D4.3 Roadmap to a cloud market structure encouraging transparent cloud pricing – Final iteration

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The focus of this document is to highlight how best to manage systemic risks in the Infrastructure-as-a-Service market that are noteworthy to stakeholders seeking to shape policies for a fair and transparent cloud market. This document outlines how the cloud computing market is structured, why it is essential for Europe and the types of activities necessary to create a fair, balanced, and transparent market. This document makes recommendations to key stakeholders for actions to mitigate risks of market failure, and deliver a stable cloud computing market.

CloudWATCH2 Mission

It is only when the innovation process is inclusive and open that we truly advance technology for humanity – from small businesses to public sector organisations and citizens as the new digital consumers. The use of open source software and open standards are becoming increasingly seen as enablers and levellers for public and private sectors alike, bundling skills to create new services and applications.

To support this CloudWATCH2 takes a pragmatic approach to market uptake and the exploitation of results coming from European sustainable competitiveness for wider uptake and commercial exploitation. It provides a set of services to help European R&I initiatives capture the value proposition and business case as key to boosting the European economy.

CloudWATCH2 services include:

- A cloud market structure roadmap with transparent pricing to enable R&I projects to chart exploitation paths in ways they had not previously considered, or help them avoid approaches that would not have been successful.
- Mapping the EU cloud ecosystem of products, services and solutions emerging from EU R&I projects. Identifying software champions and best practices in mitigating risks associated with open source projects, and ultimately, enable faster time-to-value and commercialisation.
- Impact meetings for clustering and convergence on common themes and challenges. Re-use of technologies will also be of paramount importance.
- Promoting trusted & secure services through roadshows and deep dive training sessions. Giving R&I initiatives a route to users at major conferences or in local ICT clusters.
- A portfolio of standards for interoperability and security that can facilitate the realisation of an ecosystem of interoperable services for Europe.
- Cloud interoperability testing in an international developer-oriented and hands-on environment. Findings will be transferred into guidance documents and standards.
- Risk management and legal guidelines with practical examples of cloud contracts' clauses that need to be assessed before purchasing cloud services to the cloud for private and public organisations to lower barriers and ensure a trusted European cloud market.

Disclaimer

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The information, views and tips set out in this publication are those of the CloudWATCH2 Consortium and its pool of international experts and cannot be considered to reflect the views of the European Commission.

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Foreword

The provision of IT services via the cloud is becoming the new norm. Enterprises small and large, as well as many public sector organisations are moving towards a "cloud first policy", craving the agility that on-demand IT allows. The European Commission has identified the strategic role of cloud within its Digital Single Market Strategy for Europe and has set-up a coherent strategy in order to accelerate the take-up and increased use of cloud computing across all economic sectors.

Europe wants to embrace all the benefits offered by cloud technologies. For this purpose, interoperability must be enabled and relevant standards must be leveraged. This is needed to allow benchmarking of service quality and price comparison. Emerging issues related to ownership, access, porting of data and switching of cloud service providers should be adequately addressed. In this way, we can ensure a level playing field for all cloud players which will stimulate competition and create innovative and efficient marketplaces for users of cloud services in Europe.

Pierre Chastanet, Acting Head of Unit, Cloud & Software, European Commission.

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1 Introduction

In April 2016, we published a Preliminary Version of this Roadmap, highlighting a number of risks to the global cloud computing market and hence to the digital economies that rely upon its on-demand computing capabilities. At that time, it was very unclear as to whether the market structure would evolve into a healthy, sophisticated market that encourages competition, or if its evolution would stall as a result of the dominant providers protecting their interests.

As Dr Vince Kellen, CIO of University of California at San Diego pointed out:

> *"The cloud market is growing rapidly in a rush of sometimes irrational exuberance. As we have seen so many times before in other industries, this may be just a patch of sunshine before a perfect storm of unmanageable risk rushes in. What we need right now are experienced minds with the right imagination to analyze what few are talking about: black swan events in the burgeoning cloud market."*

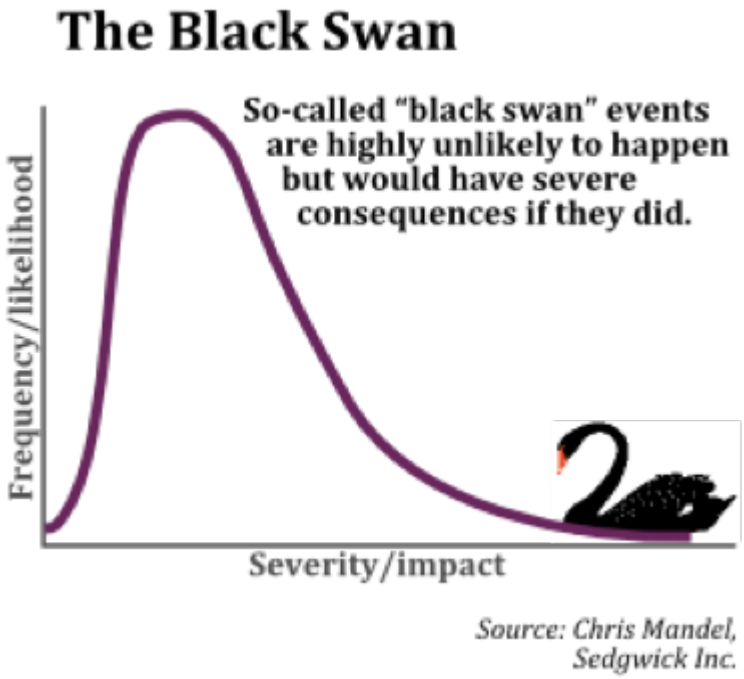

Figure 1 Black Swan events

More recently, other commentators have independently voiced related concerns, some going so far as to call for the breakup of some of the titans of the technology industry, including Google, Facebook and Amazon. Such an extreme use of anti-trust laws would itself be a Black Swan event, as it could result in significant disruption to the direct and indirect user base of the affected services. There are also commentators who argue strongly that competition is alive and kicking. As Tim Harford, a respected economist, comments on the issue in the Financial Times, "*The policy response required is subtle: after all, the growth of innovative, productive companies is welcome. It's the unintended consequences of that growth that pose problems*."

This matters because the European Commission (EC) has (rightly) identified digitisation of European industry as a key priority, with over €50 billion of funding already set aside to encourage it through digital innovation projects, many of which are likely to leverage the services of the abovementioned titans, or those companies with the daunting task of competing against them.

