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BRIEFING PAPER FOR THE ICCP TECHNOLOGY FORESIGHT FORUM

Cloud Computing and Public Policy

14 October 2009

The OECD Committee for Information, Computer and Communications Policy (ICCP) will hold a Technology Foresight Forum on 14 October on the topic "Cloud Computing: The Next Computing Paradigm?" An agenda is available as DSTI/ICCP(2009)15.

This briefing paper has been prepared by Michael R. Nelson, Visiting Professor, Internet Studies, Georgetown University, as a consultant to the OECD. It is intended to provide participants in the forum additional information about the issues to be covered and their policy implications. It represents the views of the author, and not necessarily those of the OECD or its member countries.

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BRIEFING PAPER ON CLOUD COMPUTING AND PUBLIC POLICY

Prepared for the ICCP Technology Foresight Forum¹

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1. The Internet is entering a new phase that represents a fundamental shift in how computing is done. This phase, called Cloud computing, includes activities such as Web 2.0, web services, the Grid, and Software as a Service (SaaS), which are enabling users to tap data and software residing on the Internet, rather than on a personal computer or a local server. Some leading technologists have forecast that within five to ten years more than half of the world's computing and data storage will occur "in the Cloud."

2. Although the shift toward the Cloud is clear, the shape of the Cloud—its technical, legal, economic, and security details—is not. Public policy decisions will be critical in determining the pace of development as well as the characteristics of the Cloud.

Key concepts, benefits, technologies and business models

3. The Computer Security Division of the US National Institute of Standards and Technology (NIST) has developed a widely-cited definition for Cloud computing, which has been evolved after months of extensive consultation with industry and academia:

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential **characteristics**:

- *On-demand self-service.* A user can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.
- *Broad network access.* Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs).
- *Resource pooling.* The provider's computing resources are pooled to serve multiple users using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to user demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or data centre). Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

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- *Rapid elasticity.* Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the user, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.
- *Measured Service.* Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported providing transparency for both the provider and consumer of the utilized service.

4. While the NIST definition is still under discussion and still evolving, it does an excellent job of describing the key aspects of Cloud computing. Equally importantly, it makes clear what is *not* Cloud computing, which is critical as more and more ICT companies try to jump on the Cloud bandwagon and issue press releases and distribute marketing material for products that may or may not rely on Cloud services.

5. The development of Cloud computing has been driven by several technological developments including: (1) reliable, high-speed networks, (2) commodity server hardware with open interfaces, (3) open source software (e.g. Linux, Apache, and Hadoop), which has slashed the cost of software for data centres, and (4) adoption of open Web 2.0 standards, which has made development of applications in the Cloud much easier and faster. Concepts similar to Cloud computing have been tried in the past—although other names were used such as “utility computing” and “Application Service Providers.” They failed to get traction in part because the networks needed to access such services were too expensive. But more importantly, the lack of open source software and open standards meant that most Application Service Providers only offered their own services using their own proprietary standards and software. The real power of the current manifestation of Cloud computing is that users can run a wide range of software and applications using the Cloud—and thanks to Web 2.0 and similar technologies, they can combine different pieces of code and data from different sources in order to meet their unique needs.

6. It is useful to divide the evolution of personal computing in three distinct phases. In the first phase, computers were stand-alone devices in which software and data were stored in the machine; typical applications were word processing and spread sheets. Phase two was marked by the emergence of the World Wide Web, which made it possible to access a wealth of data on the Internet, even though most users still relied on software that ran on individual machines; the quintessential application was the Web browser. In phase three most software as well as data will be accessed over the Internet; a wide variety of applications will proliferate because users will no longer have to install applications software on their machines.

7. Most of the work we do with computers is still done using phase 1 or phase 2 tools, but more and more users and individual consumers—especially among the younger generation—are starting to take advantage of the power of the Cloud, which offers:

- **Limitless flexibility.** By being able to use millions of different pieces of software and databases and combine them into customized services, users will be able to better find the answers they need, share their ideas, and enjoy online games, video, and virtual worlds.
- **Better reliability and security.** No longer will users need to worry about the hard drive on their computers crashing or their laptops being stolen.
- **Enhanced collaboration.** By enabling online sharing of information and applications, the Cloud provides new ways for working (and playing) together.
- **Portability.** The ability of users to access the data and tools they need anywhere they can

connect to the Internet.

