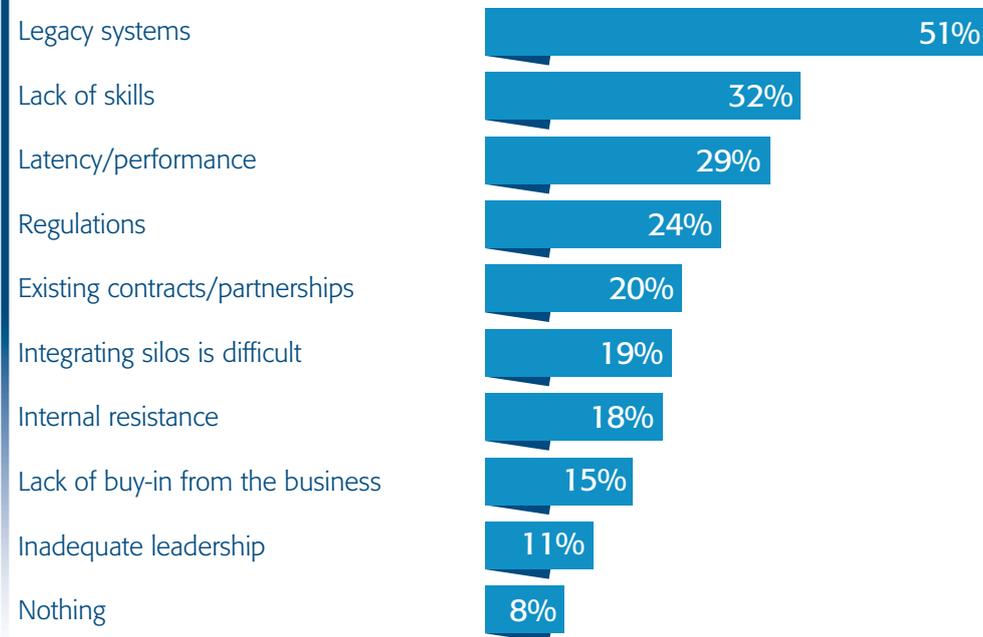
For the rest, the main hurdles are represented by legacy systems, concerns about security and compliance, worries about costs and integration issues.

FIG. 5 What is preventing you from transitioning to the cloud as quickly as you'd like?

Nothing – we are adopting at our own pace	35%
Legacy systems	30%
Concerns about security	27%
Concerns about costs	23%
Concerns about compliance	18%
Integration issues	18%
Concerns about performance	14%
Lack of skills	13%
Lack of management vision	8%
Would require internal restructuring	7%
Licensing issues	7%
Nothing – we have no interest in moving to cloud	5%

Another question in a similar vein asked: "What might prevent you from being successful in the cloud?" (Fig. 6). Once again legacy systems were seen as the main sticking point. Most organisations cannot simply jettison the systems on which their business have been built, and on which many vital business processes rely. Our respondents evidently see these systems as an impediment to success in the cloud, as they may not be easily "lifted and shifted" to a cloud platform, and integrating legacy applications into an ecosystem that includes cloud-based services can be an enormous challenge.

FIG. 6 What might prevent you from being successful in the cloud?

Legacy systems	51%
Lack of skills	32%
Latency/performance	29%
Regulations	24%
Existing contracts/partnerships	20%
Integrating silos is difficult	19%
Internal resistance	18%
Lack of buy-in from the business	15%
Inadequate leadership	11%
Nothing	8%

Even those applications that are most amenable to cloud deployment or replacement with SaaS, such as office suites and email, can present considerable integration and acceptance issues. Some respondents told us of lessons learned.

> We moved to SaaS for some primary applications including Salesforce and ServiceNow. You need to consider integration and interfaces really carefully…

> Promised integration [for a global finance system] does not work; the UI is far less efficient for data entry than a native application…

> Moving core systems to the cloud – a rebuild is often easier than migration…

> Integrating Salesforce with legacy applications was 'entertaining'…

> Migrating to O365 for Exchange? Make sure you have a good internet link…

> We shifted to O365 and Sharepoint and found that staff need a lot more training than first thought…

A lack of available skills was also considered an impediment to success. We cover this in greater detail in section 9. Some respondents had learned the hard way about the skills required for success in the cloud among both implementation staff and end users – who are sometimes the last people to be consulted during major IT interventions.

> " Poor training and planning leads to poor results…

> " With our HR system we lacked the skills and had to outsource. The quality of support is key…

Some respondents had experienced problems with latency and performance, and with the levels of support and assurance available, which did not meet expectations. Others complained that anticipated cost savings had not been realised.

> " Standard cloud offerings come with standard qualities of service, which can be very different from what the business is used to. So then there's forced upgrades. Business expectation re-alignment is needed…

> " We use IaaS for ad hoc internal systems but the cost benefits are not so great…

Technology interventions will never be without teething problems, and it's very much a matter of choosing the right approach to solve the issues at hand. The majority (63 per cent) of respondents favoured a best-of-breed or multi-cloud approach (see section 5) for reasons of avoiding vendor lockin (63 per cent), providing IT with more freedom to choose (mentioned by 52 per cent) and to strengthen their hand in negotiations (45 per cent). However, a significant minority (27 per cent) preferred to deal with one main cloud vendor because of the oft-discussed integration issues when deploying cloud services and also for reasons of easier management – the "one neck to strangle" principle. A number of those polled (35 per cent) felt they'd be able to achieve keener pricing by sticking with one core supplier too.

With careful consideration at the outset as to what is worth moving to the cloud, where and how, and of the impact on end users and the IT department there are now fewer potential nasty surprises around cloud deployment than there once were. Enterprise cloud services have matured significantly and what they can and cannot offer is better understood. It's still very much a case of caveat emptor, of course, but some respondents reported being pleasantly surprised by their experience.

> " IaaS is just so easy to deploy…

> " We moved HR to a managed service and the experience was positive in terms of ease of use and for mobile working…

> " Hosted voice – why didn't we do it sooner?

5 Defining the cloud

Getting a handle on what is happening with cloud is not helped by the inexactitude of its definitions. For every person who thinks that hybrid cloud is an integrated combination of public and private cloud services, there's another who uses the term to define a general mix and match, and another who sees hybrid as simply a combination of public and private with no requirement that they be integrated. Or, to take one step further back, why is private cloud – the hosting of virtualised data and applications behind the organisation's own firewall – even considered cloud at all?