The EC's Digital Single Market (DSM) in Europe is an unprecedented opportunity to create one of the biggest digital marketplaces in the world which can have a hugely positive impact on Europe's competitiveness and productivity across industrial and service sectors. The EC has identified five priority domains which are the building blocks of the DSM, namely: Cloud computing; 5G; internet of things (IoT); cybersecurity; and data. With growing convergence of these technologies giving value to digital systems, transparency and appropriate standardisation is urgently required so that the DSM is founded on trustworthy solutions based on interoperable systems and interfaces that keep markets open, boost innovation and allow service portability.

We are pleased to report that many of the risks we identified in the Preliminary Version are reducing, and others are being mitigated with sensible strategies. The most promising of all is the maturity of the support offered to the ecosystem of cloud intermediaries, i.e. cloud resellers and managed service providers, that provide diverse and competitive ways for cloud buyers to procure cloud services based on the dominant cloud providers as well as aggregating the buying power of numerous, diverse cloud users and using that to protect their interests.

The structure of the Infrastructure-as-a-Service base layer of the cloud market is maturing rapidly, and in general this is leading at least to rational pricing, if not full transparency in pricing, as a result of inherent difficulties in making like-for-like technology migrations or even just comparisons. Again, specialist intermediators acting as "cloud suppliers" have the motivation and the expertise to analyse and compare the multitude of wholesale IaaS product offerings in support of their end-user customers.

There is now a market that has evolved, without significant regulatory intervention, to look not dissimilar to sophisticated, regulated markets such as electricity. Here is what Germany's energy regulator, the Bundesnetzagentur says about its market:

> *"Well-functioning wholesale markets are fundamental to competition in the electricity sector. Spot and futures markets are crucial for meeting suppliers' short and longer term electricity requirements. Power exchanges play a key role alongside bilateral, over-the-counter (OTC) wholesale trading. They create a reliable trading forum and at the same time provide important price signals for market participants in other electricity sectors."*

There are a number of dominant generation technologies being used to provide most of the cloud capacity that is in use, but there are still others in operation at a smaller scale. Buyers do not have to purchase capacity directly from the dominant technology provider, but rather have a large choice of intermediaries to purchase from, often with other technical or financial value-added services included in the offering. There do remain more barriers to switching between technologies in the cloud market than in, say, the electricity markets, however switching "supplier", i.e. who invoices the customer, is just as straightforward. For those charged with the challenging role of regulatory oversight of this market, the authors recommend that the focus should be on encouraging healthy competition at the point of supply to the customer, and ensuring that cloud intermediaries all have the same fair access to competitive cloud pricing as the direct sales or "supplier" part of the incumbent cloud providers. This will leave the door open for market entry by

challenger cloud providers in the future, once technologies and other initiatives that make switching provider easier have matured further.

The next stage of cloud market evolution, at the base infrastructure as a service ("IaaS") layer, is for there to be bilateral trading between cloud intermediaries, in order to facilitate effective transfer and hence management of financial risks. With such bilateral trading, often referred to as "Over The Counter" or "OTC" trading, there usually arises a price reporting service that allows the market as a whole to have transparency on the expected future price of, in this case, cloud computing contracts. OTC markets are generally a necessary precursor to financial exchanges, whose purpose is to reduce transaction costs for intermediaries' risk management activities, and minimise credit risks through the clearinghouse function, and to take over and fully standardise the price reporting service. A market structured in such a way is far less opaque, with far more ability and indeed incentive for all concerned for there to be pricing transparency. This will underpin fair pricing in the market, leading to enhanced trust in the use of public cloud, and hence greater uptake. It is well worth pointing out that the shared cloud capacity run by the major cloud providers has a far lower carbon footprint than most organisations' private and on-premise IT facilities. The ability to transfer risk between intermediaries transforms suppliers' ability to offer price incentives in return for usage forecasts. By transferring these risks between intermediaries, they can be aggregated into firm commitments of the type favoured by cloud providers. This reduces cloud providers' capacity planning risk, making them more financially stable, again promoting trust in the cloud market. Reducing risk allows prices to be lowered, which can be passed down to buyers, accelerating uptake. This creates a virtuous cycle with benefits for all market participants.

2 Why Market Structure Matters

Innovation is all the rage. From startups to large enterprises, everyone is trying to be innovative, and create products that bring something new to the market through some kind of unique selling point. Governments are doing their best to foster this innovation, in the hope that they will seed the next generation of globally relevant companies that will drive economic growth, jobs, and an export surplus. The majority of these disruptive companies, small and large, are harnessing on-demand digital technologies, that directly or indirectly consume on-demand cloud services that are massively scalable.

Allowing society's next generation of companies to be utterly reliant upon a small group, or at worst a single, underlying cloud technology is not a good idea. It would be equivalent to a country deciding to standardise upon a single generation technology for generating electricity. Black Swan events, no matter how unlikely, can and do happen, as was unfortunately the case in Japan, when there was a tsunami that impacted the Fukushima Nuclear Power Plant. That black swan event resulted in the long-term shutdown of every nuclear power plant in Japan, with far reaching economic impacts for every power consumer in Japan. However, note that the market structure did support interoperability, and whilst there may have been some interruption, it was not catastrophic.

Having a market structure that supports and encourages diversification of such risks is key to avoiding systemic risks to not just National economies, or to the European economies, but to the global economy. The cloud computing market is a single, interconnected global market for shared IT resources, with buyers and sellers spread globally, no different to the market for natural resources such as oil, coal or even of late via LNG, natural gas.

The first step to diversification is to ensure that there is competition between different technologies. For a long-time it looked like Amazon Web Services, the pioneer of cloud infrastructure as a service, would run away with the market. That is no longer so clearly the case, and in particular Microsoft is investing the requisite billions in its Azure cloud infrastructure platform, and is doing a good job of keeping up. There are various others who are also investing billions, most of these from outside of Europe, with mixed success in building a meaningful market share.

The second step to diversification of the cloud infrastructure market, is to encourage multiple cloud service providers to own and operate third party cloud technology. This is like having various different power generating companies all use technology provided by a third party who specialises in the technology, not the operation of the technology. We do see this in the cloud infrastructure as a service market, a notable example being T-systems operating datacentres that run the Azure Stack offered by Microsoft, and the use of OpenStack in both private and public clouds.

The third step to diversification would ideally be frictionless interoperability between these different technologies, at its extreme in a manner akin to using a power grid to "mix up" and share the power from different providers. This is currently still a challenge, and really only possible for the right use cases, with sufficient expertise and sometimes scale to make it economic. The authors strongly recommend that this step towards diversification should not be achieved by holding back the leading cloud providers through regulatory action enforcing standardisation. The market should be allowed to bring forward competing solutions to solve the interoperability challenges, with a survival of the fittest approach to selecting the successful approaches. That being said, a fair, level playing field needs to be made available to innovative companies trying to compete in solving these difficult challenges, and there is clearly a role for government in policing this, through enforcement of existing regulation, where necessary. The European Commission is already actively encouraging and funding projects and initiatives in this area, including funding support for successful projects that want to achieve market readiness, and not simply technology readiness.

