CLOUD-TV:

A NATIONAL AND GLOBAL INITIATIVE TO REACH THE NEXT GENERATION OF VIDEO MEDIA

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Executive Summary and Overview

This report aims to move discussion of the next generation of video and of the underlying infrastructure several steps forward. After an introduction and historical overview (Sections 1 and 2)

1. It describes technology elements of an online-based TV medium. (Section 3)
2. It concludes that there will be multiple TVs, not a single standardized TV as in the past and present.(Section 3)
3. It identifies the reasons why the new media system will be based on 'clouds' and what their functions will be. (Section 4)
4. It then proceeds to analyze the impacts of cloud-TV on media market structure and potential policy issues (Section 5)
5. It identifies interoperability and market power issues as the key issues and proposes a simple 2-rule mechanism to maintain competitiveness and openness. (Section 6)
6. It concludes by proposing the creating of a high-level commission to analyze the emerging new media system and to make recommendations. (Section 7)

1. Introduction

Television has been around since the late 1930s as a consumer medium. In those 75 years, it moved from an analog black and white technology to color multicasting at a sharper resolution. Its bit rate per distribution channel has increased, if one is generous, by a factor of 6. That is a technological CAGR of about 2.5%. In honor of the guiding spirit of the first decades of mass market TV, this rate should be named "Sarnoff's Rate". In contrast, "Moore's Law" describes a rate of technological change in the IT sector, based on advances in the underlying semiconductors, that translates to about 40% a year.

TV is just transitioning into its third generation. Receiver sets from the 1940s would still work in many countries. This glacial pace of change was based on the needs of broadcasters to be widely receivable by low-cost devices. Such intermediary distributors controlled the technology, protocols, and modulations. They were internationally organized through collaborative arrangements such as ITU and EBU. Cable and satellite TV distribution, too, were standardized by inter-industry bodies. There were minor regional variations to cater to various industrial interests. But in general, changes in the underlying technology fundamentals was slow, as one would expect from a system that is heavy on the politics and consensus building to satisfy various incumbents and to enable governmental controls over a medium central in their societies. On the consumer end, the terminal devices were TV sets that were almost interchangeable, manufactured by a few large consumer electronics firms or brands. This system worked well to spread TV to numerous channels, countries, and audiences, and to make it the most important medium in history in terms of audience attention.

But now, TV is migrating to a distribution over the internet. Of course, this is not exactly news. In the process it is moving away from the control of traditional TV organizations. This, too, has been widely noted. But the attention has been mostly on the level of the widening of content options and providers. This is important, of course, but arguably even more fundamental in the long run is the breakdown of the system of (almost) uniform TV technology in favor of a system of multiple parallel TVs. As the video system migrates onto the internet and as TV sets become computer-like devices, different technologies can be offered to do what we used to call television. Competing providers of various technology modules, distribution systems, and content technology will emerge, and their rivalries will move TV from a system of technical uniformity

to one much more resembling that of mobile devices and games. Inevitably, this will have implications for new and different content types, styles, and genres.

We have to think through what it means for TV to move away from Sarnoff's Rate to Moore's Rate, from 2.5% to 40% CAGR. The change will inevitably have major implications beyond technology and see the emergence of

- New types of content
- A different video industry structure
- New business models
- And new policy issues with potentially regulatory implications

Right now, the major media companies are behaving in the way that one would expect established organizations to behave: do a little and talk a lot about it. They basically proceed at a Sarnoff rate. But this will inevitably have to change if such firms, industries, and their suppliers want to remain a factor in the future.

There is no time to lose. As will be discussed below, at the end of 2012, during evening peak hours, video entertainment usage on the internet in the US accounted for 68% of all traffic. Netflix accounted for about half of that, i.e. 33%[1]. Together with other video use on the internet, the overall video percentage is over 2/3 of all internet traffic, and this percentage is growing rapidly.

Thus, with technology progressing at the speed of Moore's Law, it is not too early to think about the next generation of television. It is not too early to think about its technology, public policy issues, economics, and impact, and to ask the question how things will be progressing over the next few years, and how to assure that such a media system will move in the right direction, or at least not in the wrong one.

From today's perspective there might not be much of an imminent consumer demand for new-style television. But that is also what people said when color TV began to supplant black and white TV sets, when DVDs replaced VCRs, when cable TV introduced twelve channels instead of the four or five over-the-air signals, and when the 1080 lines of digital HDTV doubled the 525 lines of the analog standard. Whatever their early reluctance, viewers get used to higher quality and quantity almost immediately and never go back. "4K" TV may not be a household

[1] Reisinger, Don. "Netflix gobbles a third of peak internet traffic in North America," *Cnet.* Nov 7, 2012.

name yet, but at the 2013 Consumer Electronics Show in Las Vegas, eleven companies demonstrated such TV sets, four of them from China. In Japan, regular transmissions for a still more advanced TV--8K – are anticipated by 2016. Netflix is offering it as an option, in collaboration with collaborating cable TV companies. Given the trends of technology we can be certain that the net generation of TV will be soon upon us. And we can be certain that it will not be simply the same traditional TV just with a sharper picture.

The very term – "television" – is inadequate, harking back to the analog broadcast model. "Video", similarly, is too narrow. "Online TV" goes in the right direction, but cannot convey that it is not just about a different distribution platform for TV channels but also a different experience – with interactive, individualized, and immersive options. "Video Media" is perhaps the most inclusive, though also vague. "TV" has the blessing of brevity. We will use all of these terms interchangeably.

It is the conclusion of this analysis that such an online TV will be "cloud" based, that is, provided through content and applications intermediaries that integrate elements and modules, and provide individualization to users. This kind of TV will be, in time, quite different from current TV, in terms of technology, style, economics, user experience, market structure, user devices, and regulation. It is the aim of this report to describe and analyze the elements of such a TV and their aggregate impacts.

In the same way that the earlier generations of TV had been underestimated in their impact, so is now the impending new one. And in the same way that public policy limped behind the past generations of TV as they unfolded, usually restrictive to innovation and supportive of established ways and players, so today's media environment is managed by policy makers and often corporate leaders without a long-term perspective. They are unprepared to a good extent because the issues have not been analyzed and prepared in a meaningful and forward-looking way, thus retarding innovation.

The elements of next generation video will take several years to develop. Infrastructure and technology necessary to support this next generation of video needs to be deployed and this is not a quick process. Bringing together all of the stake holders, whether in industry or in the public interest sector, and shaping policy could take even longer.

How to proceed is quite important. If one follows the aphorism that the medium is the message, i.e., that the distribution technology affects content, and if these messages influence

people, then the direction that today's media system take will govern tomorrow's economy, politics, and culture.[2][3] Of course, details of developments are uncertain, but the broad trend can be discerned. If there is a problem of analysis, it is often the gold rush mentality and ahistorical perspective permeating the environment which impede detached analysis.

Just as the broad trend of IT technology can be extrapolated for the next few years, so are the policy issues associated with such trends. It is natural for each generation to believe that issues and problems are brand-new and thrust upon them; whereas in reality many of them are part of long-standing fundamental conflicts.

These themes create a set of fairly predictable problems and conflicts. Obviously there are new ones too, but many are variations. This does not belittle their importance. To the contrary, they are the fundamental trade-offs that each generation must re-negotiate.

Many people prefer, on principle, for government to have no role or jurisdiction in internet issues. This is a legitimate position. But some of the same people also advocate an interventionist role for government when it comes, for example, to deal with ISP market power as a threat to openness. This is not hypocrisy but a tacit recognition that in the end, problems in our society are dealt with pragmatically, and often involve some role for government.

1.1 Why is Next Generation TV important for the US and the World?

Today, we are on the verge of a major next generation of media. It will have a major impact globally but perhaps nowhere more than on the U.S. The US is a major producer and distributor of film and TV content to the world – Hollywood. It is also the center of digital technology – Silicon Valley --; the center for corporate financing – Wall Street; and of advertising – Madison Avenue. Its defense sector conceived space communications, and many advances in wireless technology. Its university system led the pace of internet technology and digital entrepreneurship. The country's global role has rested on the "soft power" of its media and culture. Hence, the US would need to be at the forefront of this next wave to maintain its economic, technological, and political position. This calls for action, pro-action, and leadership.

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[2] Noam, Eli. "TV or Not TV?" *Financial Times Online.* May 15, 2008.

[3] Noam, Eli: "TV or Not TV? Three Screens, One Regulation?" Report to the Canadian Radio-Television Telecommunications Commission, 2008

Similarly, the next generation of video will also affect major countries in Asia with their strong consumer electronics industries, as well as Europe with its tradition of convergence of culture, technology, and global network firms.

1.2 A National Advisory Commission for Next-Generation Television

Online-TV raises numerous questions. A strong argument can be made that questions cannot be resolved in advance. Indeed, one could argue that dealing with issues too early will only retard innovation. But it can also be argued that such flourishing should be under some general principles that would assure free flows, reduce market power, reduce fragmentation, and protect innovation. If those issues are not addressed in a timely fashion they will crop up as the new system emerges and will slow it down as they get resolved.

Alternatively, developments may forge ahead and will create realities that are detrimental to a competitive and open system yet hard to undo anymore.

And a third negative outcome might be that other countries will take an initiative in shaping the future of the new medium, possibly for reasons of their domestic politics and industrial policies, that will force others, including the US, into unfavorable directions or isolation, and might create globally fragmented media systems.

Contrast this with the internet, where dynamic innovation became possible on the base of a consensus core, while that core was evolving, too.

This suggests an approach that lies between the *ex-ante* and the *ex-post*. It would be to search early for a set of broad technical and policy principles, and have these concepts debated and refined in parallel to technological and entrepreneurial innovation, neither in advance nor behind. And this means getting prepared now while such innovation is taking place.

Concretely, there is a need for an organized effort of thought leadership. And therefore, this report proposes the creation of a high-level expert advisory commission to study and make recommendations. Such a commission would be similar in concept to the FCC's Advisory Committee on Advanced Television Services established in 1987 to assist the FCC in establishing Advanced Television, the "Wiley Committee". Its recommendations led to today's digital TV. Even in those parts of the world where other standards were adopted, many of the

concepts behind the US recommendations were incorporated and thus had a significant multiplier effect. The difference to that committee would be a scope that is wider but less specific than transmission standards, the focus of the Wiley Committee.