There has been a notable buzz this year around newer cloud concepts such as multi-cloud and serverless, but as with hybrid cloud and private cloud, definitions of these concepts are slippery to say the least. One of the objectives of this years' survey was to establish which definitions and visions of the cloud were most widely shared, so we began by checking the understanding of what these terms mean.

5.1 Defining multi-cloud

Computing asked respondents to choose the definition of multi-cloud that best matched their understanding from among five options. The most popular answer which was given by 38 per cent of respondents was "a best-of-breed approach using multiple services from different vendors in a single heterogeneous architecture". However, 20 per cent of respondents opted for "deploying many different services in the cloud, SaaS, IaaS and PaaS, possibly from the same vendor"; 16 per cent chose "a seamless, integrated combination of public and private cloud services" (a description more commonly applied to hybrid cloud), while a more cynical 13 per cent opted for "meaningless vendor hype". A further 13 per cent were honest enough to admit that they were unsure.

Asked the same question about hybrid cloud, 58 per cent of respondents answered "a seamless, integrated combination of public and private cloud services". This concept has been around longer than multi-cloud and is better understood. Nevertheless, significant numbers opted for quite different descriptions, such as mixing SaaS, IaaS and PaaS services.

The spread of answers to these questions, and in particular the fact that some of the definitions were exactly the same, points to a real lack of information on what these concepts actually mean, and by extension the benefits that they can bring. Our focus group panelists also differed in their views of multi-cloud. While they all agreed with the *Computing* definition of "multiple services from different vendors in a single heterogeneous architecture", there was some debate about whether or not orchestration should be present.

For the purposes of this research, the key distinction between multi-cloud and hybrid is that the former is more of a strategy whereas the latter is more about actual technology used to deliver the mix of public and private cloud and move workloads seamlessly between them. Multi-cloud and hybrid are not mutually exclusive, however.

"There has been a notable buzz this year around newer cloud concepts such as multi-cloud and serverless, but definitions are slippery"

5.2. Defining serverless

There was also a lack of consensus on the precise meaning of serverless cloud, as Figure 7 illustrates. Thirty seven per cent of respondents agreed with *Computing*'s understanding of the term: "a platform for deploying and running code with minimal requirements to provision infrastructure". Nonetheless, 23 per cent considered serverless to be something akin to file sharing torrents, i.e. a "decentralised peer-to-peer system with no central servers"; 13 per cent thought it was cloud storage or networking and 14 per cent considered it a meaningless vendor-led buzzword.

FIG. 7 Which of these best matches your understanding of the term 'serverless' cloud?

Don't know **13%**

Meaningless vendor hype **14%**

Cloud storage and/or networking **13%**

Decentralised peer-to-peer system with no central servers **23%**

Platform for deploying and running code with minimal requirements to provision infrastructure **37%**
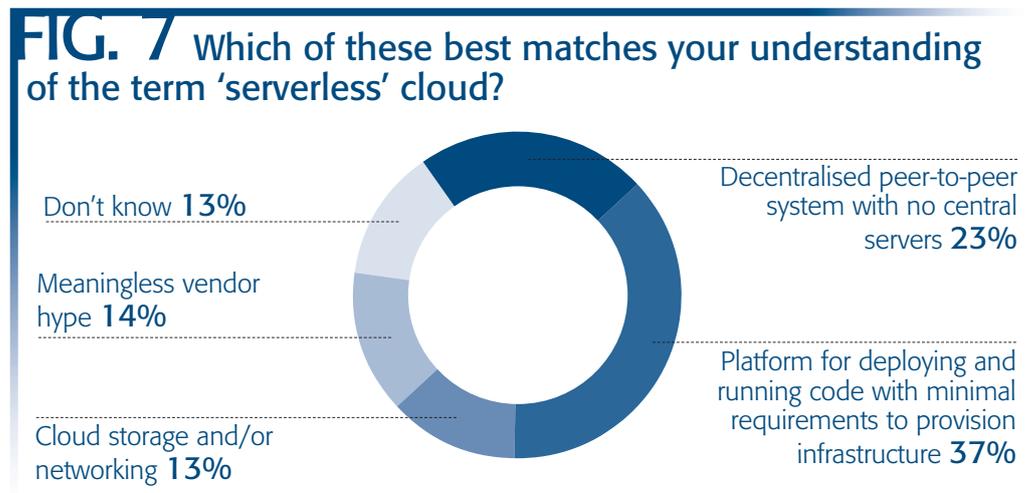
There were also diverging views from our panelists when it came to their working definitions of serverless.

> My view of serverless cloud is that it's an application or a service you get without spinning up a physical or virtual machine…
> Head of technology, NGO

> So for me it's all about the abstraction away from any tin and then using tools like Docker to provide that abstraction and then you can absolutely put those workloads in switch them off as you **need.** Head of operations, Publishing

However, the aspect of the definition of serverless which people do seem to mainly agree on is the event-driven nature of it. Applications are run on demand and only their run time is billable. The popularity of serverless platforms and containers is due to the rise of DevOps and microservices – small applications often drawing on a single data source where data does not need to be persistent and apps do not need to retain state. Such micro-applications are generally triggered by an event, run, then are terminated.

6 Cloud strategies

Having defined the models of hybrid, multi-cloud and serverless, we now turn to exactly what strategies organisations have in place to make clouds work for them. First, what class of public cloud services are they using? SaaS remains the most widely adopted type. Fifty-eight per cent of respondents overall were using some sort of SaaS application such as Salesforce or Office 365 in a production environment; 14 per cent were doing so in their development environments with a further 11 per cent in the initial stages of testing. Only nine per cent of respondents were making no use of SaaS.

6.1 IaaS and PaaS

Infrastructure-as-a-service offerings such as AWS and Azure were the next most likely cloud models to be deployed by our respondents. Thirty-one per cent were using IaaS in their production environments and 15 per cent were doing so for development and testing; 14 per cent were in the trial phase. Twenty-two per cent did not use IaaS at all.

The largest organisations, those employing in excess of 5,000 individuals, were by far the most likely to be using IaaS in their production environments (Fig. 8).