Recommendation to the European Commission...

...keep funding interoperability projects

Given that time is required for the market to solve the issue of interoperability, the door needs to be held open for future market entrants to the cloud infrastructure as a service market. The best way to do this is to ensure that the asymmetry in size, and hence bargaining power, between a few huge cloud providers and small (in comparison) cloud buyers, which is already well established, does not get any more pronounced. The way to do this is to encourage intermediation between end user cloud buyers and the cloud providers, such that purchasing power is aggregated by cloud intermediaries, such as cloud resellers and cloud managed service providers. Again leveraging the analogy with electricity markets, it was the ability to access well-structured deals with intermediaries in the wholesale electricity market that allowed the quite sudden surge in market share, and proliferation in number, of independent electricity suppliers in the UK, resulting in more competitive pricing for consumers.

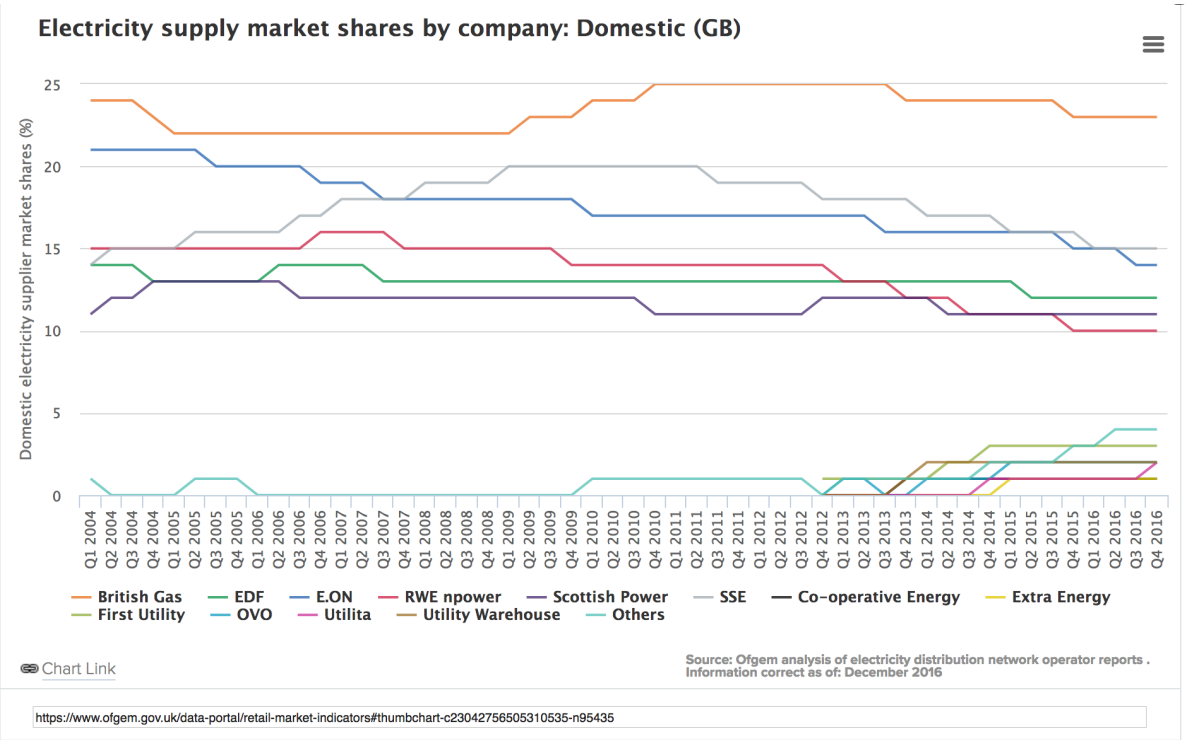

Figure 2 Electricity supply market shares by company: Domestic (GB)

Similarly, the reason why specialist electricity generators were able to compete in the UK against vertically integrated competitors, was through carefully structured sales of electricity to intermediaries who were able to manage such large, long-term transactions, with the associated credit risks.

Carefully designed market structure as highlighted in figure 3, has a final benefit in terms of providing a positive incentive for market participants to adopt standards, or at least benchmarks with standard ways to measure against them. This is because there are lower transaction costs for managing price risks for products that match the market standard.