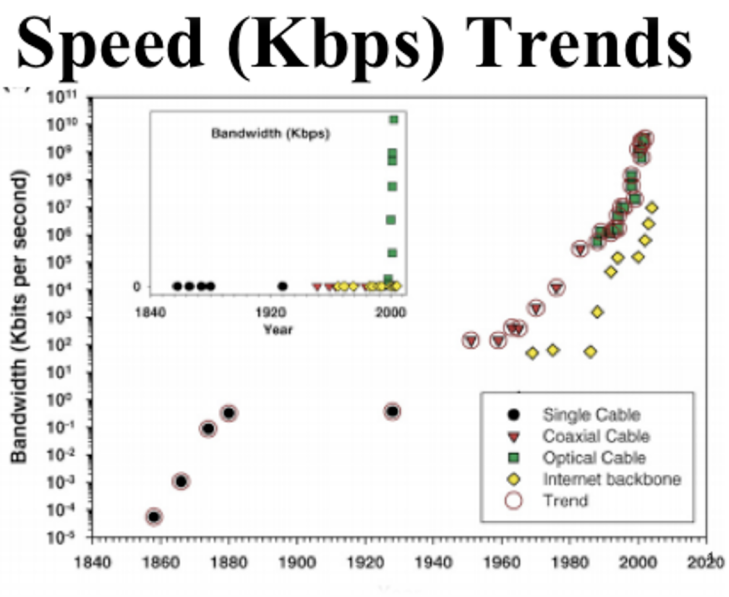
An advisory panel would be best appointed by the FCC, as was the Wiley Committee, as a Federal Advisory Committee. This would shorten the distance between advisors and decision makers. However, such a setup would also be subject to numerous procedural requirements that would impede a speedy process. Alternatively, the National Research Council could initiate a more academic effort. Still another alternative, and probably the most flexible one, would be for a university or consortium to take the initiative, with foundation support and the involvement of major types of stakeholders and thoughtful persons concerned with media and the public. Whatever the institutional arrangement, an initiative should be taken soon.

2. Technology Trends and Past Generations of TV

IT technology has become more powerful at an astonishing rate, the performance improvements of electronics described by Moore's Law-- which has now been cited repeatedly here as a shorthand for rapid change-- postulate a growth rate in the power of microprocessors of about 40% CAGR. A similar growth rate can be observed for transmission rates[4] as shown in Graph 1 below. Here, too, a CAGR of about 30% can be observed over more than a century, with no sign of a slowing down, and with an acceleration in recent years to 40%.[5]

[4] A clarification: "Speed," this is a misnomer since electronic signals travel pretty much at light speed. "Speed" is really the data transfer rate – the bit rate per second. Other people call it "bandwidth," which is equally imprecise, using an analog concept. Since everybody is using the term "speed," we will utilize it as shorthand for data throughput.

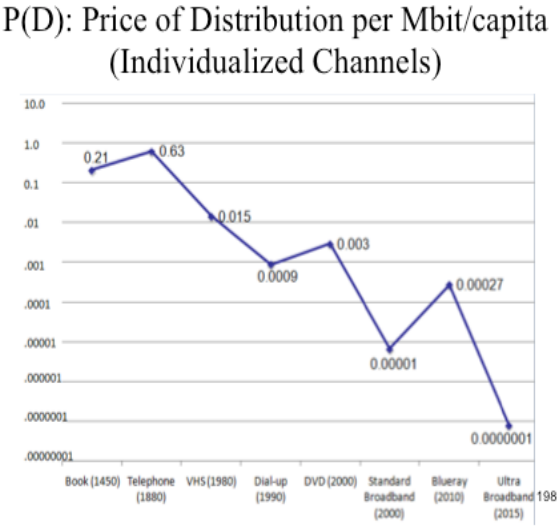
[5] Amaya, Mario A. and Christopher L. Magee. "The Progress in Wireless Data Transport and its Role in the Evolving Internet." Working Paper ESD-WP-2008-20, Massachusetts Institute of Technology, Nov. 2008.



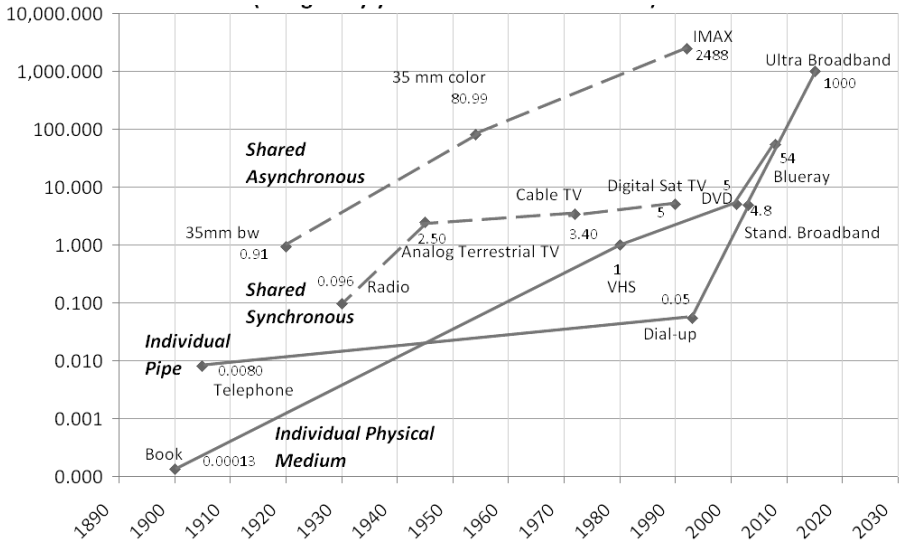
Graph 1

The corollary to this trend in transmission technology is the drop in the cost of electronic information. This is shown in Graph 2. Prices have dropped for over a century for distribution and content, on a per-bit basis.

In consequence, the user keeps consuming more and more such information units – "bits" -- because they become more affordable. And this, in turn, leads to a "deepening" – a greater "richness" of content, as measured by the number of information units (bits) per second for media over time. (Graph 3)



Graph 2



Graph 3: Bit Richness of Different Media per Second[6]

As the bit rate for a medium grows the visual imagery that is supplied by the medium rises. The growth rate of this enrichment, as measure above, is about 8% per year. In the process, the sensory content of media keeps rising.

Yet despite such steady trends, it has been characteristic of individuals, institutions, industries, and entire societies to misjudge the future. On the one hand, we tend to succumb to the various merchants of hype, overestimating short-term spread of technology or its salutary impact. On the other hand, we tend to underestimate the long term impact of fundamental technologies. It is easy to be smug about the short-sightedness of past generations. But what about our own today?

2.1 The 1st Generation: Broadcast TV

In 1940, the National Television System Committee (NTSC) was established to resolve technical conflicts among the various firms. In 1941 NTSC established a standard of 525 interleaved scan lines, with 60 half-frames per second. In 1955, NTSC introduced a color

[6] Noam, Eli. "If Fiber is the Medium, What is the Message?" Communication & Strategies, November 2008, pp 19 – 34

standard. In the 1960s, two rival European color TV standards, the German PAL and the French SECAM, were introduced, dividing the region and even some of its countries.

2.2 The 2nd Generation of TV: Multichannel Analog Cable and Satellite

People living in mountainous or built-up urban areas could often not receive clear broadcast signals. Around 1948, small local business firms started putting up antennas on hills and running cables to houses, for a monthly fee. By the 1980s such "community antenna TV" (CATV) had morphed into cable TV and spread widely across the country, reaching most households. It added numerous new channels, including premium pay services. Satellite TV emerged first as wholesale satellite transmission to cable systems, and then as a retail for-pay business.

When cable TV began consumers did not expect that it would lead them to routinely access hundreds of TV channels. Had one asked people at the time if they wanted many dozens of channels beyond the handful they had, the response would have been a puzzled look. But soon, narrowcasting and long tail content emerged, with highly specialized channels.

2.3 The 3rd generation of TV – Digital TV (DTV)

The digitalization of television emerged in stages, from satellite transmission to the cable distribution, to the emergence of digital TV. Commercial broadcasting of "Hi-Vision" started in the late 1980s in Japan, using the MUSE standard. But MUSE was analog, not digital. In the US, the FCC appointed an advisory committee, chaired by Richard Wiley. Despite opposition and skepticism, an all-digital (ATSC) standard was promoted, developed, and approved by 1992, leapfrogging the Japanese technology.

In other countries, incompatible digital TV standards were then instituted, often in support of consumer electronics industries, and promoted to other countries. In Europe, DVB-T; in Japan, ISDB; and in China, DTMB.

The transition from analog to digital TV improved picture and sound quality and increased spectrum efficiency. That said, digital TV did not hugely change the existing nature of

television. Transmissions were digital, but most users do not know or care about that. However, digitalization bore the seed of radical change. Most obviously, it permitted the use of advanced devices that could do things more powerfully and affordably than before, especially the convergence with telecom and other media and consumer electronics devices.

As digital TV emerged, the main driver was the consumer electronics industry. But two key constituencies were markedly unenthusiastic: broadcasters and viewers. The former saw only cost but no new viewers or ad revenues. The latter, because they did not perceive the quality difference worth its price. For several years broadcasters transmitted digital broadcasts in parallel to analog ones on a second channel – which they hoped to keep permanently-- but to few viewers. It was only when digital TV sets became flat, large, and affordable that digital TV took off.

Digital TV also began extending to mobile devices. Portable analog receivers of regular TV transmissions such as Sony's Watchman had been around since 1982 but were never a commercial or technical success. The use of mobile telephones as video receivers emerged first in Korea and Japan. Different technologies were developed.

- In South Korea, Digital Multimedia Broadcasting (DMB)
- In Europe, DVB-H
- In the US, Qualcom`s FLO, which was discontinued for lack of consumer receptivity.

2.4 IPTV: Telecom-network Based TV

IPTV (Internet Protocol TV) takes an intermediate and transitional position between digital TV of TV's 3rd generation and the online TV of its 4th generation. The "IP" means that the TV signal is coded according to the Internet Protocol format used on the internet, even though it is not necessarily used over the internet itself, but rather over telephone company existing copper lines by way of an upgrade to digital subscriber line (DSL), or by newly-built high speed fiber. It enables telecom companies to provide traditional cable TV-style channel packages together with other entertainment services.[7] In contrast to video streaming over the internet, such IPTV is delivered over operator-controlled channels, much like cable TV operators

[7]Hee Shin, D., "Potential user factors driving adoption of IPTV. What are customers expecting from IPTV?", *Technological Forecasting and Social Change* 74 (2007): 1448.

function. Unless granted by the operator or by law, it does not have the openness of the internet to all users and providers of content.