FIG. 8 Are you using infrastructure as a service (IaaS – e.g. AWS, Azure, Google Compute)?
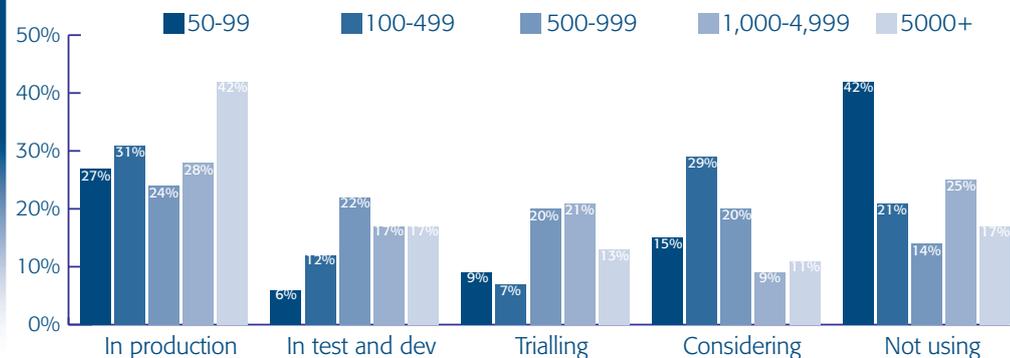
Platform-as-a-service (PaaS), examples of which include IBM Bluemix and Google App Engine, was the least used of the three. Only 35 per cent of our respondents overall were using or trialling PaaS, and while large companies were again at the forefront, the margin was much smaller than with IaaS. Overall, 13 per cent of organisations polled were using PaaS in their production environment and 11 per cent in testing and development. A further 11 per cent were at the trial stage.

However, PaaS adoption is growing as it allows organisations to develop and release applications with a reduced time to market and reduced initial outlay. As organisations of all types become, effectively, software companies expect the demand to rise.

"Many organisations are still architecting hybrid cloud infrastructure, not as reluctant latecomers to the cloud, but as organisations wanting flexibility and cost efficiency with a degree of control and security that they may not be convinced that public cloud providers can offer"

6.2 Hybrid cloud

We saw in section 3 that a "partial cloud" strategy was by far the most common cloud model, with more than two thirds of our survey respondents describing their organisation's deployment thus. This could include either multi-cloud and/or hybrid but our panelists had some interesting thoughts on how these strategies may have evolved.

While the hybrid cloud, by which we mean a tightly integrated environment comprised of public and private services, is often touted as the solution to compliance and security issues, in practice making this work can be difficult to achieve both practically and as a strategy. More common is a bolting together of services out of necessity.

> **You wouldn't engineer it that way anymore. I think it's just legacy. You've got data centres still running, you've got services that won't run in the cloud or it makes no sense to run them there, but I don't think you'd now architect a hybrid or a mixture…** Head of technology, NGO

> **Sometimes it feels like a sticking plaster…** Head of technology, NGO

> **It's like a hybrid car. They're on their way to being fully electric, they're just getting there…** Infrastructure head, Charity

However, many businesses are still architecting hybrid cloud infrastructure, not as reluctant latecomers to the cloud, but as organisations wanting flexibility and cost efficiency with a degree of control and security that public cloud providers may not be able to offer. Based on our definition of hybrid cloud – "a seamless, integrated combination of public and private cloud services", 38 per cent of our respondents said they were using a hybrid architecture in production or in test and dev; 12 per cent were trialling hybrid architecture and a further 19 per cent were considering it.

6.3 Multi-cloud

The growing maturity of many cloud offerings together with the arrival of more open APIs has meant that it is increasingly possible to consider individual cloud services on merit and not part of an ecosystem. This is the analogue of the old monolithic versus best-of-breed debates that raged in the world of enterprise applications 10 or 20 years ago.

At its simplest, multi-cloud simply means using different providers to do different things. Data sovereignty concerns may require running the same workload in different data jurisdictions. The country of origin of a particular provider may also be of concern: for example, the US government has far-reaching rights to reach into the content of US companies' infrastructure, even when it is not based on US soil.

Equally, fluctuating performance requirements may mean that different IaaS providers become the most cost-effective solution at different times. It's a strategy that leverages the maturing cloud services market with its lower cost and potentially infinite scalability – without the inflexibility that

being locked into one vendor creates. In an ideal multi-cloud world, costs are reduced and choice and agility increased without an increase in risk, complexity or latency.

Multi-cloud, defined here as "a best-of-breed approach using of multiple services from different vendors in a single heterogeneous architecture", was popular with those participating in our survey. Thirty-four per cent of respondents to our main quantitative survey reported using a multi-cloud strategy in production and/or test and dev; 14 per cent were in the trial phase; and a further 19 per cent actively considering. The similarity between the proportions of our survey respondents opting for hybrid and multi-cloud strategies would indicate that many hybrid cloud architectures are using multi-cloud strategy.

As an example, a company might be using Microsoft Azure to host its enterprise applications, AWS for development and Google for specialised big data functions.

> BP for instance – they're publicly on record as being users of both AWS and Azure and they use both pretty much equally…
> Senior manager, Technology

More common, however, is reliance on one vendor to provide the majority of cloud services, with others taking up the slack where more specialised workloads are involved.

> Typically what we see is not a 50/50 split but a 70/30 or an 80/20 split between the main two providers and then Google kind of creeping into the larger organisations specifically around the analytics side… Senior manager, Technology

However, not everybody is convinced that splitting duties between vendors is a good idea.

> I would suggest in that situation you can achieve most of the things you want with one vendor and in a lot of situations it's best to just focus on what value you're going to get out of it and what tools you need. So you might want to pick one vendor and stick with it because the cost of constantly checking prices versus other vendors is probably more than the value you'd get from switching. You're not going to find that it's desperately cheaper to run a particular server in Google than it is in Azure or anywhere else. So pick one, stick with it but always keep your eye on potentially the killer features that are being released elsewhere. CIO, Healthcare