- **Simpler devices.** Since both their data and the software they use are in the Cloud, users don't need a powerful computer to use it. A cell phone, a PDA, a personal video recorder, an online game console, their cars, even sensors built into their clothing could be their interface.

8. Cloud computing has the potential to reduce the cost and complexity of doing both routine computing tasks and computationally-intensive problems. By providing far more computing power at lower cost, Cloud computing could enable researchers to tackle hitherto impossible challenges in genome research, in environmental modelling, analysis of living systems, and dozens of other fields. Furthermore, by enabling large, distributed research teams to more effectively share data and computing resources, Cloud computing will facilitate the kind of multidisciplinary research needed to better understand ecosystems, global climate change, ocean currents, and other complex phenomena.

9. One of the largest benefits of Cloud computing for corporations and organizations is that it can dramatically reduce the expense and hassle of managing IT systems. This is particularly important in the public and non-profit sector, where hiring top-notch systems administrators can be difficult. Developing countries, at least those with an adequate Internet infrastructure, stand to benefit most from the development of Cloud computing because they often face critical shortages of IT professionals trained on the latest computing technologies. With the Cloud and an Internet connection, researchers, government employees, and entrepreneurs in least developed countries (LDCs) will be able to access the very best software applications, wherever they are located.

10. Combining the power of Cloud computing with data collected by thousands or even millions of inexpensive networked sensors (part of the "Internet of Things") will give scientists new and exciting ways to track how our planet and its ecosystems are changing. At the same time, such sensor nets will provide entrepreneurs new ways to provide new services ranging from traffic monitoring to tracking livestock to improving surveillance on the battlefield or in high-crime neighbourhoods.

11. Realizing the full benefits of Cloud computing will require contributions by thousands of different ICT companies working as part of a complicated ecosystem. Access to Cloud services will be made possible by network providers, whose customers will need ubiquitous, reliable, broadband Internet service so they can use Cloud services anytime, anywhere. (The growth of Cloud services could cause a 20-50 fold increase in the demand of network capacity similar to that caused by the growth of the Web in the mid-1990s.) Some companies will provide simple Web hosting services while other companies will provide much more sophisticated, specialized Cloud services tailored to different corporate and government market niches. A growing assortment of consumer services will be available in the Cloud (e.g. e-mail, word processing, spreadsheets, and hard drive back-up). And consulting firms will help businesses and organizations of all sizes demand how best to use Cloud computing to meet their needs.

12. To date, there have been five dominant pricing models for Cloud services. In the consumer market, many Cloud services (e.g. e-mail, photo storage services, and social networks) have been provided free of charge, with revenue generated through advertising and the sale of data on user behaviour. Other consumer services, such as hard drive back-up or Web-hosting, are sold on a monthly subscription basis.

13. In the corporate sector, many Cloud services are sold by subscription. For instance, Salesforce.com charges a monthly fee for each employee using its software service to track sales leads. Other corporate Cloud services are sold to corporate IT companies to supplement their existing corporate IT infrastructure. For instance, a company might contract with a Cloud service provider to provider extra storage or computing capacity in case of emergency or a sudden surge in usage of their e-commerce Web site. In many cases, companies are charged according to the amount and type of services they use. Since

companies only pay for what they need and don't have to invest in IT infrastructure that may be unused most of the time, this can result in huge cost savings. A third pricing model in the corporate sector includes cloud services as part of a larger package of IT services. In such cases, customers may not even care whether the computing and storage they need are being done using machines on their premises or in a cloud run by their IT service provider.

14. The different types of Cloud customers have different requirements when it comes to reliability and confidentiality. Furthermore, they face different regulatory requirements. As a result, different models have developed. The NIST definition of Cloud computing identified four different deployment models:

- *Private cloud.* The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.
- *Community cloud.* The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.
- *Public cloud.* The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
- *Hybrid cloud.* The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

15. While most press reports have focused on the consumer services made possible by public clouds most of the money being made from Cloud services is from services provided to corporate customers, often using dedicated private clouds. Financial institutions and companies in computationally-intensive fields (such as petroleum exploration or bio-informatics) have embraced private clouds because of the significant cost savings and greater computing power they can provide. Other corporate customers have contracted to use public clouds. For instance, thousands of corporations, universities, and government agencies have outsourced their e-mail services to Google, which provides a corporate version of Gmail with additional features (and no advertising). Thousands of e-commerce sites are now running entirely on Amazon.com's Elastic Compute Cloud, which is provided over a public cloud.