3. Elements For The Next Generation of TV

It would be surprising if the third generation of TV would be its last. We observe that the previous generations have accelerated – about 50 years for the broadcast stage, about 25 years for the multichannel stage, and about 15 years, so far, for the digital HDTV stage, we should therefore expect a new generation to emerge soon. That stage is TV provided online, over the internet. This form of TV has been around for a few years, but it is now coming into its own.

This type of TV will incorporate, in some combination, a variety of technology and operational elements. They include:

- Fiber and wireless transmission
- Server farms
- 4K and 8K resolution
- Multilateral peer social interactivity
- Peer-to-peer content-level interactivity
- Reachability of other content providers
- Person-to-computer interactivity, as pioneered by video games
- Branching story lines with content individualization and interaction
- User-curated video feeds
- Integration of video with other content types and applications
- Virtual Reality
- User-generated content
- Asynchronicity
- Personalization
- Multi-platform distribution
- Cross-platform viewability
- User-defined immersiveness
- Globalization
- Video traffic management
- 3D capability

- Next generation home audio
- New methods of user interface
- Payment systems
- Encryption and security elements
- IPR protection technologies

3.1 Fiber and wireless transmission

The extraordinary trends of increase in the power of fiber and wireless technologies has already been discussed. Transmission over a single fiber strand has now reached, with over 100 "colors" of dense wave length division multiplexing (DWDM) about 1 Petabits per second. Such a simple fiber strand could therefore carry, in theory, about 400,000 simultaneous standard definition TV channels. The cost of reaching users in metropolitan areas though fiber is not low, but is within the range of commercial viability, at least judging by fiber-to-the- home investments made by major companies like Verizon, and even small rural companies like Vtel in Vermont, which plans to offer 1 Gbps service.

3.2 Displays

These 4K and 8K generations of picture quality represents an impressive move forward in the clarity of the moving image. Is such an advance is truly necessary? Traditionally, satisfaction levels in video quality have been shaped by shortsightedness; each generation persuaded itself, and was persuaded by marketers, that it was using a technology that was life-like in video and audio quality. Each generation eventually moved to higher levels of quality and soon wondered how it could have endured the past poor resolution.

When it comes to TV quality, is HDTV enough? Some people have argued that the human eye does not perceive the difference, and that is correct for a viewing of conventionally-sized screens. But the main driver is the emergence of super-large screens. TV screens have moved from clunky models based on CRT tubes shooting electron beams on phosphorous coatings to flat LCD and plasma displays. 'Flat' enabled also 'large,' and screens moved to 60 and 80 inches, with a leading edge for high end of consumer products, in 2013, of 110 inches. But while screens grow larger and will cover entire walls multifunctional and multipurpose

displays, homes did not grow much in size. Hence, viewers are sitting close to larger screens, and pixel density needs to be raised just to keep the picture sharp.[8]

In April 2012 an 8K Super Hi-Vision (SHV) video was successfully broadcasted over the air by NHK, Japan's national public broadcaster.[9] In 2012, NHK and BBC jointly tested 8K resolution TV at the Olympic Games held in London. At the 2013 Las Vegas CES, where almost a dozen companies showed 4K sets, Sharp demonstrated an 8K TV set. Regular 8K broadcast service by NHK was anticipated by 2016. Netflix started to offer 4K with cooperating ISPs in 2013. So far, these TV sets aim to follow ITU and EBU standards, but sooner or later they will start competing on features that require differences, and where they might hold patents. It would not be different than the different types of mobile phones or tablets.

An important direction for displays is for images to be projected through video glasses and heads-up displays. For such media participation, a TV is not a box one looks at, but it is something one straps on and wears, like eyeglasses. This, too, is an important element for an immersiveness of video media, and for virtual and enhanced reality. Companies such as Google, Sony, and Vuzix have been active, and a variety of approaches are emerging.

3.3 Personalization

Creating a personalized user experience has long been a goal for media creators and marketers. But "personalization" is hard to define let alone operationalize, and it must be user-friendly and be done automatically.[10] More advanced personalization requires identification of the user's characteristics, based on several techniques that may be combined: user-behavior observations, collaborative filtering, or user-supplied references, site-based observations, user's track record, and correlation with other user online behavior. Multiple approaches are emerging.

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[8]Puopolo, Scott et al. "*The Future of Television: Sweeping Change at Breakneck Speed 10 Reasons You Won't Recognize Your Television in the Not-Too-Distant Future*". February 2011. Last Accessed 07/09/2013. http://www.cisco.com/web/about/ac79/docs/sp/10_Reasons_Future_of_TV_IBSG.pdf

[9] Holloway, James. "*Japan broadcasts Super Hi-Vision signal over the air*". May 23 2012. Last accessed on 07/09/2013 http://www.gizmag.com/first-ota-shv-broadcast/22649/.

[10] Bulterman, Dick C. A., & Hardman, Lynda. "*Structured multimedia authoring*." ACM Trans. Multimedia Comput. Commun. Vol. 1, issue 1 (February 2005): 89-109.

3.4 Interactivity of the User with Content (2-way Communication)

Interactive TV (iTV) means interaction between viewer and content,[11] a vertical relation. This must be differentiated from multi-lateral, peer-to-peer interaction among viewers which is horizontal.

Interaction blurs the distinction between viewing and authoring.[12]For video providers, creating interaction may make business sense. Using a return channel for TV viewers enables further revenue be generated, customer loyalty enhanced, and information about the audience gained.[13]

Participation software enables the user to alter the video in real time while watching. At the same time, authoring software enables scriptwriters and producers to include participatory structure of content. To create this requires user-friendly software tools of "content engineering", -- to create, analyze, filter, select, segment, alter, further develop, and reassemble content.

3.5 Interactivity with other Users (Peer-to-Peer)

In P2P TV a user communicates with other viewers as part of the viewing experience. Together, they might also interact with the content. The interactivity might be peripheral to the viewing experience, such as in an exchange of comments in a social viewing room. In other cases, the interaction might be central to the experience, such as in the case of multi-player games.

Interactivity was advanced, in particular, by online multi-player gaming.[14] Massively Multiplayer Online Role Playing Games (MMORPG) link millions of players.
Video games, however are thus not structured in the way films or comic books are, and a story is not necessarily as important as the challenges and interaction by itself. A different narrative style is evolving.

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[11] Chorianopoulos, Konstantinos. "*Content-Enriched Communication – Supporting the Social Use of TV*". The Journal of The Communications Network 6, no. 1 (2007): 23-39.
[12] Hausenblas/Michael, Nack/Frank. "*Interactivity = Reflective Expressiveness*" Multimedia IEEE 14, no. 2 (April 1st 2007): pp.56-60.
[13] Jensen, Jens F.."*Interactive Television: New Genres, New Format, New Content*" in IE '05 Proceedings of the second Australasian conference on Interactive entertainment, Sydney, 2005, pp. 89-96.
[14] ITU-T Technology Watch. "*Trends in Video Games and Gaming*." ITU-T Technology Report September 2011."

3.6 Virtual Participation

A virtual world is a computer-based simulated environment through which users can interact with content providers and one another and use and create content elements. Users can appear in the virtual world, as “avatars"“ visible to others.

Enhanced reality technology takes a live or recorded image from a real-world environment and enhances it using computer-generated content. Mixed Reality (MR) is a way to combine computer-created realities and reality.[15]

3.7 Immersion

Immersion is a presence within a visual surrounding which creates in the user the impression that they are participating in a realistic experience. One such system uses 11 lenses arranged in a sphere to film a scene from multiple perspectives and merges them together.

Putting together these elements (and others) enables TV to become a high-resolution, immersive, participatory, personalized, social, and world-wide experience.

Now obviously much of video will not be like that. Linear video will continue to be around, in better quality. The transition will be soft. Users will use interactivity sometimes, but most often they will watch in the traditional way. Even so, the new style of content will be the frontier of technical and cultural creativity and will challenge established styles and industries.

As has been mentioned earlier, the migration of TV to a distribution over the internet has been widely noted. But the widening of content options and providers, as important as it is, is less fundamental in the long run than the breakdown of the system of fairly uniform TV technology in favor of a system of multiple parallel TVs. As the video system migrates onto the internet and as TV sets become computer-like devices, different technologies can be offered to do what we used to call television. Competing providers of various technology modules, distribution systems, and content technology will emerge, and their rivalries will move TV from a system of technical uniformity to one of great diversity. Inevitably, this will have implications for new and different technology systems, content types, styles, and genres.

4. The 4th Generation of TV – “Cloud TV”

[15] Abavi, Daniel and Reinhold, Silvan and Doerner, Ralf. “*A Toolkit for Authoring Non-linear Storytelling Environments Using Mixed Reality*.” in Goebel, Stefan et al. (3105), ed. Technologies for Interactive Digital Storytelling and Entertainment. Berlin Heidelberg: Springer Berlin Heidelberg, 2004, pp.113-118.

4.1 Clouds

The central nodes in an online TV system will be "clouds". Before we analyze the reasons, let us look at what they are. The concept of "cloud" has undergone an evolution, which can easily mean that people talk past each other. Originally the term connoted the network (at the time, the telecom network) as a whole. Later, it became to mean a provider of a network-based service, in particular of storage and soon online server-based value-added services such as software and processing, with a taxonomy of SaaS, PaaS, NaaS, or IaaS[16] cloud providers, typically servicing large organizations. On the consumer end, content providing server-based online services were also soon called clouds, first as remote storage facilities but soon with functions of music and video providers, P2P social networks, and user-generated content. It is the video content-oriented form of clouds which is the focus of this report.

What we call today a 'cloud' is really just a continuation of concept that earlier was called 'time sharing', 'grid computing', 'utility computing', 'thin clients', 'terminal computing', and 'network computer. The words change, the players rotate, but the plot stays familiar. The basic idea is constant: for a user to obtain computing resources such as storage, processing, databases, software, networks, platforms, etc, from somewhere else.