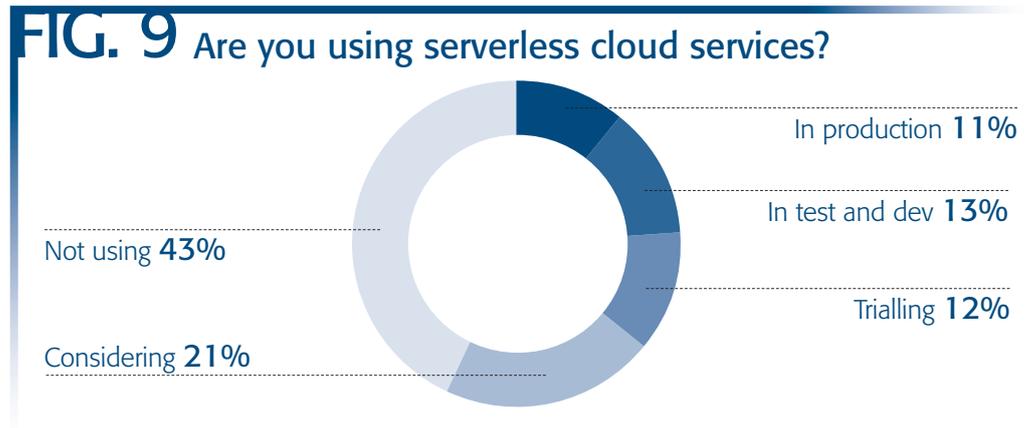> We've gone with a single provider because I want to avoid either working with the lowest common denominator, or a constant productivity drag of discussions as to which provider project X is going to work with… Head of operations, Media

> Pick the right cloud for the right workload and then fully embrace it because that's how you're going to get the most value from it. Senior manager, Technology

7 Serverless cloud

Having spent some time defining serverless in section 5 as "a platform for deploying and running code with minimal requirements for provisioning infrastructure", *Computing* asked how many of our survey respondents were using it. The answers are shown in Figure 9.

FIG. 9 Are you using serverless cloud services?

In production **11%**

In test and dev **13%**

Trialling **12%**

Not using **43%**

Considering **21%**

Serverless, examples of which include Amazon's AWS Lambda, IBM Open Whisk, Microsoft Azure Functions and Google Cloud Functions, is less mature than other cloud strategies under discussion here – but the trend is very much in an upward direction. Eleven per cent were already using serverless in production, and 13 per cent were doing so in testing and development. Twelve per cent were trialling but more than one fifth of respondents (21 per cent) were actively considering serverless.

Serverless prompted a degree of cynicism from some quarters. Fourteen per cent considered it meaningless vendor hype and the term itself does invite a pithy response – after all there are servers there providing the compute behind the scenes, it's just that developers don't need to think about them. However, while the technical capabilities of serverless aren't actually that new, the financial aspects of simply paying for the compute used when your code runs are more novel – a fact that prompted considerable discussion between those participating in our focus group.

> **The reasons for doing it? It's highly scalable and it's cheap, so typically – depending on the workload – it's much cheaper than having a set of servers running overtime. You're just getting CPU when you need it…** Development lead, Media

> **Taking it to the level where you're just paying for code execution is amazing…** CTO, Investment

> **Paying for a machine for an hour could be 50 cents or something, but for a Lambda to be on for a couple of minutes is a fraction of a penny. And if you need 200 of them to handle a big spike in load, you can have 200 of them…** Development lead, Media

> **AWS gives one million requests free per month…** Principal consultant, IT consultancy
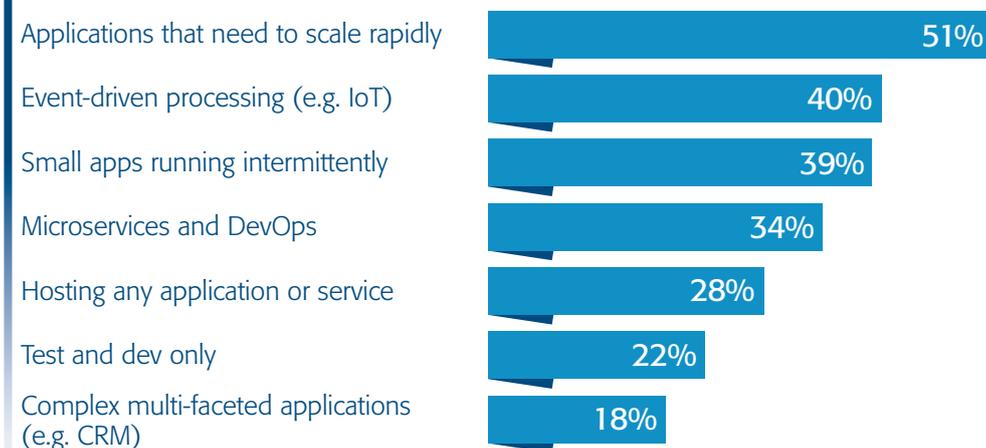
The reduction in management and administration that serverless can potentially deliver means that DevOps and other Agile-type development practices may be facilitated. This has the potential to reduce costs further and create a virtuous circle of shorter release cycles, faster feedback and increased efficiency.

> **It facilitates a DevOps approach and a continuous delivery model, because the team are empowered to do their own deployments, and we monitor systems as well…** Development lead, Media

These benefits were underlined by answers to the question: "What is the main driver for considering/using serverless in your organisation?" The most popular answer, given by 29 per cent, was scalability. However, 26 per cent opted for cost savings and 16 per cent for simplicity; 13 per cent chose speed. In reality, these factors are all very much related.

On the whole, responses to the discussion on serverless were generally positive, but it isn't universally suitable. Figure 8 illustrates answers to the question: "What sort of use-cases is serverless cloud suitable for?" While serverless may be considered the proverbial no brainer for small applications requiring rapid scaling and event-driven processing such as in IoT use cases, it is less so for complex, multi-faceted applications such as CRM.

FIG. 10 What sort of use cases is serverless cloud suitable for?

Applications that need to scale rapidly	51%
Event-driven processing (e.g. IoT)	40%
Small apps running intermittently	39%
Microservices and DevOps	34%
Hosting any application or service	28%
Test and dev only	22%
Complex multi-faceted applications (e.g. CRM)	18%

* Respondents could select multiple answers.

Serverless is likely to be for use cases where it is not necessary to retain state, and if loads are constant rather than intermittent cost savings are unlikely to be realised.

> **Not everything is suited to serverless. If you've got a constant high load on the server, then you're still better off with a dedicated EC2 instance, or a number of EC2 instances in auto scaling groups, which is what we tend to deploy…** Development lead, Media

One of our interviewees also touched on another potential drawback of serverless – the requirement for development skills.