Cloud Services: infrastructure, platform and software

16. The variety of Cloud services in the marketplace and the amount of marketing hype has led to a good deal of confusion about Cloud computing. Fortunately, the NIST definition includes a useful taxonomy of three different Cloud services models:

- *Cloud Software as a Service (SaaS).* The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

- *Cloud Platform as a Service (PaaS)*. The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.
- *Cloud Infrastructure as a Service (IaaS)*. The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over the operating system, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).

17. This taxonomy has been widely-adopted by the IT industry in the US and elsewhere and is helping potential Cloud services users understand the large differences between the different models—and the different benefits and challenges each present. Typically, Applications as a Service (AaaS) are easiest to adopt, since often they provide services that are designed to be almost identical to those offered on a desktop computer. For instance, Microsoft’s Windows Azure services offers word processing services and other services that are very similar in function to Microsoft Word software running on a laptop computer using the Windows operating system.

18. In contrast, the Platform as a Service model, exemplified by Amazon.com’s Elastic Compute Cloud (EC2), requires users to select and install their own application software on the “virtual servers” that Amazon provides. This has enabled e-commerce companies and others to avoid buying and maintaining their own machines. Indeed, according to one account, for many Silicon Valley start-ups, their total capital expenditure consists in buying employees laptops and mobile phones—and a coffee maker. Their Web site, all their order processing, and all their internal corporate applications run on machines in Amazon’s data centres. The rapid growth of EC2 is why Amazon now devotes more of its infrastructure to serving Elastic Compute Cloud customers than they do to processing purchase orders for books, records, and other items.

19. The Infrastructure as a Service model is probably the most familiar and well-established model; large corporate customers have been outsourcing their IT infrastructure needs for decades. The key difference with the Cloud model is the added flexibility provided by open software and hardware standards. Whereas in the past, companies were often locked into a particular provider, due to the unique characteristics of one company’s proprietary hardware and operating system, open interfaces and virtualization technology makes it easier for customers to shift between IaaS providers.

Portability, Competition and Innovation

20. A key question that will affect how broadly Cloud computing is adopted is whether consumers and corporate customers will have real choices between Cloud services providers and whether they will be “locked into” a particular provider. Having several Cloud service providers to choose from is not very helpful if once a customer becomes reliant on one provider it is next to impossible to transfer his or her data and applications to a different provider because of proprietary formats or software. The reason the Internet saw such phenomenal growth and spurred so much innovation in the late 1980s and 1990s is because it was a “network of networks.” No one was in charge and everyone was in charge. Everyone could build and run their piece of the network infrastructure; no one company or handful of companies had a dominant position and could single-handedly determine the standards or architecture of the network or the Web.

21. The key question is whether the architecture of the Cloud will develop in a similar way or whether two or three companies will dominate. Will open standards enable a “network of clouds” or will there be different clouds run by a few companies each running proprietary software?

22. It is useful to consider three possible scenarios for the Cloud. The first, the “Clouds scenario” will result if a handful of companies are able to take advantage of economies of scale, proprietary standards, and government policies to control the market. They are likely to create separate, unconnected cloud platforms based on proprietary technologies. While such a scenario would provide some efficiencies, because it would be very difficult for data and software on one company’s cloud to be combined with data and software on another cloud, much of the potential for new applications and closer collaboration would be lost.

23. A second scenario, the “Cloudy Skies scenario,” would still be dominated by large cloud service providers using proprietary systems, but in this future, data could move between the different clouds. But there would not be common middleware, like single sign-on authentication, that would make it easy for users to combine data and services operating in different clouds.

24. The third scenario, the “Blue Skies scenario,” would use open standards, open interfaces, and open source software to enable thousands of different organizations to link their infrastructure into a single, global Cloud. Such a scenario would maximize collaboration and enable users to easily assemble software and data into services that meet their particular needs. In this scenario, new authentication, security, and privacy-enhancing technologies could be deployed globally.

25. In the 1980s, the Internet user community, particular researchers and government worked to ensure that the Internet became a truly interoperable “network of networks.” Rather than adopting proprietary networking technologies, users embraced the Internet Protocol, which was based on open standards and could be implemented in open source software. Likewise, in mid-1990s, users rejected efforts to create proprietary Web standards that would have segmented the World Wide Web, requiring users to use a particular Web browser to reach certain Web sites that could only be properly viewed using that browser. By adopting cloud services built using open standards, users can provide a counterforce to the natural centrifugal forces that cause companies to attempt to differentiate their service by using proprietary technologies and lock-in customers.