Server farms are at the heart of clouds. In most cases, such server farms are offered by third parties, to users, whether small or quite large, and to smaller clouds. The picture below shows Apple's North Carolina 500,000 square foot iCloud and iTunes facility, constructed at the cost of $1 bil.

4.3 Media Clouds

On the consumer side, a cloud might start out as a content provider, such as Pandora or Spotify for music. They then might expand to provide storage services such as music "lockers" of content owned by users, such as Apple iCloud, Google Music, or Amazon Cloud Player. They also enable a sharing of music files among users, and social networking among them. They

[16] ("Software "– or "Platforms", "Networks" or "Infrastructure" – "as a service"). These categories are overlapping. There are also services beyond computing and processing such as content, aggregations, interactions, the bridging of standards and other applications. Better yet, one could drop these sub-classifications altogether.

might enable users to post their own content and share it with others, such as YouTube or Facebook.

Online video distribution emerged as what became known as Over-The-Top Content (OTT) [17]-- delivery of video and audio without the ISPs (typical telecom or cable TV companies) having control over the content or the transaction, beyond potentially charging for the transmission (a controversial subject). The video OTT providers include: Netflix, Amazon Video On Demand, Hulu, Walmart Vudu, Apple iTunes, Microsoft Xbox Video, Sony Crackle, Google YouTube, Daily Motion (France), Ultraviolet, YouView (UK), and Veoh.

At the end of 2012, during evening peak hours, entertainment usage on the internet in the US accounted for 68% of all traffic. Netflix accounted for about half of that, i.e. 33%[18]. Together with other video use on the internet, the overall video percentage is over 2/3 of all internet traffic. (Table 1.)

[17] Hall, Gannon. "What Will It Take To Make "Over-The-Top" Video Successful?" Last accessed 07/09/2013. <http://www.slideshare.net/gannonh/kyte-new-teevee-2010-ott-final>.
[18] Reisinger, Don. "Netflix gobbles a third of peak internet traffic in North America," *Cnet.* Nov 7, 2012.

	Share of total peak traffic[19]	**Video as part of traffic (est.)**	**Video as share of total internet traffic**
Netflix	33%	~100%	33%
YouTube:	13.1%	~100%	13.1%
HTTP	11.7%	~45%	5.26%
BitTorrent	10.3%	~80%	8.2%
iTunes	3.43%	~25%	0.86%
SSL	2.2%	0%	0%
MPEG	2.05%	~100%	2.0%
Flash Video	2.0%	~100%	2.0%
Amazon	1.8%	~10%	0.18%
Facebook	1.5%	~10%	0.15%
Hulu	1.4%	~100%	1.4%
RTMP	1.4%	~100%	1.4%
Total	83.88%		68.1%

Table 1

Access to cloud services is not only from computers, but also from tablets, smartphones, and TV sets.

4.4 Why Clouds Will Dominate the Media System

There are several main reasons (plus several lesser ones) why an online TV system will lead to cloud-based video media. They are:

- Standards
- Convenience and cost
- Law
- Finance
- Marketing, Branding, and Quality Control

[19] "Sandvine Global Report: Internet Data Usage Up 120 Percent In North America" *Sandvine.* Nov. 7, 2012. Last accessed 07/09/2013. <http://www.sandvine.com/news/pr_detail.asp?ID=394>.

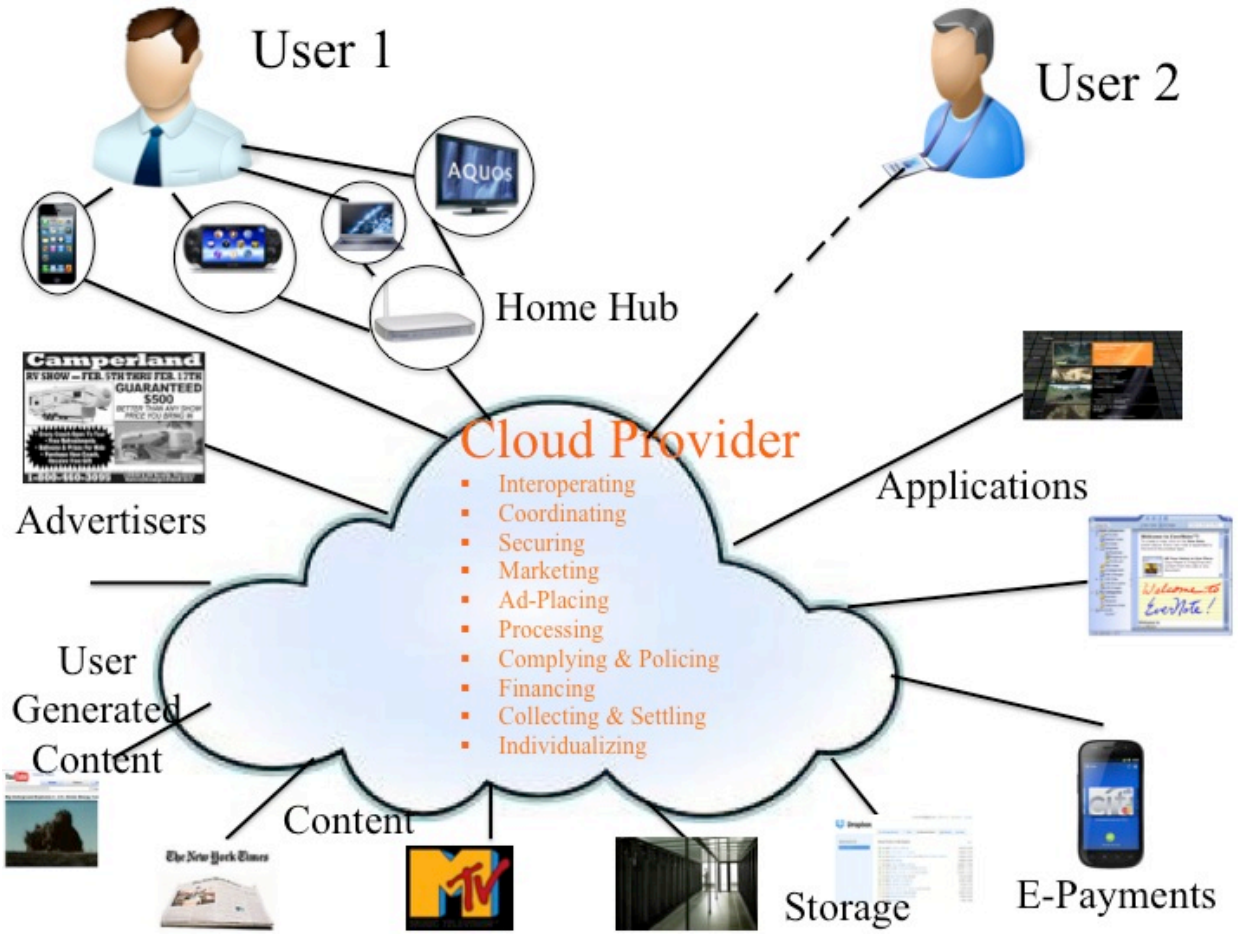
- Privacy and Security

4.4.1 Technical Standards

One reason for clouds to emerge as central media institutions are therefore technical standards, or rather their absence. For next-generation type TV, interoperability is required of content types, users, devices, networks, as well as of prioritization of traffic, of software operating systems, payment systems, and IPRs. In addition, there are the dimensions of interactivity, P2P, virtual-worlds, global distribution, copyrights, and many more.

For the different pieces in an advanced video service to interoperate, there are three options:

1. Comprehensive standards. But realistically, full end-to-end, cross-device, cross-platform, cross-national standards are unlikely to emerge. There are too many companies, countries, stakeholders, technologies, and rivalries. Any such standard that might arise is likely to be out-of-date and inefficient, yet hard to change.
2. A vertical silo, in which a single firm provides all elements and controls the technology, and dictates them to others. Such end-to-end integrator firms, like Apple, with its end-to end, "silicone-to-user" approach creates certainty and confidence, but it also easily leads to end to end control, even into the production side.
3. Intermediary organizations that create interoperability. Clouds can do that. Graph 5 depicts the basic concept. Clouds translate and interoperate various systems of hardware and software. They bridge standards among different elements, and users need only to connect to them.



Graph 5

4.4.2 Convenience and Cost

The second advantage of clouds is convenience. As everything electronic – even kitchen appliances – gets connected with everything else, things get complicated. So instead of amateur users struggling with connecting at home, it is more effective to let the IT professionals do it from a distance. This has implications on consumer electronics. There is no need to keep hardware as multiple duplicative hardware systems at home. In such a scenario, consumer electronics move from consumer electronic hardware to consumer electronics as a cloud service. A familiar analogy is voicemail by a phone company that replaces an answering machine.

4.4.3 Law

Each country has its own rules on protection of children, morals, privacy, consumers, VIPs (libel laws), governments, media producers (copyrights), and more. It is unrealistic to expect these rules to be the same worldwide. In fact, it would be undesirable to be so. Countries, societies, governments, histories are different. And attempts to 'harmonize' will only result in acrimony, delay, disappointment, and unstable compromises. More realistic is to expect that different countries will have diverse arrangements in the online world, just as they have in the offline world, for better or for worse.

National sovereignties will therefore persist in the online world. And the question is, how the providers of content, apps, and networks can deal with that. Must they comply with many dozens of different rules? That would be and impractical burden. Or, will they simply apply the strictest national rule to everything, so that they will not be in violation anywhere? That would create a race to the bottom, with the toughest restrictions prevailing.

But there is another possibility, the possibility of going through intermediaries who would tailor the material to comply with the various national laws before it goes to that country. This would be a cloud's function. These intermediaries could be large and sophisticated enough to be able to deal with the multiplicity of national rules. There are economies of scale in compliance, too. This intermediate sanitizing by privately owned clouds is not a particularly desirable arrangement. But it is the one likely to emerge. And the question is whether there would be an undue gatekeeping by such intermediaries, based on risk-avoidance and their own judgments on morality, politics, etc. It is therefore important that there are multiple intermediaries in this role, and that content need not go through any particular intermediary but has other options, too. And if there is market power, there would be a policy of a non-discriminatory use in terms of content.