> **Generally to use that kind of microservices architecture you need to expose your business logic as code, and if you're an organisation that would typically buy something off the shelf, this is not something that's going to work for you. If you are mostly a non-technical organisation, you just want the service; again it's not really a great fit…** CTO, Investment

The same concerns also exist around vendor lock-in as they do with any other cloud service, perhaps more so as serverless functions may require databases to retain data and state, and those databases will almost certainly need to be part of the same ecosystem.

Another aspect of the discussion on serverless is the degree to which it is likely to supersede containers. AWS Lambda has been phenomenally successful since its launch at the end of 2014. However, Docker has also continued to grow. It is estimated that in 2016, Docker grew 2.6 times.[3] While this is an estimate based on those listing Docker as a skill or as part of a job description on LinkedIn during the second half of 2016, it suggests that those claiming that serverless will kill containers fairly quickly may be wide of the mark.

Those responding to our survey were certainly not uniformly convinced. Among those who were familiar with platform such as Lambda, Open Whisk or Microsoft Functions, when asked, "In your opinion will serverless cloud spell the end of containers for most DevOps tasks?", five per cent gave a definite "yes" and 20 per cent a more cautious "probably"; 32 per cent went with "maybe" and a further 28 per cent "probably not". Five per cent gave a definite "no".

Some of the participants in our qualitative research did believe that containers will ultimately be superseded by serverless, at least in the cloud.

> **I don't really see a point in containers in the cloud, because you're already working on virtualised servers and because we do everything with cloud formations, so everything just gets spun up instantly. It's not like you have to spend time installing software on individual machines – it's already a virtualised deployable unit…** Development lead, Media

> **Our new platform includes Docker in order to give us some of the serverless architecture. So I think for us – and hands up we might have got it wrong – but as far as our internal skills are concerned that's where we're headed at the moment…** Head of operations, Media

[3] www.linkedin.com/pulse/docker-momentum-2016-analysis-michael-mullany

However, as has already been touched upon, serverless is not suitable for every workload. Steady state workloads mean that the economics of pay per use compute become far less compelling.

> I wouldn't use serverless if there's a steady state load because then it's cheaper to use dedicated computers. But if you've got fluctuating load, which is almost always the case, then serverless pays dividends.
>
> Development lead, Media

Others thought that both were likely to continue growing, although perhaps not as sharply in Docker's case as it has, arguably, reached the mass adoption stage anyway. One is a technology – the other almost more a commercial model. Both have their place.

> Will serverless take over from containers? If the whole thing were to start from scratch then maybe, but realistically I think that people are still going to use VMs, they're still going to use dedicated infrastructure, they're still going to be on-premise so serverless is going to sit alongside all these other technologies that are available to developers and the enterprise… Analyst, Technology analyst firm
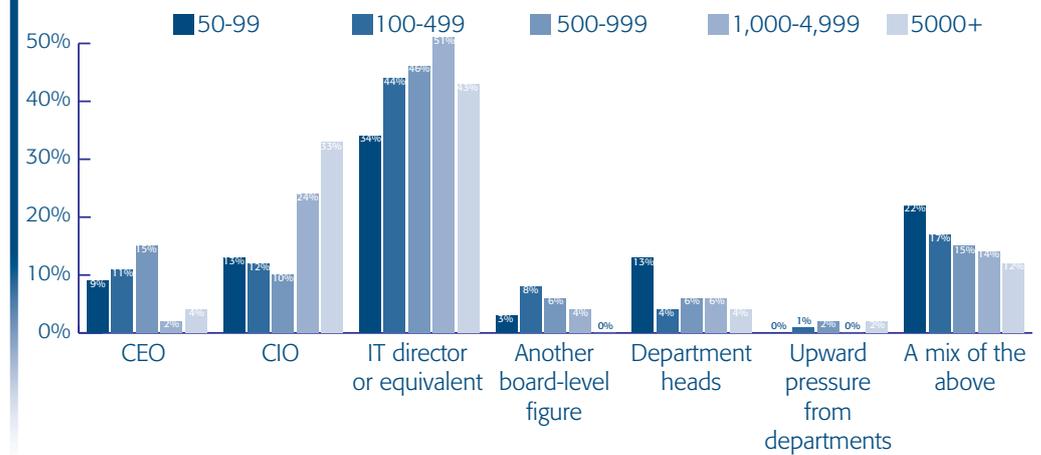
8 Cloud services market

Decisions on infrastructure strategy affect every part of an organisation. Arguably this applies even more so if decisions are made to utilise the cloud. It follows that cloud strategy decisions should involve more than just the IT department, particularly because SaaS applications can be procured and operated with a minimal amount of technical understanding. Is this the case in reality? The short answer is no. Overall, 44 per cent of strategic cloud platform decisions were made by IT directors or their equivalent. The CIO made 18 per cent of decisions and in 16 per cent of cases it was a mixture of executives. Department heads accounted for just six per cent. The panelist quoted below is probably typical of the IT led approach.

> We've consolidated – we had a market-based set of development teams and people doing automotive, people doing stuff around consumer electronics, or whatever our various markets were, and IT doing the more traditional stuff and now we just have a technology team and probably more people work in our technology team than there were.
>
> Head of operations, Media

The size of an organisation certainly has an impact on who makes the decisions. The CIO is far more likely to be leading in organisations numbering in excess of 5,000 employees – probably because they are more likely to have one in the first place. The smaller the organisation is the greater likelihood there is of cloud platform decision making being more of a team pursuit.

"The cloud services market is generally agreed to be consolidating around three providers – but Amazon is still dominating by a considerable margin. In 2016, AWS profits exceeded the total revenue of Azure"

FIG. 11 Who makes your strategic cloud platform decisions?

Legend: 50-99 | 100-499 | 500-999 | 1,000-4,999 | 5000+

A bar chart showing percentages by company size across decision-maker categories (y-axis 0% to 50%):

- **CEO**: 9%, 11%, 15%, (low), 4%
- **CIO**: 13%, 12%, 10%, 24%, 33%
- **IT director or equivalent**: 34%, 44%, 46%, 51%, 43%
- **Another board-level figure**: 3%, 8%, 6%, (low), 0%
- **Department heads**: 13%, 4%, 6%, 6%, (low)
- **Upward pressure from departments**: 0%, 1%, 4%, 0%, 2%
- **A mix of the above**: 22%, 17%, 15%, 14%, 11%

So, what platforms are businesses choosing? Again, there is a degree of variation here based on company size but among those we surveyed, Microsoft Azure was the most popular platform, with VMware vSphere/vCloud Director/vCloud Automation Centre coming second, presumably representing the private cloud contingent.