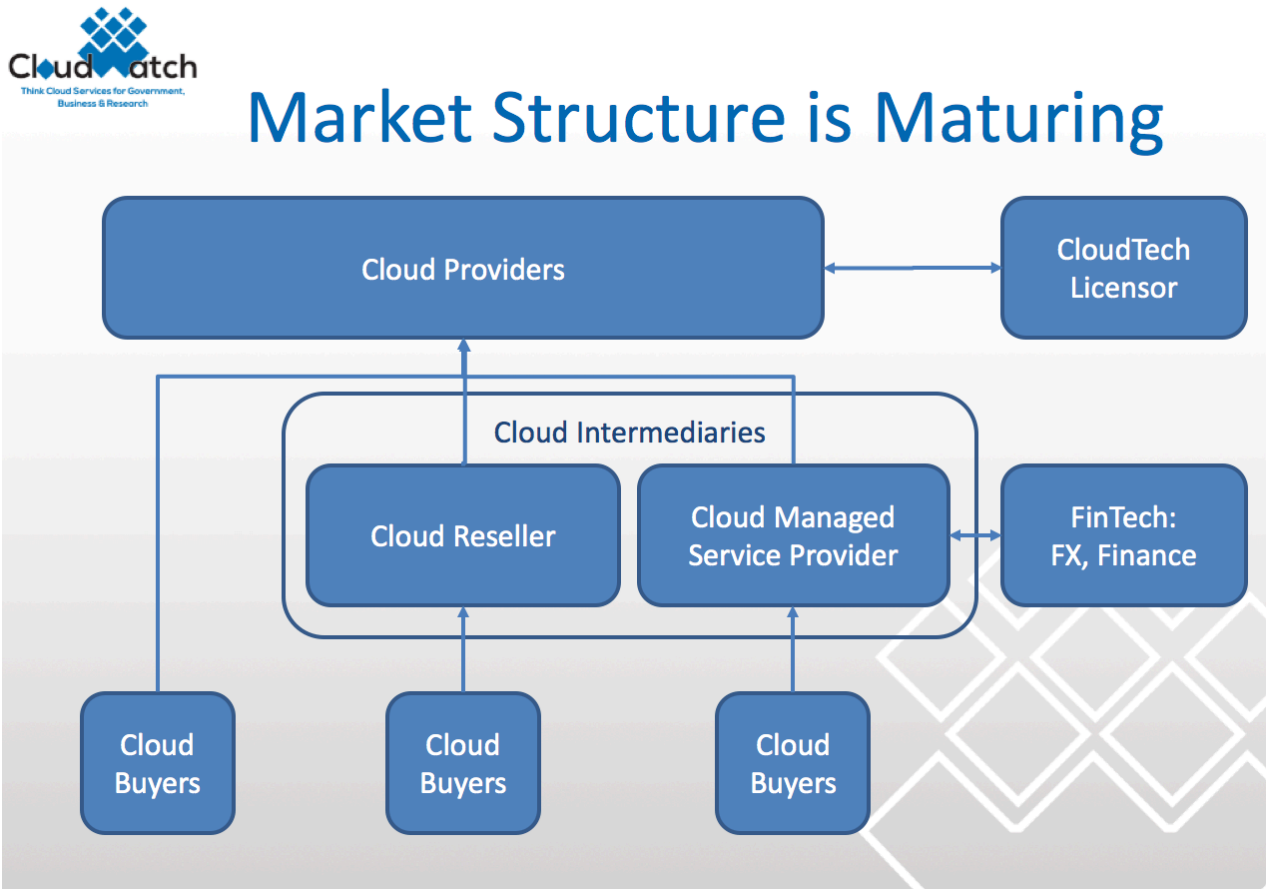

Figure 3 The market structure is maturing

Recommendation to the European Commission…

…encourage intermediation in the cloud market,

so that specialists can compete with the

vertically integrated cloud providers

who sell direct to end user buyers.

3 How we got here

When computing was originally offered to industry, it was as a private service using vacuum tube-based and later transistor-based mainframe technology. Organisations large enough to afford their own "private mainframe" would however share it across many local users, and capacity was very carefully planned in order to maximise utilisation of such a huge capital expenditure. When timesharing was first introduced, smaller organisations would take out timeshares on "public mainframes", and this shared computing model persisted until the introduction of the "personal computer". The PC made capacity planning unnecessary given the relatively inexpensive capital outlay for a device that fit under or on a desk and provided processing and storage power locally, and generally much faster than could be accessed via the telecommunications technology of the day. As more demanding uses for computing became common, simpler maintenance needed to be facilitated and the heat and noise being put out by the box under the desk became a problem, computer servers were placed in a separate "server room" and the desktop devices were used as "thin clients" to gain access to the servers - somewhat of a replication of the mainframe/terminal model employed before. As server rooms outgrew the buildings they were housed in, and the growth in ever higher bandwidth internet access, computer servers were relocated to more distant and dedicated datacentres. This provided the opportunity to benefit from the economies of sharing again, with colocation datacentres becoming popular, sharing air-conditioned buildings as large as shopping malls, but still with the servers themselves being private to the user, or at least the user's organisation. It was also not lost on many that energy efficiency was higher as well, a major consideration when 2% of all power generated in the US (and likely EU) is for powering and cooling datacentres. Initiatives such as a Code of Conduct for Energy Efficiency in Datacentres have been helpful in driving this trend.

The introduction of virtualisation, where software is used to create the illusion to several users of having direct, private access to a physical server, when in fact they are sharing the resources of that physical server, dramatically shifted the trend further towards sharing not just datacentre space, but the physical servers themselves. The "private cloud" was born, where multiple users from within an organisation could share the same physical servers, dramatically reducing the number of servers that had to be available to service the spiky usage profile of a group of users.

Then in 2006, the US online retailer Amazon, launched Amazon Web Services, a "public cloud" enabling anyone with a credit card, anywhere on the globe, to provision compute and storage infrastructure of such a quality that within a few short years, AWS' public cloud was putting many large enterprise "private clouds" to shame. In order to classify the capabilities of competing public and private clouds, the National Institute of Standards and Technologies ("NIST") put forward a definition for cloud services that has been widely adopted. Public cloud services that are fully compliant with the "Essential Characteristics" allowed on-demand, self-service access available over a broad network, to rapidly elastic resources taken from a shared pool, with a payment model that depended upon the measured resources consumed, not simply the capacity reserved. Such a definition could equally be applied to electricity and other commodity markets from which insights can be drawn.

In a market that requires billions in capital expenditure to achieve the hyperscale needed to compete with a global offering, it was always unlikely that the cloud infrastructure as a service market would be shared evenly across a large number of competing vendors. The economies of scale, together with the significant lead in innovation enjoyed for several years by the pioneer of the market, Amazon Web Services, have meant that only a handful of vendors, notably Microsoft, Google and IBM, have really challenged the dominance of the market leader.

However, many of the risks associated with having a market dominated by so few are being mitigated by each vendor responding to both each other's price drops, and each other's introduction of different deal structures. Furthermore, the market leader is setting a good example to the others, by supporting an enormous ecosystem of reseller and managed service partner "intermediaries" who are able to step into the billing chain between the cloud provider and the customer, in order to offer tailored pricing, billing and other managed services. The smaller cloud vendors are also doing this, but with varying levels of maturity and success. There are large numbers of European companies, both large and small, who have built businesses as cloud intermediaries, leveraging the advantages they have over the non-European cloud providers in terms of local knowledge, existing customer relationships and native language, and adding a wide variety of value-added services.

The result is that whilst there are a limited number of core cloud technology choices that a buyer of cloud infrastructure services can make, if they want a modern, globally available, low latency service that fully meets NIST's essential characteristics for a "cloud service", they do have a myriad of different suppliers to buy it from, including European suppliers. These suppliers, i.e. cloud resellers and cloud managed service providers who invoice the end customer, actively compete to offer the best overall deal, with variations in contracting terms, commitment, payment terms, financing, billing, currency options and technical support, as well as offering to bundle into the deal a plethora of other technical services.

The enthusiastic support for this ecosystem of intermediating cloud suppliers is how the largest cloud providers are dealing with the apparent conflict between a provider wanting to sell on their standardised preferred terms, on the one hand, and the buyer needing to buy on terms that meet their particular procurement needs. This is really quite analogous to the way that electricity is provided to the grid by a generating company (who often specialise in a particular power generation technology), but the power is supplied and charged to the customer by a supplier. It is equally analogous to gas and oil markets where the wholesaler sells under very different terms to the way a retailer sells to end users. This means that lessons learnt (often the hard way) in the various mature, sophisticated and largely transparent energy markets across Europe and around the world, can be applied to the rapidly maturing cloud infrastructure market. With this analogy, we can think of the leading cloud providers such as Amazon Web Services, Microsoft Azure and Google Compute Platform as being akin to generators who specialise in a particular generation technology, with independent intermediating suppliers who buy from these generators and sell-on to end customers, competing directly with the supplier business unit owned by the generators. There is therefore plenty of competition amongst suppliers, even though, as a consequence of economies of scale, generation is limited to a relatively small number of dominant generation technologies that are becoming the de facto standard for the market.