A related issue is the role of liability of a party in an interactive communication such as games or virtual worlds, for the actions of another participant. Absent some policing, violations by some part of a system would affect the others and expose them to legal risk. This leads to intermediaries who establish usage policies, police them, and lower risk to users.

4.4.4 Financial Distribution

The fourth dimension of cloud coordination is that of financial flows. Somehow, the various providers of special modules, whether they provide services, copyright licenses, apps, transmission, storage, etc., require compensation from users or each other. Once the linear relation of a specific user consuming the product of a specific provider is replaced by a multiplicity of interacting users using a diverse and changing menu of elements, financial flows need to be channeled through intermediaries. In other cases, some financing might be in order. In film, such a role of a financial clearing house had been a major role of the major Hollywood distributors.

4.4.5 Marketing, Branding, and Quality Control

To produce immersive, interactive video and game content is difficult and expensive. It requires creativity, many programmers, and many new versions. The film *Avatar* credited the participation of over 800 computer graphic artists. And that was without interactive story lines, user participation, and multi-platform formatting.

Such expensive content exhibits strong economies of scale on the content production side and network externalities on the demand side. Both favor content providers with big budgets who can diversify risk, distribute over multiple platforms, distribute globally, and coordinate specialized inputs. Few firms can do this. And organization cannot sustain such an activity level in-house, neither financially or in terms of quality. Many firms, however, can contribute specialized elements. Therefore, most likely to emerge is a two-tier media structure, with a few major "central node" companies integrating the many elements that are supplied by smaller specialists.

Such a system has already emerged in Hollywood decades ago. The 'studios' are mostly distributing and marketing. Direct production is done only in selected cases. In most cases, the production is done together by entrepreneurs (independent producers), who in turn are putting together the services of highly specialized providers, of which there are thousands.

A similar dynamic takes place in news. A traditional print newspaper had a limited offering of news it produced or selected. But online, each news item is expandable to deeper and more specialized information, with more news about any particular topic, and on many other topics. And all of this not just once a day but on a continuous basis. It is impossible for any media organization to produce such content alone, and to do it well.

The role of major media companies therefore becomes, to a significant extent, that of integration and quality control of elements produced by others, and to provide users with the assurance of a branded product package. Clouds (or similar organizations) are such integrators.

4.4.6 Privacy and Security

From the perspective of content providers, a cloud arrangement helps protect copyrighted materials from piracy in comparison to physical media such as DVDs. A cloud provider can offer sophisticated security handled by expert security staff. It can monitor user behavior and based on such awareness provide security alerts. Also, the existence of convenient, user–friendly and moderately priced cloud-based media provision strongly reduces the incentives to piracy, which often flourished because legal commercial online distribution did not exist as an option for users.

How does this add up to? People have argued for a long time that the future of media will be one of domination by large media conglomerates centered around production. “Content is king”. Other people, fewer in number, believe that distribution holds the key. But the conclusion of our analysis is different, that the key media institutions of the future will be those based on bridging and integration, and that the cloud companies will be the central providers in the system. Some of them might be traditional media companies that have moved into technology. An example are several of the traditional American broadcast TV networks with their online service Hulu. But it is doubtful that traditional media firms can whole-heartedly embrace the integrated function which gives them a wider scope of activity but with a substantially lessened control. The same can be said for traditional public service media such as the BBC or NHK. A second category will be tech companies that have morphed into media. Google and Apple are the most obvious examples. And third category are hybrid “tech-media” firms such as Netflix.

Such firms will drive the change in media industries. Telecom and cable providers will gain because of the enormous increase in bit transport, and because of the rising economies of scale which are likely to reduce competition. Content producers will also benefit from the globalization of demand but will also face greater competition for each content element. Creatives around the world will find a new toolset for entirely new forms of expression, as revolutionary as the introduction of film was in the early 20th Century. And media managers and entrepreneurs will build new business and advertising models that will reshape industries. Thus, great opportunities exist for creative innovation. But not all is upside. There are also clouds over

cloud-TV, beyond those of 'creative destruction' of firms and practices that fail to adjust. This will be discussed now.

5. Policy Issues For Clouds

As mentioned earlier, it is natural for each generation to believe that issues and problems are brand-new and thrust upon them; whereas in reality many of them are part of long-standing fundamental conflicts. It's been said that in literature there are only 20 plots. In ICT and media there are even fewer basic plot lines, about four:

1. **Power** (monopoly, competition, vertical integration, ownership)
2. **Access** (interconnection, compatibility, standardization, non-discrimination, affordability, universality, diversity)
3. **Growth** (innovation, infrastructure, development, industrial policy, trade)
4. **Protection** (children, privacy, security, copyrights, reputation, national culture)

These themes create a set of fairly predictable problems and conflicts. Obviously there are new ones too, but many are variations. This does not belittle their importance. To the contrary, they are the fundamental trade-offs that each generation must re-negotiate.

Societal control over media has been around, in one way or another, since our stone age ancestors danced around the fire. More recently, television media were tightly controlled through a variety of means such as the requirement to obtain a scarce license that came with many conditions. But it is not spectrum scarcity that required governments to control television. TV spectrum was scarce because governments chose to make it so, by allocating frequencies only sparingly. TV regulation exists because the various societies are concerned about certain issues, such as political control, national identity, morals, racism, etc. These concerns are reflected in respective national media policies, and they will not disappear because the programs are transmitted over a different platform. A number of questions will emerge and for which one needs to be prepared. Ignoring them will only delay the next generation of television.

5.1 Policy Issue: Is There Enough Wireline?

Today's online connectivity speeds (rates) are impressive. Fiber offerings supports today 150 Mbps on the consumer level and can easily go higher. Cable's DOCSIS 3.0 runs at over 50 Mbps over hybrid fiber-coax, and can readily reach 200. DSL, using slightly improved copper-based telephone networks subscriber lines, can reach in newer versions over 20 Mbps. Many people believe that there is no need for greater transmission. But this would be short-sighted. Applications will continue to rapidly grow in their needs for transmission rates.

4K transmission rates[20], uncompressed, add up to 61 gigabits per second (245 Gbps for 8K.) Add to that 3D capability, two-way interactivity, superior surround-sound audio, superior digital sampling, and multiple language tracks, all requiring more bandwidth. Adding all this up results in a transmission requirement of about 100 gigabits per second. Three such channels per household would bring the transmission requirement to 0.3 of a terabit (for NHK's 8K standard, it would be 1.2 Tbps), far above today's low-megabit networks. Obviously, all of these numbers can be squeezed by compression and other techniques. But this is the reference point, the gold standard from which engineering must artfully whittle bits away to fit the narrower channel. Today, MPEG-2 compression ratios are about 15-30. MPEG-4 compression ratios are about 50, and H.265, released in 2013, to about 1:100.[21] But even if we compress and reduce bandwidth by a presently futuristic factor of 1000, one would still require over 1 Gbps per household for an 8K generation of TV. This demand will take a while to build, of course, but the trend lines of Graphs 1 and 3 suggest that that it will happen faster than many skeptics believe. And since the required upgrades of networks will take time, one needs to look ahead. TV-based internet usage requires enormous bandwidth, both in the last mile reaching the users, and in the network core, where numerous streams of individual use merge together in huge streams.

In 2011, overall internet traffic use grew from 23 GB/month per average user to 51 GB/month in 2012. If 68% of such traffic are "video bits", (as reported and calculated earlier) this would account for 34 GB/month per user). Video consumption in 2012 already put a load on

[20] 4000x2000 pixels, 4 colors, 16 bit coding, 120 fpm.

[21] But compression does not work as well for live events, interactive competitive games in which low latency is important, or for transmissions in which there is a lot of fast action such as sports. Its lossiness reduces picture quality, and it costs money to compress and decompress in terms of more advanced hardware.

the telecom network of about 650 times of the load of voice. Video thus has rapidly become the main traffic on telecom networks.

The implication is that there will soon be a significant stress on network resources. And while private investment is likely to be available for metropolitan areas it might not be forthcoming for low density rural areas. [22] The politically realistic assumption has to be that the definitions of universal service and the various interregional redistribution mechanisms will be adjusted upwards.

Would wireless be a substitute? At first, it would of course be an improvement for those who currently have no broadband access at all, and would provide competitive alternatives to others. This would be welcomed with open arms. But soon, the reality of a second-rate quality of connectivity will sink in, and it is unlikely that rural areas accept it, and seek wireline upgrades that would involve the migration of fiber closer to homes, supported by a subsidy mechanism created in the political realm.

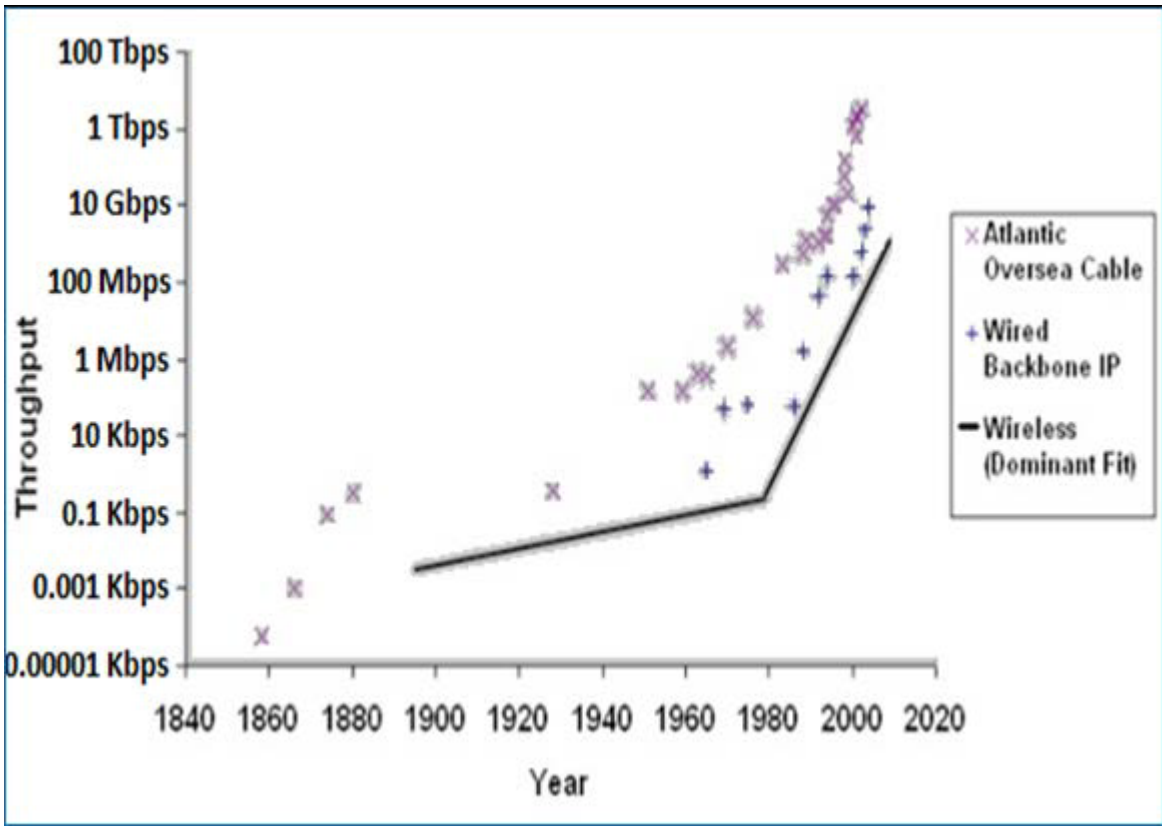
5.2 Policy Issue: Are Wireless Resources Adequate?