26. A number of organizations and companies have embraced the open Cloud, including the Open Grid Forum, the Open Science Grid, an academic consortium led by Google and IBM, and almost 200 companies and organizations who have endorsed the Open Cloud Manifesto. However, there are a number of factors that may work against the development of an open Cloud. Governments that wish to censor the information their citizens can view online and the services they can use may try to limit development of the Cloud. Poorly designed efforts to increase Internet security could limit the flexibility needed for the Cloud to grow and evolve. Proposals to impose filtering requirements on Internet Services Providers in order to detect copyrighted material transmitted over the Internet could eliminate many of the potential benefits of the Cloud. Government procurements could either foster open Cloud standards or--by favouring one or two vendors--increase the odds of the Cloud or Cloudy Skies scenarios. The academic and research communities can use their role as “super-users,” the results of their economics and policy research, and their access to the media to highlight the need for policies and practices that favour the development of an open Cloud, interoperability, and competition.

27. The architecture of the Cloud and the market structure for Cloud services are not the only factors that will determine the pace of development and deployment of the Cloud. It will also depend on such factors as: (1) how quickly the basic technology matures, (2) how quickly the computer and telecommunications industries agrees on standards, (3) how aggressively companies invest in the needed

infrastructure, (4) how many cost-effective, compelling applications are developed, and (5) how quickly potential users accept and adopt this new way of purchasing computing resources.

28. Government policy can influence each of these factors. And there are other ways in which governments can accelerate or hinder the growth of the Cloud. Just as the pace of development of the Internet has varied by country and industry, the pace of development of the Cloud will vary widely. The key policy factors that will influence the pace of progress include:

29. **Research.** Giving researchers around the world access to Cloud computing services will lead to a further internationalization of science and a broadening of the base of first-class research. It will make it much easier to participate directly in multi-site projects and to share data and results immediately. It is particularly important that researchers in LDCs have access to the Cloud, which will enable them to be equal partners in global research collaborations. In addition, by learning how to use Cloud computing, researchers in LDCs (and the students they train) can become a catalyst of commercial adoption of Cloud services in their countries. A similar thing happened in the late 1980s and early 1990s, when researchers at universities and government labs in LDCs played a key role in getting their countries connected to the Internet.

30. But whether this happens will depend on decisions made by government research agencies. Will they make the investments needed to provide Cloud services to a large portion of the research community? Or will separate Cloud initiatives be funded that are restricted to a narrow subset of researchers with especially large computational needs? Pre-commercial research is still needed on some of the building blocks on the Cloud, such as highly-scalable authentication systems and federated naming schemes. Will there be sufficient funding for this critical research and development? Will government agencies (and the politicians who determine their budgets) be willing to fund Cloud services that will be increasingly international? Will they be willing to invest government money in international collaborative projects when the benefits (and funding) will be spread among researchers and businesses in several countries?

31. **Access to the Cloud.** Cloud computing has the potential to dramatically level the playing field for small and medium sized enterprises (SMEs) who cannot currently afford to own and operate the type of sophisticated IT systems found in large corporations. Furthermore, SMEs will also be in a position to offer their local knowledge and specialized talents as part of other companies' services. Likewise, developers entrepreneurs in every corner of the world could use Cloud computing to collaborate with partners elsewhere, share their ideas, expand their horizons, and dramatically improve their job prospects—but only if they can gain access to the Cloud. Telecommuters and workers who are on the road will also have access to the same software and data used by those in the office provided that we increase broadband access in the home and over wireless connections.

32. As a result, development of the Cloud will increase pressure on governments to bridge the digital divide by providing subsidies or adopting policies that will promote investment in broadband networks in rural and other underserved areas. Unfortunately, the main impact of many previous efforts to promote network deployment has been to distort the market or protect incumbent carriers from competition. As Cloud computing become critical for a large percentage of companies, governments will need to find cost-effective ways to ensure that homes and businesses have affordable access to the Cloud no matter where they are located.