An interesting comparison can be drawn between the recent state of the cloud computing infrastructure market, and what happened in the US telephone market, when Judge Green threatened AT&T with breakup, due to a lack of competition caused by a vertically integrated monopoly provider. AT&T, in order to avoid the threatened loss of absolute control over its supply chain, instead voluntarily gave up exclusive control of its route to market by selling off the so-called "Baby Bells". The major cloud providers' enthusiastic support for cloud resellers and cloud managed service providers, who act as independent intermediaries between the providers and end customers raises the prospect of another flurry of entrepreneurial opportunity being available for cloud intermediaries, European or otherwise, who build on top of the leading cloud providers.

Another initiative that is also promising is by Microsoft Azure, who have partnered with T-systems, a major European systems integrator, to act as Data Trustee, controlling who has access to customers' data held in Azure datacentres based in Germany. This is notable as a voluntary initiative by a major cloud provider who elsewhere is highly vertically integrated, to decouple the role of designing the system that "generates" cloud capacity, from the role of "operator", as is normal in the more "complete" electricity generation markets.

4 The Road in front

According to widely accepted economic theory, markets tend to be healthier, more competitive, and more resilient to external shocks, when they are closer to being "complete". This is an area that has been researched heavily following the Global Financial Crisis, albeit comparisons between financial and "real-world" markets are full of pitfalls. A complete market is one in which it is possible to specialise in one particular area (thus minimising the barrier to market entry), whilst outsourcing all non-core risks to third parties, at fair, rational and transparent prices. Markets that approach completeness may well have vertically integrated participants, but the market is structured such that specialists are able to thrive alongside them. Where the market is not structured in this way, for example in Germany where the vertically integrated Deutsche Telekom owns "the last mile" of telecoms connectivity to residential properties, competition suffers.

"*The vertically integrated giants of the computer industry, firms such as IBM, Digital and Burroughs, were felled like young saplings when at the end of the 1970s Apple formed a network of independent specialists that produced machines far more efficiently than the do-it-all giants*." - The Economist

As explained above, the leading cloud providers have enabled a plethora of intermediaries to specialise in supplying the cloud providers' services to the end customer. So, at least from a procurement perspective, the cloud buyer does have a lot of choice. In Box 1, we explain the different ways in which a cloud buyer can purchase infrastructure cloud services.

Box 1 – How to Buy Cloud on Your Terms

Direct: Buying directly from the Cloud Provider is the most obvious approach, and is the most straightforward provided there are no differences between the standardised way in which the Cloud Provider wishes to sell to you, and the way in which you, the buyer, wish to make the purchase. However, the moment you need anything non-standard, it is worth considering the other choices below.

Reseller: A Cloud Reseller has a very strict definition. It means a company who will resell cloud services in a manner approved by the Cloud Provider, who has engaged the Reseller to effectively act as its proxy, in order to contract with non-standard customers. Resellers generally receive only a small rebate from the Cloud Provider for providing an outsourced negotiation service, and are expected to achieve profitability by adding value to the customer in other ways. However, using a Reseller is not the only way to place a third party into the billing chain in order to get a tailored deal. A Managed Service Provider ("MSP") can be used for this too.

Managed Service Provider: Cloud Providers treat Managed Service Providers as customers, no different to any enterprise customer. Managed Service Providers are allowed to provide access to cloud provider accounts that they nominally "own", but which in practice may be used exclusively for the benefit of a

particular customer of the Managed Service Provider. This should not be confused with the major cloud vendors' definition of "resale", however all the benefits of having a third party in the billing chain who can intermediate between the trading preferences of the cloud provider on the one hand, and the cloud buyer on the other, are the same as when buying through a reseller, with the added advantage of the MSP being far less restrained than a reseller. There are even examples of where a billing chain is composed of a large Reseller followed by a small, more innovative Managed Service Provider.

Independent cloud suppliers (i.e. cloud intermediaries who sell directly to the end user buyers) are likely to grow their market share, firstly because end customers often do prefer the tailored services that a specialist can offer, but also because it is in the interests of the biggest cloud providers to encourage this, certainly in Europe. There is a European Directive that places particular obligations on any market participant deemed to control more than 30% of any given market. Such a dominant vendor must be very careful in applying vertical restraints on its "resellers", where this use of the term may be broader than that used (in a poorly defined manner) in the cloud market, and as such could include intermediaries other than Cloud Resellers such as Cloud Managed Service Providers, although some recent contractual updates make this unclear. The leading cloud providers are really in a difficult position, as there are great advantages for everyone in having a go-to-market approach that is consistent, logical and ensures that as many buyers are serviced as possible, by leveraging outside help in servicing customers and prospects. However, go too far with the orchestration of resellers, and the major cloud providers could be accused of undesirable market practices, which is clearly not their intention, at least in the experience of the authors and those interviewed over the last 2 years. This area is of particular concern to AWS, who is widely assumed to be above the 30% applicability threshold, and may be relevant to Microsoft too.

In markets that do support both vertically integrated participants, who both own and operate facilities, and sell direct to customers; and specialist participants, there is a big issue around transfer pricing. For example, in the electricity markets, it is very common for vertically integrated companies to claim that their supply companies, who sell direct to their customers, sometimes under a range of brands, make virtually no profit, thereby implying that their pricing is highly competitive and hence fair. The accusation frequently levelled at these companies is that the transfer pricing of sales from the generation part of the business that provides the power, to the supply side of the business that sells it to the customers, is deliberately set high enough to wipe out all profit in the supply company. i.e. it is the generator that reports all the profits. The most common way to avoid this is for transfer pricing to be linked to the published pricing from wholesale trading amongst intermediaries, as we go on to describe in the next section.

5 Making the case for Cloud Trading

As mentioned above, the next stage in market development is to enable bilateral trading between cloud intermediaries. Such trading serves a valuable purpose - it allows intermediaries to offload risks they prefer not to hold, to their peers, at a negotiated price, as well as limiting the market power of the primary sellers. If an intermediary can know the price at which they can offload a risky deal, then they will be far more willing to take on that risk from a cloud buyer or cloud provider who would otherwise have to keep the risk. Box 2 goes through a worked example of how OTC trading delivers benefits for a cloud provider, and Box 3 for a cloud buyer.