The mighty AWS only polled third place in our survey. Whether this is truly representative is debatable. The cloud services market is generally agreed to be consolidating around three providers with Amazon still dominating by a considerable margin and Microsoft and Google in second and third place, respectively. In 2016, AWS profits exceeded the total revenue of Azure.[4] It is possible that our survey recorded this surprising result because Microsoft Office 365, which is SaaS, is sometimes confused with Azure, a misunderstanding which no doubt Microsoft is in no rush to correct.

The dominance of Amazon is no great surprise given that it was the innovator of many cloud products and services.

> " Amazon is at least 18 months ahead of Microsoft from a general cloud provider perspective and that lead is only increasing. It doesn't try to force you into its ecosystem…
> CIO, Transport

> " We're on Amazon's innovation curve. This one has been a huge win – our technology adoption cycle has changed completely. Since the migration, we've created an entire data infrastructure leveraging super-cheap storage and innovative tech, especially serverless. This has required very low input from the infrastructure teams… CIO, Transport

The interviewee quoted above saved £1.2 million per annum from capital budget and even managed to slightly reduce operating budget as well as increasing productivity by using AWS.

[4] www.infoworld.com/article/3165508/cloud-computing/aws-google-and-microsoft-cement-their-cloud-dominance.html

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However, not everybody was convinced that AWS is the answer, being wary of the hype, particularly around the compliance- and performance-friendly new regional UK data centres that Amazon is building with much fanfare, which are supposed to divide the UK into three regions.

> **I talked to a chap from HMRC and he sort of smiled and said 'yeah, well that [AWS regions] might be true but do you know they're all clustered around the M4 corridor?'. That's not quite the impression they gave**… CIO, Healthcare

Confusions over Office 365 aside, is the dominance of Microsoft Azure in our survey a sign of changes to come in the market? It's possible. The interviewees quoted below are not the first people to raise the subject of the strategy being employed by Microsoft to claw some ground from AWS.

> **Azure is more focused on enterprise where they have an existing relationship with Office 365 and other applications and I think especially in Europe they are putting in sweeteners and they're pretty much undercutting the market**…
> Principal consultant, IT consultancy

> **If you're in the market for some Office 365 licences or a Dynamics ERP licence then you are almost certainly getting a very well-incentivised package that combines Azure spend as well**… Senior manager, Technology

It is certainly an intuitive approach to take – for Microsoft and its customers.

> **If you have people in your business who are using Office 365 they're probably doing something with the features in Azure because it's kind of part of the Office 365 migration from Exchange. And so they've already picked up some skills, they already know a bit of Azure. For us the move to Azure was a very natural one**… CIO, Healthcare

Furthermore, we all know (although possibly not as well as Microsoft) that you don't have to be the first to the market to end up dominating it in the longer term.

> **If I was betting on the Azure side from a revenue perspective I would say it's probably about a third of AWS right now but it is growing very successfully and Microsoft has invested very significantly in this in a way that Microsoft is very effective, or has been, historically. You don't always need to be the first mover, you need to be a fast follower that can invest heavily and can execute well – and Microsoft can**…
> Senior manager, Technology

Google is still quite some way behind Microsoft in terms of market share and revenues for the Google Cloud, but it would take a brave individual to bet against it longer term. As a panelist quoted below points out, Google has access to data that its competitors can only dream of, as well as considerable expertise in scaling infrastructure to a massive degree. If an organisation is seeking to leverage big data analytics, Google Cloud could be a good fit.

Google has chalked up some big wins – HSBC and Verizon to name but two.

> **The core part of its insanely profitable business is all around data and data at a scale that very few other organisations can ever really even dream of…** Senior manager, Technology

> **We're seeing more and more interest as this year progresses and I think in the UK especially, which is a pretty mature market and pretty favourable towards Google in general as an organisation, with the announcement of its London data centres, which will follow on from Amazon and Microsoft announcing theirs, I think we'll start to see some more Google cloud platform traction – again, focused primarily around analytics.** Senior manager, Technology

What of other service providers? Depending on how success is measured IBM is sometimes considered to be the third or fourth biggest player in the cloud platform services market. IBM was seen to have strength in more traditional consultancy led markets and also in AI, as represented by its Watson cognitive computing platform.

> **What IBM is good at is implementing solutions. It does have some very strong consulting workforce and I expect it to reinvent itself a little bit in that space and recognise the value of working with the other market-leading cloud providers…** Senior manager, Technology

Likewise, Oracle's cloud efforts have so far focused on existing customers. One interviewee felt that both Oracle and IBM should move their cloud business focus away from their traditional customers and concentrate instead on broader horizons.

> **My personal view is IBM and Oracle are focusing on the wrong things. Realistically the only people properly using Smartcloud are people who have had massive historic long relationships with IBM going back decades and those relationships are driving what I'm sure are some pretty heavily discounted deals…** Senior manager, Technology

There was also some cynicism about Oracle services.

> **If you go to Oracle – what it is doing is it is saying buy the capacity and we will give you the latest hardware, but after three years it won't be powerful so you are basically coupling your code or architecture to a particular hardware…** Principal consultant, IT consultancy

> **The only reason anyone would buy an Oracle cloud solution is because they were forced to through existing licensing arrangements…** Senior manager, Technology

9 Skills gap

It has become apparent throughout the course of this years' research that one of the biggest potential challenges organisations face when moving their strategies to encompass cloud infrastructure is one of skills and mindset. Our supplementary survey (Fig. 6) found that the skills shortage was second only to legacy infrastructure as a factor likely to limit cloud success.

As we can see in Figure 12, a huge 69 per cent had a shortfall in technical skills. Thirty-eight per cent were struggling to source the required project management capabilities and 29 per cent were concerned about communication. Communication will also have been uppermost in the minds of the 28 per cent of users who were concerned about the skills of end users. The final category was leadership – 22 per cent of respondents also indicated shortages here.

"The seemingly serious shortfall in skills is delaying cloud infrastructure projects – and limiting how successful they can truly be…"

FIG. 12 What skills gaps can you identify, either in people or the organisation when thinking about the adoption of cloud technologies?