Promoters of the new generation 4G wireless generation (LTE) claim that it would be an adequate alternative to wireline reaching speeds of 300 Mbps. More sober projections speak of a top-speed of 13 Mbps. But once a lot of people are using data-intensive applications, speed would drop further. Such a transmission rate is only a fraction of the speed of wire line speeds, and even much less of fiber. It would also be more expensive than wire line in absolute terms, and even more so per unit of data.[23]

If millions of people were to stream movies over wireless, the networks would come to a crawl, unless one would add huge amounts of spectrum, which is unavailable. The only way to counteract this would be to construct a huge number of additional cell sites, so that the number of "pops" (people) per site would drop. This is not a matter of better engineering, it is physics. Engineering might improve spectrum efficiency (perhaps doubling the number of bits per Hertz) and other elements, but the headroom is neither large nor cheap. Thus, wireless is not going to catch up with wireline. Graph 5 below shows the technology trends for wireline cable (i.e. fiber)

[22] Atkinson, Robert C. & Schultz, Ivy E.. *Broadband in America Where It Is and Where It Is Going (According to Broadband Providers)*. New York: Columbia Institute for Tele-Information, 2009.
[23] Satellite-based broadband internet, including its next generation, is still more expensive.

and for wireless. As much progress as wireless technology is making (the solid line), it is not gaining on wireline technology (the scatter of x-points). Wireline seems to stay roughly two orders of magnitude ahead, i.e. about 100 times as fast, while actually accelerating over wireless in recent years.



Graph 6: Wired and Wireless Data Throughput Evolution Comparison[24]

Secondly, and at least as importantly, these are engineering numbers, not economic ones. The problem with wireless is that it has negative economies for speed, i.e. to add speed becomes progressively more expensive, while wireline has positive economies for speed.

Thus, wireless broadband will probably not be a substitute but rather a complement for wireline broadband. Even for this role as a complement in the video field, significant new spectrum allocations must be made available through the governmental process.

[24] Amaya, Mario A. and Christopher L. Magee. "The Progress in Wireless Data Transport and its Role in the Evolving Internet." Working Paper ESD-WP-2008-20, Massachusetts Institute of Technology, Nov. 2008.

5.3 Policy Issue: How to Assure the Financial Viability of Infrastructure?

Network providers will argue that for them to undertake the upgrade investments they need to increase their share of revenues from cloud transmission services. The financial balance between infrastructure, services, and users is a critical issue. The infrastructure is expensive and wants to be paid. Some of the media services are young and want to be left to grow. Users want to be served generously with free content and low-priced, flat-rate data service. Fundamental economics of competition push towards price deflation, but market power, and maybe regulation, pull in another direction.[25] And there is another dimension. Developing countries want to see money from communications as they did in the days of traditional telecom. But their users and the global media companies do not want to pay this indirect tax.

5.4 Policy Issue: How Much Network Management?

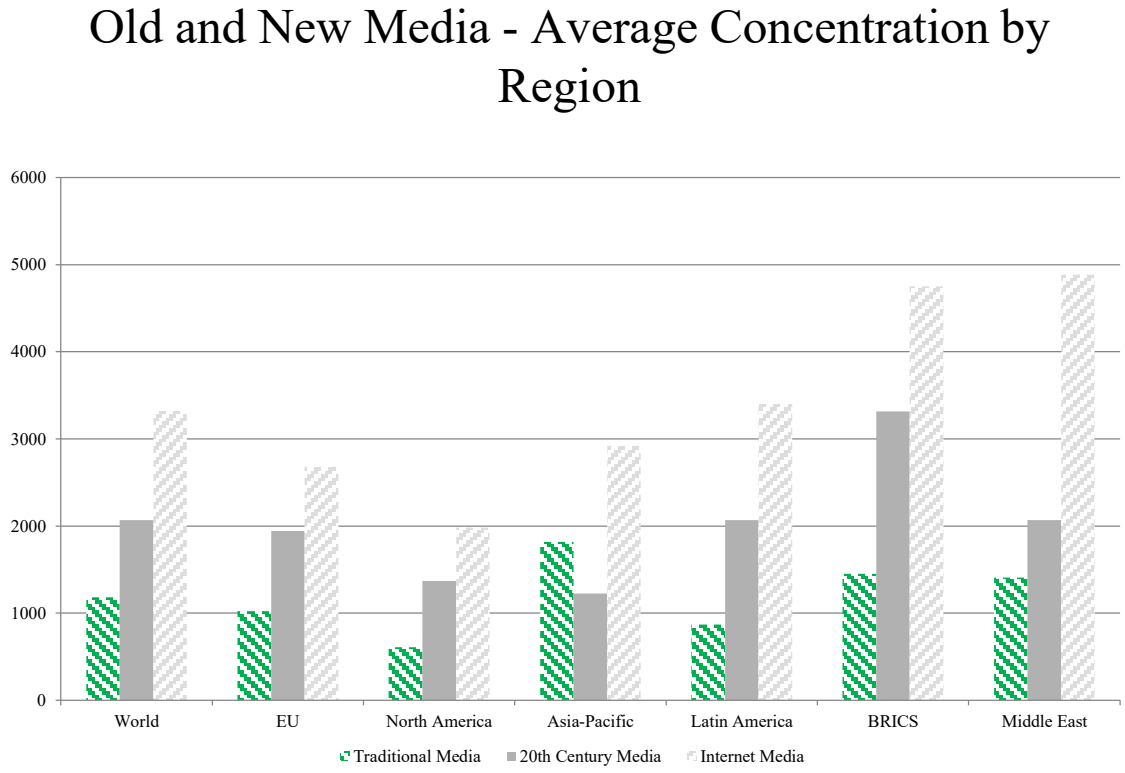
Where network peak loads would exceed network capacity some form of allocation must take place. The question is whether higher prices for better service (i.e. priority) and ceilings on user consumption should be the tools of such network management. This has been the subject of bitter debates, and video traffic accelerates that debate.

5.5 Policy Issue: Will There Be Market Power in Online TV?

The power of gatekeepers over information flows, has been long recognized. This led to common carrier status for telecom firms, must-carry rules for cable TV distribution networks; restrictions on TV networks; multiple arrangements; a non-discrimination by ISPs; antitrust litigation over operating systems in microcomputers; and search engines in pursuit of information; and to debates over "walled gardens" in mobile services. The question is now, whether similar gatekeeping issues arise for online TV. It would be surprising if they would not. On the infrastructure side, an online-based media system requires more powerful pipes. And these pipes exhibit strong economies of scale. There are high fixed costs, low marginal costs, and therefore average costs keep dropping with expansion. This makes it difficult to compete against large incumbents. Such a market concentration would raise regulatory issues.

[25] Noam, Eli. "Over the Top: New Business Models with New International Telecom Rules?" Columbia University, New York, NY, 24 September 2012.

As we discussed, clouds will be central organizations for an emerging online media system. There will not be many of them, for reasons of scale and scope. And this means that the media of the future will be more concentrated than that of the past. When it comes to TV, the conventional wisdom is that new media are less concentrated than the old. But even today, that is not what the data shows.



Graph 7

Graph 7 shows, through differently shaded bars, media concentrations for three types of media in six regions of the world.[26] First, traditional media such as newspapers, books, and magazines. Second, 20th century media such as film, radio, TV, cable TV. And third, internet media such as online news, search, and ISPs. The data shows that each newer generation of media is more

[26] Eli Noam, *Media Ownership and Concentration Around the World*, Oxford University Press, forthcoming 2014

concentrated than the preceding one, and that this is true almost everywhere. Traditional media have a concentration index, worldwide, of about 1100, which is almost unconcentrated. In contrast, twentieth century media have a concentration index of about 2000, which is highly concentrated. And internet media have an index of over 3000, which is still more highly concentrated. These are the industries that were believed to be wide open and competitive, and which would open things up for the rest. But they exhibit strong concentration trends.

The main reason is that as new types of technology-intensive media emerge, and as traditional media move towards online activities, media become more capital intensive and hence more concentrated in the long run. In the past this has happened with TV broadcasting relative to radio, with radio relative to newspapers, and with newspapers relative to books. These economics are quite fundamental. They show themselves globally and are thus not just due to some particularly greedy media empire builder or a complacent regulator.

The trend of market equilibria of media structure will therefore favor higher concentration. Current or foreseeable technology and entrepreneurship will not easily overcome that problem in a long-term sustained way.

5.6 Policy Issue: Does Vertical Integration Impede Competition?

Competition among clouds is affected by vertical integration. For example, if an ISP also owns a cloud service provider, that cloud might realistically have an advantaged access to and by the ISP's customers, whether "net neutrality" rules exist or not. And with a strong customer base from a large ISP, it gains economics of scale and network effects. This, in turn, raises its attraction to the suppliers of content and advertising. Conversely, the ownership of a successful cloud with access to content makes an ISP more valuable to endusers, in comparison to an ISP without such vertical integration.