Box 2 – How OTC Trading Helps the Cloud Provider

A cloud provider creates a risk when they build a new datacentre, lease more collocation space, or even just buy a new rack of servers. They pay or commit a certain value, and if they do not recoup that investment over the lifetime of the asset, they will lose money. If they wish to borrow money from a bank to finance the investment, the bank would typically ask for a contract of sale that shows the future cashflows that will repay the loan. The way cloud providers currently finance their expansion is not done like this, with the smallest providers having to raise equity to fund growth. The trouble is that whilst many cloud providers do offer fixed price deals that cover the full 3-year life of a server rack, cloud buyers buy relatively little of what they use on these long-term deals. The cloud buyers have been sold on the idea that the public cloud is all about elasticity and on-demand bursting, rather than about long-term capacity planning, which is all true, but this flexibility is included in the on-demand price at a 400% premium.

Therefore, rather than relying solely on selling to end user cloud buyers, primarily at on-demand pricing, at certain times it is far better for a cloud provider to be able to sell a large volume of capacity to a cloud intermediary under a long-term deal, at a fixed price, and even prepaid. This then allows lower cost financing of the cloud provider's growth, particularly for smaller, new entrant cloud providers. Of course, in order for the cloud intermediary to be able to deal with that risk, they need to be able to break it up and sell it on "vertically" to its own cloud buyers, and also "horizontally" to other cloud intermediaries who may be willing to immediately take on a share of the risk at a price. It is clear that even the largest and best funded cloud providers would like to be able to sell long-term deals, as Amazon Web Services has offered "heavy utilisation Reserved Instances" for several years, and Google recently announced long-term "Committed Use Discounts".

Box 3 – How OTC Trading Helps the Cloud Buyer

The usage of cloud resources by most cloud buyers is not totally ad hoc. Beneath the autoscaling usage, there are some virtual machines and databases that are deliberately left running long-term, with good forecastability as to size, operating system and location. There are then others whose use is better described as "persistent" than necessarily as "forecastable". Enterprises tend to be subject to a lot of inertia, and when you ask a developer the chance of a particular migration happening within a certain period you can often extract a probabilistic forecast for the project. With the right financial incentives to hand, a cloud supplier who has a close relationship with its cloud buyer, is able to collate these probabilistic forecasts and convert them, given a reasonable attitude to risk, into long-term purchases that match either how the cloud providers like to sell, or shorter contracts that could be available by trading bilaterally with other cloud intermediaries. The cloud buyer is then not only helped by the cloud supplier to think about its future cloud usage, but is also given a lower price than the default on-demand pricing.

For the sophisticated cloud buyer, who has invested in technical systems that allow their cloud infrastructure to be provisioned in multiple different ways given sufficient notice, they can access even better pricing from a cloud intermediary, by helping to manage the capacity planning risk of the intermediary.

Such OTC trading is not far down the road ahead. Several global cloud intermediaries, headquartered in Europe and elsewhere, have expressed interest in managing their capacity planning risks through bilateral trading under an OTC market structure and the authors are working hard to convert this into a reality.

6 European Initiatives paving the way

This section of the roadmap highlights several areas where European initiatives are helping to guide, bolster and reinforce the structure of the cloud market towards one that encourages healthy competition. These are specialist frameworks and services that address very specific market requirements, that remove friction in the adoption of cloud services. We include this, as we believe it is important to highlight areas where the European Commission's prior actions have been helpful, rather than simply asking for new actions.

6.1 Digital Single Market

The fragmented nature of the European Union from a regulatory perspective, is deeply unhelpful to home-grown European companies trying to compete with global competition, particular that from the USA. A Silicon Valley startup can specialise in a tiny niche digital service, and sell that in a standard way to any customer across the huge US market, with essentially no friction. This allows them to rapidly achieve a scale that then permits international expansion, and competition in a global market, with all the attendant regulatory and process barriers. In contrast, a European company, with a similar idea, can currently only target equivalent niche customers for its particular specialist digital service, in its own country. The moment they try to sell into even a neighbouring country, in addition to inevitable language barriers, they have to contend with differences in regulatory approach and bureaucracy. Working towards a Digital Single Market is a hugely worthwhile aim, bringing enormous benefits to all who have access to it.

One of the ways in which the cloud computing market has not yet caught up with the electricity markets is in the area of standards and interoperability. A user of electricity is totally unaware of what blend of power generation technologies is being used to deliver its needs, because the electrical (transport) grid sits between the generator and the consumer, effectively mixing up the electricity generated by different providers, using different technology. The reason why this works such that supply and demand remain balanced at all points on a stable grid is due to a combination of standards, and careful market design: injection into the grid is subject to strict standards of electrical power, frequency and voltage; and there is a carefully orchestrated short-term capacity market. Whilst the internet may appear to be equivalent to the power grid in terms of providing access to capacity, the internet does not force cooperation in standards and market design, allowing highly granular control of which users can access which capacity. On the one hand, this is a huge advantage, but that advantage comes at a cost to the level of competition in the market, as it leads to fragmented markets where cloud resources may be traded in provider/generator silos, but not across providers/generators in a market that spans all. This effectively commoditises users into fungible sources of revenue for the cloud providers, but inhibits the users from treating the cloud providers as interchangeable.

European cloud computing initiatives have long proven that technically, API-level access to IaaS resources across resource providers is technically achievable, feasible and adds value for the cloud resource consumers across a wide variety of significant use cases, where sufficiently supported by the providers. However, there remain challenges in making this work across all cloud providers.

By way of example, Oliver Tearne, a senior mathematical modeller at the UK's Animal & Plant Health Agency, wished to use the public cloud to add elastic burstable infrastructure to their limited on-premises capabilities.

> *"Initially we tried to abstract ourselves from the underlying cloud providers, by provisioning via a common API. We wanted to avoid vendor lock-in, and felt that for our fairly simple use cases it should actually be easier. We found that the technical challenges of doing this were still too big to justify the effort for the scale that we are currently at, so we decided to interface directly with the cloud provider, whilst maintaining the ability to switch funds from one provider to another by procuring through a financial cloud broker."*

Such frustrations with being cloud agnostic at small scales with particular providers are unlikely to remain the case indefinitely, as it is certainly already possible with sufficient effort for the right use cases, with sufficiently compliant cloud providers.

As for electricity, it will be a combination of carefully agreed standards (or at least benchmark metrics), and market structure that will accelerate this trend. The European Commission has shown steadfast support for initiatives to develop cloud standards, such as those listed here, and to encourage federations of smaller clouds, such as EGI for researchers. This trend is very likely to accelerate with the EU GDPR coming into force in March 2018, which enshrines consumers rights to (personal) data portability into its article 20. Already, the Commission through commissioning studies such as SMART 2016/0032, explores expanding this issue to general data portability towards switching cloud providers in the same or similar fashion as switching energy suppliers.

It is now important that the Commission also supports more sophisticated market structure, as to be a success, the two need to go hand-in-hand.