33. **E-government and open standards.** Cloud computing could spur innovation within governments, too. The Cloud is not a magic wand for solving hard computing and managerial problems, but it will reduce barriers to implementation, eliminate delays, cut costs, and foster interagency cooperation. A few pioneers, such as the government of Washington DC, have already demonstrated the huge potential of Cloud computing for e-government. Vivek Kundra, then the CTO for DC, led an effort to

migrate thousands of DC government employees to Google e-mail and office software based in the Cloud. "Why should I spend millions on enterprise apps when I can do it at one-tenth cost and ten times the speed?" he said in 2008. "It's a win-win for me." Kundra was able to use Google's infrastructure and cut his costs for hardware and software maintenance.

34. Cloud computing will be particularly attractive to government users because of the increased reliability and security, lower maintenance costs, and increased flexibility. Running government operations on a unified Cloud infrastructure will be more secure and reliable—and less costly—than trying to maintain and manage hundreds of different systems. In addition, if done right, Cloud computing can help governments avoid being locked in to a small number of vendors.

35. Governments have the potential to be model users of Cloud computing. As the largest economic entity in most countries, government has the leverage to set standards and requirements that can influence actions throughout the economy. National governments can be an early adopter of Cloud computing, which would demonstrate and publicize the technology. But if governments are going to become early adopters of Cloud services, they must overcome bureaucratic, regulatory and cultural barriers to resource sharing that could slow adoption of Cloud computing. Government IT procurement rules covering purchase of hardware and software must be updated to enable purchase of Cloud services.

36. Government procurement decisions in the 1980s, which led to the widespread use of the Internet Protocol to link together previously unconnected agency networks, were a critical driver at a crucial time in the development of the Internet. Likewise, major government users could play an important role by compelling industry to quickly reach consensus on open, international Cloud standards so that government suppliers, contractors, and partners would be able to easily tap into government-funded Cloud services.

37. Today, many different grid and Cloud architectures rely on incompatible proprietary software. Achieving the full potential of Cloud computing will require a "Network of Clouds"—different network-based platforms all linked together by common middleware so data and applications software residing on one company's piece of the Cloud can be seamlessly combined with data and software on systems run by another Cloud service provider.

38. **Competition.** The structure of the Cloud will be defined over the next few years as key players adopt the standards and technologies for Cloud services and as business models and business practices evolve. Perhaps the most important factor determining how the Cloud evolves is whether one company--or a handful of companies--are able to achieve a dominant position in the market for Cloud services or whether the Cloud becomes an open, interoperable system where hundreds or even thousands of different companies are able to build and run part of an interlinked, interoperable Cloud capable of running different applications developed by millions of developers around the globe.

39. With the Internet, there were both strong economic benefits and customer demand pushing network service providers to link their different networks and create a "network of networks." The situation may not be clear cut with the Cloud, and some companies building the infrastructure of the Cloud may be able to use economies of scale, ownership of key intellectual property, and first-mover advantage to block or slow competitors. Governments will need to watch carefully that companies do not use their dominant position in one sector of the IT or telecommunications market to gain an unfair advantage in the market for Cloud services. A Cloud built by only one or two companies and supporting only a limited set of applications would not be in the best interest of either individuals or corporate customers.

40. Governments need to take cautious rather than radical actions at this time, and to promote open, international standards for the Cloud so that users will be able to switch Cloud service providers with a minimum of cost and risk. Flexible, far-sighted government policy and procurement decisions could

promote interoperability, without dictating a particular architecture or set of standards for the Cloud. Since the Cloud is still evolving rapidly, governments need to allow and encourage different companies and groups to experiment. For instance, in government procurements for cloud services governments can require interoperability and migration plans in case an agency wishes to change cloud service providers at a later date—without specifying a particular standard or a particular company's service.

Security, Privacy, and Accountability

41. ***Privacy and security.*** Many of the most successful and most visible applications of Cloud computing today are consumer services such as e-mail services, social networks, and virtual worlds. The companies providing these services collect terabytes of data, much of it sensitive, personal information, which then is stored in data centres in countries around the world. How these companies, and the countries in which they operate, address privacy issues will be a critical factor affecting the development and acceptance of Cloud computing.

42. Who will have access to billing records? Will government regulation be needed to allow anonymous use of the Cloud and to put strict controls on access to usage records of Cloud service providers? Will government regulators be able to adapt rules on the use of private, personal information when companies are moving terabytes of sensitive information from employees and customers across national borders? Companies that wish to provide Cloud services globally must adopt leading-edge security and auditing technologies and best-in-class practices. If they fail to earn the trust of their customers by adopting clear and transparent policies on how their customers' data will be used, stored, and protected, governments will come under increasing pressure to regulate privacy in the Cloud. And if government policy is poorly designed, it could stymie the growth of the Cloud and commercial Cloud services.