Some vertical integration is taking place between hardware devices and content provision.. Microsoft moved into game consoles. Sony had a strong leg in both, as did, for much of the 20th century, RCA/NBC. TV set makers now add video content to their "connected TVs". Sony, for example, offers its own film studio's content to buyers of its TV sets. Apple has its computers, tablets, MP3 players, and phones linked tightly to its i-store content and apps. This kind of vertical integration is only a problem in those situations where a strong consumer lock-in

effect exists, which then makes it difficult for users, once they have chosen a hardware platform, to chose content and applications offered by rival providers, even where no technical compatibility issues exist.

5.7 Policy Issue: How To Protect Children and Traditional Morality?

Historically, new forms of media have always been looked on with suspicion, and the negative impact on children—real or imagined-- has often been used as a leading wedge to block the new medium or slow it down. It is also true that new types of media enabled people to produce and consume images of sex and violence in new ways. Today, adult film companies and game designers work on augmented reality and on interactive games that raise concerns and legislative responses. The cultural and business struggles are entirely predictable, and now add international dimensions.

5.8 Policy Issue: How to Protect Privacy and Security?

The cloud provider, as the central node, knows users' activities, locations, social partners, shopping and intellectual preferences, even character as revealed in interactive behavior. Privacy is challenged. This is especially the case where sensitive user information is transmitted to others for targeted commercials. None of this is a new phenomenon, but it is raised to new levels and to a new generation of privacy issues.

Clouds also creates new security issues, even as they also remediate others. As mentioned, from the perspective of content providers a cloud arrangement helps protect copyrighted materials from piracy in comparison to physical media such as DVDs. A cloud provider can offer sophisticated security handled by expert security staff. It can monitor user behavior and based on such awareness provide security alerts.

Yes at the same time, clouds are also a magnet to hackers. They are easy to find and contain data on many thousands of people's accounts and usage patterns. Sony PlayStation was hacked in 2011, compromising the credit card information of thousands of users. The overall damage to Sony is said to have reached $130 million. Some clouds have grown so fast that their security did not keep up.

One would expect market competition to generate different consumer options in security. However, for most users security is hard to assess when selecting a service provider. More

fundamentally, in a highly interactive chain of operations security is only as strong as its weakest link. This is a classic situation of negative externalities, where any module is optimizing its security level and may affect others' security negatively.

5.9 Policy Issue: Who Gets To Tax?

In many countries, TV users must pay a licensing fee that supports public service TV. One question therefore is how the new-style of online TV would be treated, especially where it is not merely an additional transmission platform for existing public broadcasters. Is it a taxable activity by a user? And who are the recipients of funds raised by such taxation? In many countries, telecommunications bills serve as a source of tax revenue. Who will pay in a cloud-TV system, and who will receive funding?

Additional complexity is provided by the global nature of cloud TV. Content is provided across national boundaries and one can easily combine service elements from several countries. Because of the distance insensitivity of online services, providers will often locate themselves in low tax, low regulation jurisdictions, and shift profits to them through internal pricing.

5.10 Policy Issue: What Kind of Standards?

Are TV technical standards necessary? To most traditional TV people, a positive answer is obvious and part of the culture. Television standards were certainly essential in a broadcast world. A small number of transmitters had to reach a large number of users, who wanted to receive them all.

The transition to digital TV in the US was based on a new standard (ATSC), but it already gave broadcasters the flexibility to choose among 18 variations under that umbrella. Digital technology made such diversity easy.

And now, the question is whether for the next generation of standards for the next generation of TV should perhaps be no standard at all, or perhaps only a broad set of very loose parameters and minimum specifications, within which the makers of hardware, networks, software, and content would develop their own technologies and approaches. They would then compete for the users' adoption – or more likely for adoption by intermediate cloud providers. Standards are slow to be adopted and even slower to be changed. While useful to lower cost in a slow-moving technology, they are a retardant to innovation in a rapidly evolving field. In the future, there may be "open standards" for cloud TV. Digital technology does not require

uniformity, and enduser devices and smart TV sets can process multiple standards. Nevertheless, various industries and standards bodies have been forging ahead to maintain their role and dominance in their sphere.

5.11 Policy Issue: What is the Impact on Trade?

Is there a trade impact of clouds on America exports and imports? On the enterprise side, clouds probably accelerate outsourcing and offshoring and thus have a negative employment effect if seen narrowly. This might be partly offset by several major cloud providers being US-headquartered.

On the consumer end, with entertainment the major cloud service, the trade impact is more positive, from the US perspective. First, it generates a stronger way to export content globally by making distribution easier and reducing the gatekeeping of national TV networks in favor of user selection. Of course, such opening and ease is true for all the world's content providers, but Hollywood has always done well in this kind of context.

Secondly, the cloud-based system opens TV to apps and technology modules of the internet and IT industries, where the US ("Silicon Valley") has been strong. Thirdly, the general convergence of IT and consumer electronics strengthened US makers who had been soundly defeated in the past by Asian CE firms. Now, Apple, Microsoft, Roku, Logitech, or Linksys have done well where RCA, Zenith, Magnavox, Sylvania, Motorola, or Emerson have not.

5.12 Policy Problem: What is the Impact of Globalization?

Cloud-TV works in two opposite directions. On the one hand, advanced cloud-TV content might be too expensive to produce for small markets while global distribution will be cheap. On the other hand, user generated content might play an important role, and would enhance national culture and local traditions.

Drivers for globalization of Next-Generation content are

- The price of international transmission is dropping rapidly.
- Domestic internet penetrations are increasing rapidly
- E-content has large economies of scale
- Modules of content are produced in various technology and content centers around the world, and production clusters become virtual rather than geographic

Broad principles of public policy interoperability and access make restrictions on content more difficult than in the past, where the few TV or cable channel providers could be easily controlled.

As a result of these factors, cloud-TV content will become much more global in nature, more like the Hollywood system in film than the more domestic model of TV broadcasting.

6. How To Assure The Interoperability of Clouds

We have now discussed several policy issues that are likely to be associated with the emergence of clouds. However, none is more significant than that of *interconnection*. For a hundred years, the main issue for telecom regulation had been interoperation and its cousin, interconnection: technologically, operationally, internationally, and financially. Similarly flavored issues existed for cable and broadcast TV.

A complex structure emerged to ensure this interoperation: Technical standards, the ITU, the FCC, and other regulatory agencies; ICANN; Common carriage; etc. Telecom's biggest battles were fought over interoperability. Typically, the biggest networks want to interoperate with similarly situated international partners but not with direct domestic rivals. They have the advantages of scale and scope on the supply side, and network effects on the demand side. So why share them with a smaller interconnector? Similarly, they have wielded gatekeeping control over access by providers of content and hardware, with the potential to extract economic rents. But is this the end of the story? Today, the next generation of interoperation is emerging, the interoperation of clouds.

As was discussed, one should not expect many firms to be general cloud providers. The important question then is how to keep such a cloud-based system competitive? The history of networks suggests that the strongest remedy to deal with market power by dominant players is through interoperability and interconnection. This would create a system not of parallel and separate clouds but of a 'cloud of clouds'.

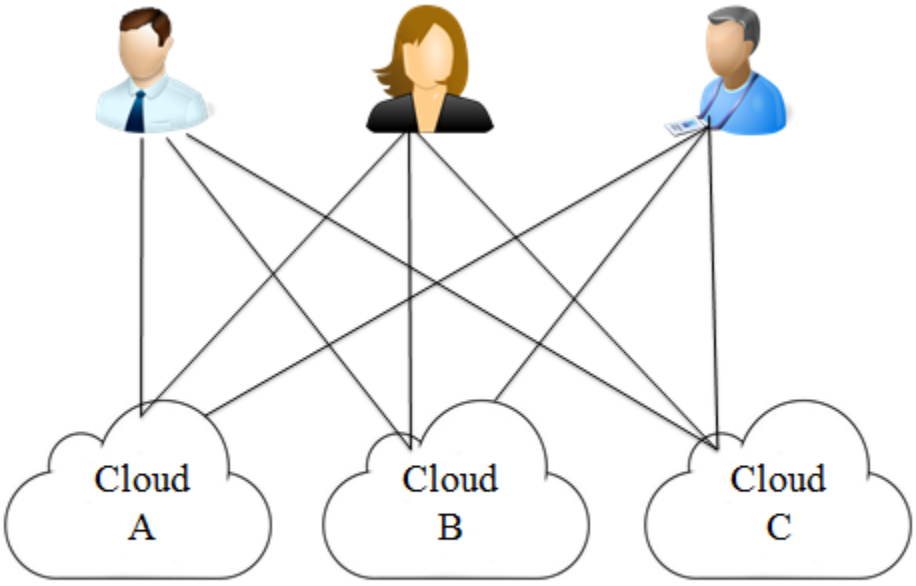
The major question of a cloud-based media system is therefore the extent of interoperability among the various clouds. A mandated "harmonization" can easily stifle innovation, but if clouds are not interoperable, there might be

- Market power over users who could not easily switch ("lock-in").
- Difficulty of the users of one cloud to interact with the users of other clouds.

- Market power over providers of hardware, software, and content.

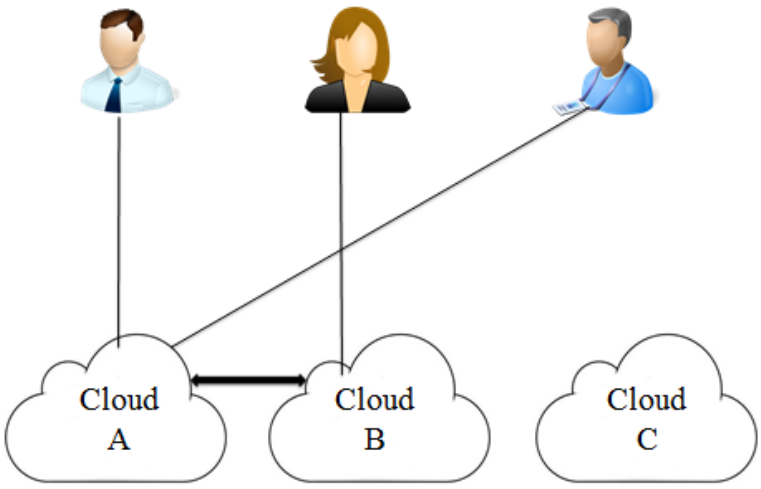
To encourage interoperability, the first step is to rely on market forces. This leads to three types of interoperability mechanisms: on the user side, on the provider end, and by third parties.