Technical IT skills	69%
Project management capabilities	38%
Communication	29%
End-user adoption	28%
Leadership skills	22%
Other	2%
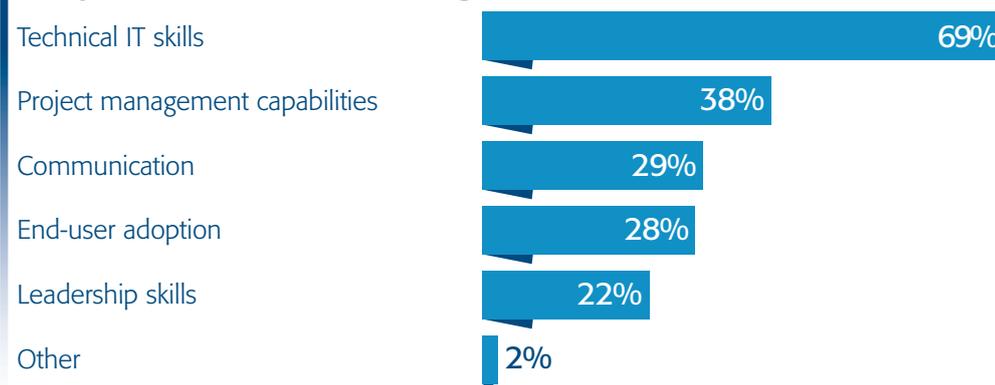
In order to gain greater insight we also asked users to give a free text answer to the question. The answers are illuminating. Technical shortages were a problem for businesses of all sizes (seemingly exacerbated by poor documentation from some cloud service vendors), although the issue was more acute for businesses employing fewer than 500 individuals. A selection of responses follows:

Technical IT skills

"Because budgets are too tight to afford training…"

"It's moving too fast, getting further away…"

"No-one has previous cloud experience…"

"The landscape is changing so quickly…"

"The skills gap means heavy use of contract resource…"

Businesses of this size were also more likely to experience problems with end user adoption.

End-user adoption

"It is often a challenge for people to understand new concepts and they can be quick to condemn a new direction at the first sign of a perceived issue…"

"It could create a support headache…"

"It can be hard to get across to users what the benefits would be…"

"People just don't like change…"

One of our panelists had some uncompromising views on the personal issues around end-user adoption and the wider cloud culture.

> **You do need traditional training. The skills gap is not always a skills gap, it's sometimes actually reticence from our people in the IT team to go to the cloud. Some teams just seem to be scared of losing their jobs…** Head of infrastructure, Charity

Larger organisations were slightly more likely to be experiencing shortfalls in leadership and project management skills. Again, a selection of responses from organisations employing in excess of 1,000 people follows:

Leadership skills/project management

"Technical staff are generally very willing to learn new technologies, but leadership can sometimes be harder to achieve. Without drive from the top, major strategic change in unlikely to work…"

"We have project management skills traditionally based on a Waterfall-type approach and unused to the mind-set required for full agile cloud adoption…"

"Effective project management is crucial for cloud-based projects as control of the systems is passed to a third party. Attention to detail and clarity of project deliverables is essential…"

"There just doesn't appear to be a clear cloud adoption strategy."

Barely one quarter of users (27 per cent) answered in the affirmative to the question, "Do you have a training plan in place to facilitate a smooth transition to the cloud or once using a cloud solution?". While 21 per cent were making plans at the time of asking, a huge 52 per cent of respondents had no such plan at all.

This seemingly serious shortfall in skills is delaying cloud infrastructure projects – and limiting how successful they can truly be. Research from other bodies has drawn similar conclusions. The House of Commons Science and Technology Committee stated in 2016 that an extra 745,000 workers with digital skills would be needed by this year alone.[5] Others have found that the skills gap is as high as it was a decade ago during the Great Recession.[6] The impact of the cloud skills shortage can be profound and the cycle continues as existing staff have to work even harder to attempt to plug the gap. They tend to spend more time fire-fighting, meaning a reduced focus on strategic tasks and greater levels of stress, burn-out and attrition. Nobody wins.

Perhaps this is why 40 per cent of our respondents were considering formal personal training as a way to get more out of their individual cloud platforms and/or careers. A further 24 per cent were seriously thinking about it.

FIG. 13 Have you considered formal training as a way of getting more from your cloud platform or career?

Thinking about it **24%**

Yes **40%**

No **36%**
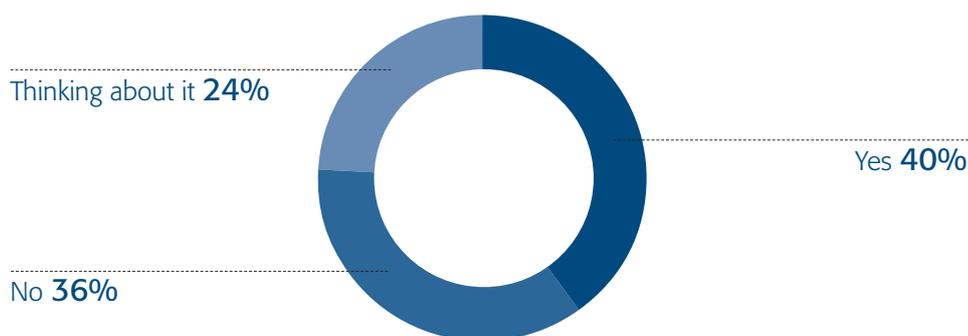
10 Conclusions

Data centre strategies are evolving, and in the manner of all evolutions it has been a very gradual process. However, the trend of utilising cloud infrastructure services has picked up some pace. In 2014, 52 per cent of respondents to our data centre survey had no experience of outsourcing any aspect of their infrastructure to the cloud. This year that proportion stands at nine per cent. The most popular cloud strategy was "partial cloud", with 70 per cent of respondents describing their strategy thus. However, the growth in cloud services is not being uniformly seen across all sizes of organisation. Those employing between 1,000 and 4,999 individuals are the most likely to be avoiding the cloud for various reasons and those that number in excess of 5,000 are the most likely to be pushing ahead with "cloud-first" strategies. Seventy-one per cent of those we questioned expected their takeup of cloud services to increase in the year ahead.

Despite the huge growth in the revenues of cloud service providers, the progress away from the traditional on-premise data centre has been – and remains – extremely slow. Approximately 30 per cent of our respondents' year-on-year are simply not moving at all. Compliance, control and security all feature highly in the persistence of more traditional infrastructure – as do very long depreciation cycles.