43. ***Wiretapping and electronic surveillance.*** One of the thorniest issues related to the Cloud may be electronic surveillance, particularly when it spans international borders. In most OECD countries, citizens are protected against unreasonable searches by requirements that the police get a search warrant to examine data on someone's home computer. It is not clear that the same data is similarly protected if it is backed up in a data centre in the Cloud—particularly if that data centre is in another country. And if the situation regarding law enforcement surveillance is unclear, it is even less clear as to how and when intelligence services can access data stored in the Cloud. If users believe that governments will be monitoring all of their activities (e.g. for taxation or security), it will surely decrease willingness to use the Cloud for important functions.

44. ***Intellectual Property and liability.*** Related to the question of wiretapping is whether governments will try to enforce laws against online piracy in ways that limit or slow development of Cloud services. By giving customers access to almost unlimited computing power and storage, Cloud services could make it even easier to share copyrighted material over the Internet. Will Cloud service providers be required to take special measures to prevent that? Will they be liable for illegal activities of their customers? Would doing so make it impractical for companies to provide Cloud services to the general public?

45. ***Consumer protection.*** If companies and individuals come to rely on Cloud services (e.g. e-mail, word-processing, data back-up) and then discover that the services is down for a protracted period of time or, worse, their data is lost, they will seek recourse—most likely in court. If the reliability of Cloud services becomes a serious problem, state and national governments may step in to ensure customers get the service they expect.

46. What kind of liability will a company that provides Cloud services be expected to assume in the event that there are serious outages? If a program running in the Cloud malfunctions, it could affect other users. Yet, tracking problems in the Cloud and assigning responsibility for failures will be difficult. The Internet is already causing telecommunications companies and the courts to adopt new approaches to assigning liability for outages and security breaches.

47. Crafting a consistent, global approach to this problem will not be easy, but if it can be done, it could increase consumer trust and significantly accelerate the adoption of Cloud services. Given the difficulty of finding an international governmental approach to consumer protection in the Cloud, a global self-regulatory approach based on best practices, insurance, and contract law may be faster, more flexible and adaptable as technology evolve and new services are offered, and more effective.

Taking the lead

48. Governments will play a critical role in shaping the Cloud. They can foster widespread agreement on standards, not only of the basic networking and Cloud communication protocols, but also for service-level management and interaction. By using the power of the purse in their IT procurement policies, governments can push companies to find consensus on the key Cloud standards.

49. Governments need to assess how existing law and regulations in a wide range of areas will affect the development of the Cloud. They must both “future-proof” existing law and ensure that new policy decisions do not limit the potential of this revolutionary new approach to computing.

50. One concern would be premature regulation. The Cloud will be a fundamental infrastructure for the economy, national security, and society in general. A natural reaction would be to demand uniformly high quality and to regulate a number of features and services that use it. But without a lot more experience, we simply do not know enough about what the right set of underlying services will be, what are appropriate differences in price and quality of services, what techniques will be best for providing reliable service, where the best engineering trade-offs will be.

51. Governments can add value by encouraging experimentation and new services. They must avoid locking in the wrong technology, which will either put a country at a competitive disadvantage or reduce the value of the Cloud as a whole. Governments must follow industrial practice as much as possible rather than mandating untried solutions.

52. Like the Internet itself, the Cloud is a disruptive technology that challenges existing business models, institutions, and regulatory paradigms. As a result, there is likely to be resistance from many different quarters to the widespread deployment of Cloud technologies. Governments must be willing to challenge and change existing policies that could be used to hinder the growth of the Cloud. Simply trying to adapt existing regulations to the Cloud might allow entrenched interests to delay the investment and effort needed for widespread use of Cloud computing.

53. Many of the public policy issues, including privacy, access, and copyright protection, raised by Cloud computing are similar to Internet policy issues that governments have been struggling with for at least fifteen years. However, addressing these issues for the Cloud will be at least as difficult—and even more important. Because the Cloud is inherently global, policy solutions must be cross-jurisdictional. Because the Cloud is a many-to-many medium, it is not always easy to determine who’s responsible for what. And because the Cloud technology and Cloud applications are evolving so quickly, government policy must be flexible and adaptable. Because the challenges are great and the opportunities widespread, it is imperative that policymakers and the technologists developing the Cloud start now to look for innovative technical and policy solutions.