Recommendation to the European Commission…

…encourage removal of any barriers to (voluntary) abstraction of the user experience from the services of the underlying cloud provider

6.2 European Open Science Cloud

The European Open Science Cloud("EOSC") is a high profile European Commission funded effort to ensure that European science has access to the requisite cloud infrastructure resources to maintain its leading global position in scientific research and development. It plans to interconnect through a European Data Infrastructure, existing research infrastructures across Europe allowing 1.7 million researchers and 70 million science and technology professionals the ability to access and process large datasets stored in the cloud in a manner that is Findable, Accessible, Interoperable and Re-usable ("FAIR").

The EOSC's High Level Expert Group has recommended framing the EOSC as the EU contribution to a future, global Internet of FAIR Data and Services underpinned by open protocols. They have also highlighted that the larger market opportunity lies closest to the business application. They estimate that half a million "core data scientists" are needed to make the most of open research data in Europe.

It is hugely encouraging that the European Commission's focus is on enabling the applications that cloud facilitates, rather than on the cloud infrastructure itself. In the same way that on-demand electricity catalysed innovation and business growth in heavy industry, public cloud services will catalyse innovation and business growth in the applications they support, many of which will doubtless come out of scientific R&D.

> *"Research Infrastructure's long-term needs are measured in decades and hence a stable and well-structured cloud services market is essential."* - Dr Bob Jones, CERN

6.3 Procurement Innovation for Cloud Services for Europe (PICSE)

The elasticity and on-demand access of the public cloud, has been both a boon and a bane for procurement professionals. It is amazing to be able to meet unforecast organisational computing demands by procuring on-demand public cloud resources. At the same time, a consumption-based pricing model simply does not fit well into inflexible procurement systems that expect a fixed price for a fixed amount of a fixed deliverable. The PICSE project was funded by the European Commission to try to find innovate ways to manage these procurement challenges. At the same time, leading cloud providers have been tackling the same challenges by trying to be more accommodating to the needs of the public sector, setting up specialist teams for public sector sales, and supporting cloud resellers and managed service providers who have built a core competency of intermediating between these conflicting trading preferences.

Delivering projects that find innovative ways to address these needs with technology that is deemed to be ready, i.e it has a high "Technology Readiness Level", is all very well, but unless it is also "market ready", it will never have an impact. It is very pleasing to see that the European Commission funded, and its projects embraced, other work done by CloudWATCH2 that brought forward a combined framework for Market & Technology Readiness Levels.

Recommendation to the European Commission…

…ensure that successful EC-funded projects achieve market-readiness, not simply technology readiness.

7 Potholes to Avoid

The journey towards a healthy, competitive cloud market that is trusted, reliable and sustainable, is unlikely to be a smooth one. Most other more mature markets that bear some resemblance to the cloud infrastructure market have had their fair share of bumps on their journey towards market sophistication, and it is generally sensible to try to learn from prior mistakes, to avoid repeating them. Below, we have listed a number of "potholes" that should be avoided as Europe continues on its cloud journey.

7.1 Optimal Standardisation

Standardisation and innovation are both positive attributes, and yet in many ways they are the opposite of one another. Judicious application of widely accepted standards can remove unnecessary variability, driving down operational costs associated with supporting multiple variations, and providing a platform for

valuable further innovation. Overly enthusiastic enforcement of immature standards, on the other hand, can make innovation impossible. The cloud market participants must collectively judge the right pace at which to standardise the technology and contractual elements that make up the market, in order to achieve the optimal balance between these two positives. It is also worth pointing out that if there is a flaw in a particular standard, and it has been adopted in all cases, then it represents a single point of failure. In many cases, it is better to have at least 2 standards that are available for adoption, in order to diversify this risk. Standardisation onto a single standard that turns out to be fundamentally flawed could cause enough damage to consumer trust in cloud as to bring our cloud journey to a grinding halt.

7.2 With great power comes great responsibility

An unusual facet of being a cloud provider, is how many additional services can be incrementally built out once you can offer the underlying core compute, storage and networking capabilities in a manner that meets NIST's essential cloud characteristics. Without offering any service that looked like anything other than a logical extension of their core business, several of the major cloud providers have gone from offering hourly rental of virtual servers, to offering to make on-demand predictions about their customer's organisation by automatically building machine learning algorithms that interrogate and process vast amounts of your organisation's big data.

It has been observed by commentators such as the Economist that the major cloud providers look remarkably like conglomerates. It is usual for investors to apply what is known as a "conglomerate discount" when putting a value on the shares of companies who run a multitude of different businesses, i.e. conglomerates. The discount is attributed to a host of justifications such as inefficiencies due to a lack of specialisation, and the risk that top management cannot be focussed everywhere at once. It has been observed that the conglomerate discount does not appear to be being applied in this case, which implies that investors may be ignoring the risk, and judge that the cloud providers can keep on running so many different specialisms in parallel, without fear of mishap. These major cloud providers are responsible for supporting the majority of the world's digital businesses, and it is critical that they continue to keep their core business stable. One example of a conglomerate who runs an IT hosting business, in this case a "private cloud" for their online gamers is Sony. They suffered a "Black Swan" event, which caused weeks of disruption to their Playstation Network customers, who had no other means of playing those particular games with another provider. Their business processes were not as sophisticated as other less diversified companies, such as Microsoft, who had implemented 2-factor authentication 3 years earlier for the competing Xbox online platform. *"It was the largest security breach of its kind to ever hit console gamers, and an event with huge repercussions for PlayStation - both in the short term for its users, left for weeks without access to online services, and longer term as Sony sought to win back customer trust."* - Tom Phillips, Eurogamer.

The impact of an IT process failure is not limited to online gamers. Take the recent British Airways example of where a "computer glitch" has caused a systems failure. Unlike other recent examples affecting Lufthansa and Air France, where "glitch" is arguably a fair description, given the short duration of the systems failure, the British Airways failure caused a global outage of a whole swathe of BA systems. This resulted in the grounding of all flights globally to and from Heathrow and Gatwick for over a day, with knock-on disruption felt in every airport that BA flies to.

Investors in IAG (the parent company of BA and Iberia) would certainly have seen this "computer glitch" as a pothole in their runway, as share prices dropped by 4% in London and 2.8% in Madrid, as a result.

The point we are making here is that where companies grow to the kind of size where a failure has a noticeable impact on society as a whole, they should have a responsibility to worry about these "Black Swan" risks and implement procedures to mitigate the effects. This is generally something that requires the input of senior management, whose attention should not be spread too thinly across different businesses.

Imagine how much worse such a global outage could be for consumers, if it happened to the core infrastructure services of a major IaaS provider disrupting a large number of their diversified customers who provide services ranging from real-time airline arrival times to train bookings to weather reports to vacation planning to supermarket deliveries to scheduling GP appointments?