"While the cloud has opened up a world of possibilities, simplification is not one of them"

[5] www.thehrdirector.com/business-news/it/uks-digital-skills-shortage-hits-crisis-levels

[6] www.thebunker.net/digital-skill-shortage-could-lead-to-increased-security-risks-and-failed-cloud-migrations-says-the-bunker

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The progress of new data centre technology such as software defined and hyperconvergence has been slow to date but has seen an uptick with 10 per cent of respondents using these technologies as opposed to four per cent a couple of years ago. The awareness of newer technologies has increased. For example, 16 per cent of respondents thought SDDC was at the very promising end of the spectrum in terms of the likelihood of meeting their organisation's requirements over the next three years. It is reasonable to infer that a sizeable proportion of the 30 per cent who are unwilling to place infrastructure in the cloud are likely to begin transitioning to technologies like this over the next few years.

The precise definitions of the steadily increasing number of cloud service models and concepts are still a subject of debate. The difference between hybrid and multi-cloud architectures were very far from being universally agreed on. It follows that the popularity of such architectures may be being throttled by a genuine lack of understanding about the benefits that they can potentially deliver. Fewer than 40 per cent of respondents understood serverless computing in the same way as the technology industry.

Having defined their strategies, organisations are taking various routes to the cloud. SaaS remains the most popular way to utilise public cloud infrastructure with 58 per cent of respondents using some sort of SaaS. IaaS was also popular with 31 per cent of respondents using it in their production environment. The larger businesses were the more likely to be using IaaS. Only 13 per cent were using PaaS in their production environments and 11 per cent in testing/development. A further 11 per cent were at the trial stage.

The wisdom of the prevailing hybrid cloud strategy was debated. A thread of opinion emerged during our research that hybrid strategies weren't really strategies at all – more a staging post on the way to cloud-first rather than a deliberately architected attempt to realise the best of both worlds. However, this opinion was not shared by everybody we spoke to. Many of those we surveyed were engineering such a strategy to combine the scalability and agility of the public cloud with the control and security of a private one. Thirty-eight per cent of our respondents were using a hybrid either in production or test and dev. Multi-cloud was only slightly less popular, with 34 per cent using public cloud services from more than one provider. Many respondents were using multi-cloud as a component of a wider hybrid strategy to leverage competition between vendors and avoid being locked into deals that become less attractive as time progresses.

Despite its lack of maturity when considered against other cloud strategies, serverless was already attracting interest. Almost one quarter were already using serverless in production or test and development. A further 21 per cent were actively considering it which means growth is likely to be strong in the three years ahead. The commercial model of utilising computing power as and when it is required was creating a virtuous circle of reduced costs, facilitation of DevOps and shorter release cycles for some of those we spoke to. The almost infinite scalability and cost savings that serverless can provide

were the most frequently given benefits for those who had implemented it but it isn't without its drawbacks. The same concerns around the security and compliance implications of multi-tenancy which so often crop up in relation to the public cloud are also present here, as are concerns about the development skills required to fully utilise serverless.

Will serverless supercede containers completely? The answer was a resounding maybe – but probably not. This finding was based largely on the fact that for the processing of steady state workloads, pay-per-use compute looks considerably less inviting. Serverless and containers do not have to be mutually exclusive. They can work together as part of a hybrid strategy alongside the panoply of technologies available to the enterprise.

When it comes to making decisions about these technologies, the technical teams still exercise the power. Forty four per cent of strategic cloud platform decisions are made by IT directors or their equivalent. Our research found that other heads of department are poorly represented in the decision-making process.

Despite the continued and growing dominance of AWS, Microsoft Azure was the most popular platform among those we surveyed – perhaps the beneficiaries of reported assertive marketing and pricing strategies from Microsoft. Google Cloud makes up the big three dominating the cloud services market. While Google lags quite some way off AWS and Microsoft's share of the cloud services market, its advanced analytics make it a natural choice for those seeking them.

One of the biggest challenges facing businesses as they press ahead with their cloud strategies is a shortage of the necessary skills. Sixty-nine per cent were facing a shortfall of technical skills. Project management, communication and leadership skills were also in short supply. For those with fewer than 500 employees, the lack of technical skills was the most pressing issue, closely followed by end-user takeup.

Larger organisations were slightly more likely to be experiencing shortfalls in leadership and project management skills. Over half of our respondents had no training plan in place to facilitate a smooth transition to the cloud. The impact of this digital skills shortage is difficult to overstate. Cloud infrastructure projects are being delayed, and their success is being placed in jeopardy. A lack of the right skills can doom a cloud project before it's even got off the ground and teams have to work harder to make up the shortfall. The resulting increase in staff attrition rates just exacerbates the original problem.

Our research this year has shown that the cloud is, in its various guises, playing an ever-increasing role in the delivery of the infrastructure on which our economy and public services run. That role is only going to increase as the early part of the 21st century rolls on. How is the cloud likely to develop as those years draw to a close? One of our interviewees believes that the role of AI will be crucial.

> **"** One of the things for me that I find really interesting is the applicability of the cloud for machine learning. I think that's an incredibly strong use case for the cloud – and actually for all different kinds of reasons. If you're looking at, say, anonymised data at a big data scale and you want to run a big overnight task or one two weeks long you need lots and lots of resources; things like that really lend themselves to the cloud. They're very much natural bedfellows. Anything around big data and machine learning or round the kind of training that you have to do with the supervised and non-supervised models in machine learning is really well suited to cloud… CTO, Investment

We touched on the fact earlier that Google was pushing ahead with the use of machine learning in data analytics. IBM too is seeking to make this territory its own. The cloud can facilitate the increasing use of machine learning by virtue of its scalability. Equally, AI could enable the development of the cloud services with AI-as-a-Service. It is not difficult to see a symbiotic relationship between the two. The application of machine learning to decision making is another use case for the cloud to add to the rapidly proliferating number of cloud services and architectures. Still another is for orchestrating data flows from the multitude of devices that make up the Internet of Things.

One of the early premises of the cloud was that it would simplify infrastructure. While the cloud has opened up a world of possibilities, simplification is not one of them. Instead, organisations must navigate their way through an increasingly crowded and complicated field to establish what type of cloud strategy will enable them to meet their objectives. The shortage of skills in leadership, project management and above all the technical skills necessary to architect increasingly complex cloud infrastructure means that task is likely to become more challenging in the years ahead.

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