7.3 Rebalancing the asymmetry in market influence

At present, the major cloud providers define their services, how they are priced, and the terms under which they are sold. There is negligible negotiation with even the largest buyers, who must simply accept the terms, or use an inferior service. This isn't too unreasonable, until you add in the fact that the cloud provider has likely included in its terms and conditions that it can unilaterally change those terms and conditions whenever they want.

Most other markets either have less pronounced asymmetry in how buyers and sellers influence the market, or there is more negotiation (with all the higher transaction costs that that entails) and in regulated markets there is considerably more consultation, with major buyers being represented by some form of industry body, such as the Major Energy Users Council, that represents 25% of all the energy used for industrial purposes in the UK, an example at national level. At a supranational level, IFIEC Europe "represents the interests of industrial energy users in Europe for whom energy is a significant component of production costs and a key for competitiveness in their activities in both Europe and throughout the world.". There is even a global equivalent, IFIEC World, a Non-Governmental Organisation recognised by the UN.

It is very tempting to paraphrase IFIEC Europe's mission statement for some future association of major cloud users under the Digital Single Market, by swapping "energy" for "cloud": *"An International Federation of Industrial Cloud Consumers should be founded on the belief that competitive cloud supply, responsible use of cloud and consumer choice and flexibility, are the necessary ground rules for competitive and sustainable industrial activity in Europe."*

The cloud market is already in this particular pothole, as there are contractual terms technically in force today that are so inappropriate as to likely be unenforceable. "Unlikely" however, is not enough to comfort risk-averse potential users. Unless a better approach to managing changes to terms and conditions is adopted, we run the risk of falling into similar potholes in the future. An industry association for cloud buyers could help represent the interests of the consumer.

Recommendation to the European Commission...

...support (with funding) any well-organised industry bodies that represent the interests of buyers and intermediaries, and are independent of the dominant cloud providers.

8 Recommendations for the European Commission

The authors would like to put forward the following two lists of recommendations, one being policies to encourage, the other to avoid.

Encourage:

1. Public sector procurement of cloud through intermediaries such as cloud resellers, managed service providers, or even public sector cooperatives, in order to aggregate buyers' purchasing power, whilst keeping tailored procurement terms.
2. Even-handed treatment of each class of cloud intermediary by cloud providers, in order to maximise competition in the cloud supply market, maximising buyer choice.
3. Innovation in how to facilitate switching between cloud solutions, and how to abstract the user experience away from the underlying cloud provider.
4. Uptake of standards, where commonality brings economic advantage through increased sharing and competition.

Avoid:

1. Distorting market forces by providing state aid to a European "cloud champion"
2. Imposing standards where that would inhibit innovation
3. Disadvantaging local cloud buyers, by creating local rules
4. Repeating the mistakes already made in other related markets, by looking for analogous past situations in other markets.

9 Methodology for Researching this Roadmap

Much of the research conducted for this Roadmap was carried out in the form of informal, non-attributable, off-the-record interviews. This approach was found to be necessary as we found there to be a stark difference between views expressed privately, and what could be cited and attributed to particular individuals at particular companies. We have gone out of our way to respect the anonymity of those people who were kind enough to share their honest views and concerns regarding the state and future of the cloud market. We can however list the types of organisations we have interviewed, in order to give a flavour for the breadth of interested parties:

- US "hyperscale" IaaS public cloud vendors
- EU multinational private cloud vendors
- EU smaller scale IaaS public and private cloud vendors
- EU and US datacentre operators and collocation providers
- Technology providers to public cloud providers
- EU regulatory agencies and authorities
- US & EU end user customers, both commercial and public sector, large and small.
- Law firms specialising in market regulation
- Other experts in market evolution and innovation

Where the authors have leveraged the benefit of years of experience in analogous markets, we have sought to back up any analogies by seeking support from the interviewees above, and/or by finding suitable references.

The development of the content for this Roadmap went through multiple iterations, and we sourced feedback at each stage. We started off with a deliberately provocative draft, highlighting many of the Black Swan risks that could be envisioned for the market, and circulated it to selected industry figures, confidentially due to its provocative content, in order to assess how widely and deep Black Swan risks were felt across the market. We presented our early thoughts and sourced more general feedback at various conferences, but most notably at Helix Nebula 7th General Assembly, where John Woodley gave a keynote speech. At that point, it was decided to delay decisions as to whether to publish some of the content until this final version, as several of the issues were in a state of flux, and it was felt that a better outcome might be more likely if the issues were not further publicised at that time. Based on the feedback from various experts, some of whom had advised the European Commission previously on related issues, we prepared the Preliminary Version of the Roadmap, which was published in April 2016, following consultation with the European Commission and certain regulatory agencies.

Following the issue of the Preliminary Version we have continued to consult widely on this subject.

10 Conclusion

Innovation in the cloud computing market has been, and continues to be, conducted at breakneck pace, with every incremental service layer added on top, and every feature enhanced around the sides, providing ever greater value and convenience to the user of the cloud solution. This frenetic pace of development, along with a complete lack of "official" market structure holds both the promise of continued unfettered innovation, and the risk of mishap as a result of structural market instabilities that pose systemic market risks.

However, the market does seem, in many areas, to be self-regulating in a fairly healthy way. Support for cloud resellers, cloud managed service providers and other cloud intermediaries by the largest cloud providers is largely healthy, with good support for the natural conflict that occurs when indirect sales operate in parallel with vertically integrated direct sales. This gives the cloud buyer plenty of choice around who to buy cloud services from, and the terms on which to make that purchase, even if behind the scenes, the underlying technology choice is dominated by those at hyperscale.

The authors recommend that any regulatory effort is focussed on ensuring that the current level and fairness of competition persists at the interface with the cloud buyer, such that buyers retain choice and ease of switching their cloud supplier. As cloud intermediaries build market share in supplying public cloud services to end buyers, the current market asymmetry between hyperscale sellers, and comparatively tiny buyers may reduce, balancing their respective negotiating positions. The existence of cloud intermediaries, particularly if they are able to trade risk amongst themselves, will leave the door open to future cloud providers, who are more likely to enter the market by specialising in an innovative new means of providing cloud services than by competing on price for an inappropriately standardized "lowest common denominator" cloud service, against those with hyperscale economies.

Log Table

DOCUMENT ITERATIONS		
V1	Version 1 of document	John Woodley, James Mitchell & Frank Khan Sullivan, Strategic Blue
V2	Internal review	Nicholas Ferguson & Silvana Muscella, Trust-IT; David Wallom & Michel Drescher, UOXF
V3	PMB review	Nicola Franchetto, ICTL; Marina Bregu, CSA
VFinal	Final version	James Mitchell, Strategic Blue