1. *Users' create their own interconnection by being linked to multiple clouds*. In Graph 7, each user connects to each cloud. But that would be complicated for users and require major transaction costs by them as they link and bridge diverse systems.



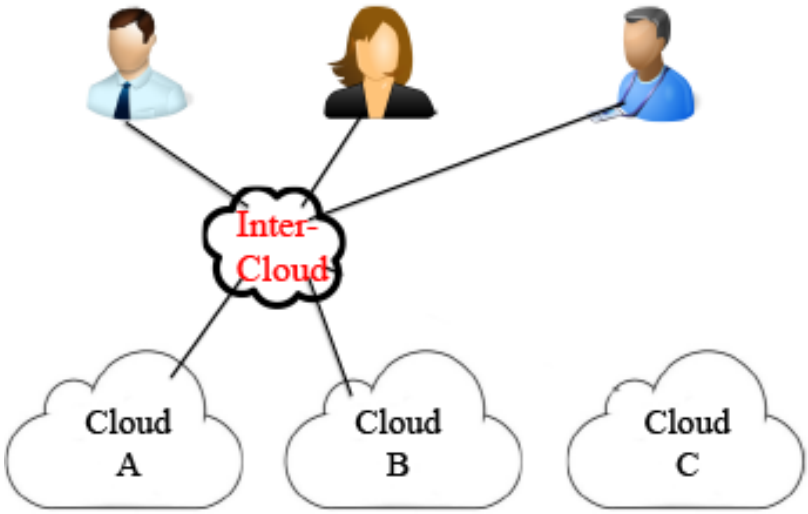
Graph 8: Self-Connection by Each User

2. The second market-based option is *Peer Interconnection by clouds*, based on commercial deals. For example, in Graph 8 clouds A and B interconnect, and a user who is connected to one of them is also connected to the other. But, because it is a contractual system, Cloud C might not be included, and users would have to find independent ways to deal with it. Cloud C might therefore be cut off. The peering of clouds has emerged through, for example, agreements by Google, Salesforce, Dreamforce, and Facebook.



Graph 9: Peer Interconnection by Clouds

3. The 3rd market-based option is the emergence of an *Intermediate 'intercloud' or 'cloud of clouds'*, into which other clouds interconnect. (Graph 10) This could be a purely commercial arrangement, and hence will not necessarily incorporate Cloud C, either.



Graph 10: Cloud of Clouds

Such commercial "meta-clouds" or "cloudbrokers" have started to emerge. Examples are:

- RightScale– runs on Amazon, GoGrid, Flexiscale
- Cloudshift by Cloudkick, moves files fom Amazon to Rackspace
- Kaavo, enStratus
- Oxygen Cloud

- Backup Box

The initial capabilities of these meta-clouds has been adequate for simple file transfer, but anything more complicated has been described as a challenge. Clouds such as Google App Engine and MS Azure are proprietary and one cannot use the others' apps or move things around. The cloud company Salesforce, in particular, created Force.com as a kind of integration service. The meta-clouds provide intermediation, aggregation, and arbitrage across cloud providers. Some clouds permit inbound transfers, such as Nirvanix.

4. Regulated interoperation. The purely market-based system of meta-clouds might leave out rival clouds and potential competitors. This then leads to the second major approach to assuring interoperation – that of a regulated assurance of interoperation and access by all clouds to each other or to a meta-cloud.

Government regulation could several approaches:

- Market structure regulation – Antitrust enforcement to prevent vertical integration, merger control, ownership ceilings, cross-ownership rules, etc. This is the approach taken frequently, whether in America on net neutrality, or in Europe and Japan on the unbundled loops pricing.
- Behavioral regulation – including access requirements or controls over pricing.

But these would be traditional responses by traditional governmental institutions. They would end up either backward looking or used to protect established stakeholders. An example is the imposition, by the EU Commission, of traditional TV rules on linear online TV, to establish 'symmetry' with traditional TV. And there is a particular problem with the regulation of media company behavior– the danger is that it puts a lot of discretionary power in governmental hands. In an area such as media, a solid distance between the media and government is desirable, for the sake of both.

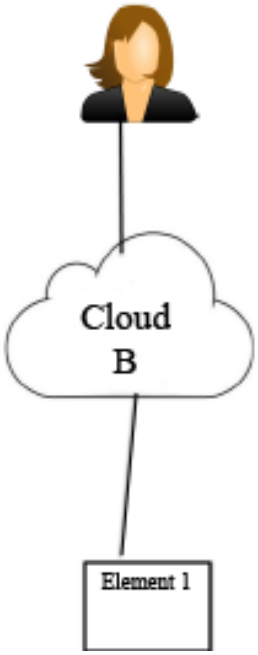
There might be some need for certain regulatory involvements to assure a competitive and diverse cloud media system. But the main directions need to be promotive and positive rather than restricting and negative. There are three dimensions to that direction for governments:

1. Support for diverse clouds
2. The public provision of a public cloud
3. Assuring interoperability

The first dimension means to create new forms of funding new platforms and integrators, in effect, the creation of public and national clouds. This is still a fairly traditional approach, though applied to a new set of players. The second approach might be a publicly funded system in some countries where commercial provision might not be viable, or the arrangement of such role to established industries such as public broadcasters might play a role, though they need to be wide-open platforms, which has not been their traditional role, responsibility, or inclination.

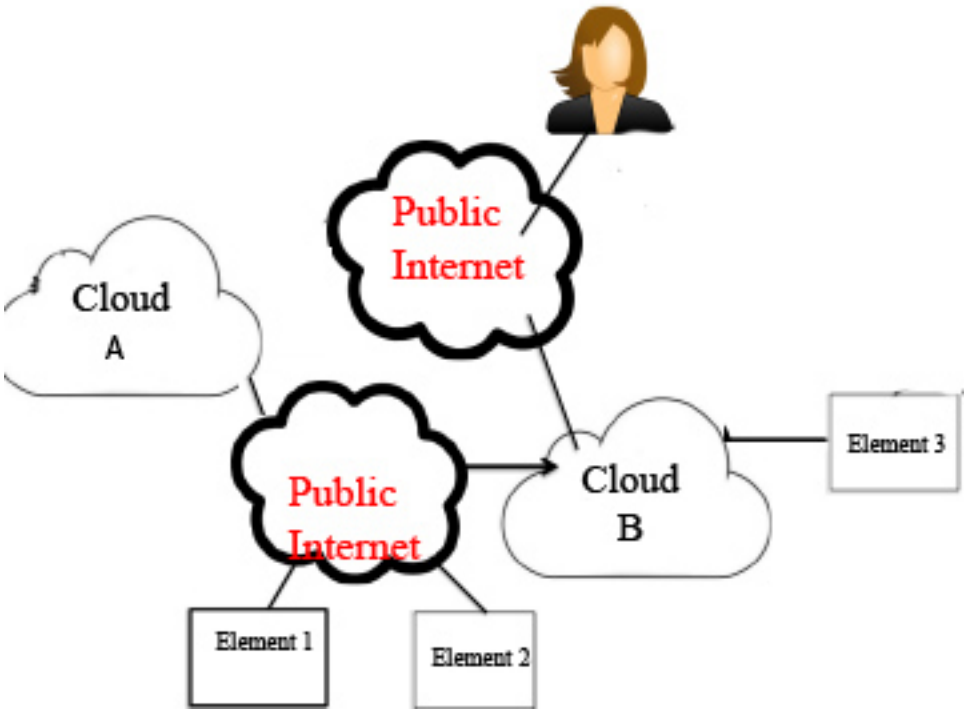
Perhaps most important is the third role for government, the assurance of interoperation. A mandatory interoperation would enable new or small providers to piggyback on the economies of scale, and the network effects, of the incumbents. But it would lead to disputes over prices, quality, standards, and technology. A century-old history over telecom interconnection bears witness to this fundamental problem. And such mandated interconnection would prevent a cloud from offering end-to-end control to enhance the user experience, in the way that Steve Jobs insisted for Apple. Should a cloud provider not have that option?

To deal with this there is an intermediate option, combining market based interoperation with a light-touch rule-of-the-road, basically consisting of giving users the option of picking services on an unbundled basis, and connecting to outside providers. The cloud provider would have a choice. It can decide to be an end-to-end island of its own services (Graph 10), and free in its relations with suppliers and customers.



Graph 11: End-to-End Private System

But where a cloud service also offers content and services from the public internet, it must permit its own users to connect to other users, clouds, services, and devices.



Graph 12: Cloud Using the Public Internet

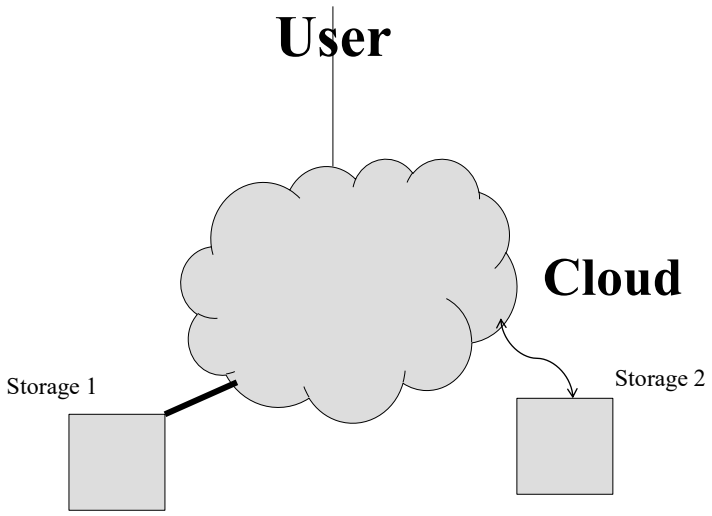
For example, a user connecting via the public internet to Cloud B that offers Element 3 should be able to also reach Elements 1 and 2 via that cloud.

A related problem is that of bundling. A cloud provider might permit a user to access the independent Element 1, but if it offers the same element as part of a required – take-it-or-leave-it-package, the user would have to pay for it twice, once to the independent provider and once to the cloud provider as part of its package service. There are regulatory ways of price regulation to tackle both of these problems, but they are burdensome and meddlesome. Fortunately, a simpler way exists.

The best approach for clouds is that of unbundling. Charge what you want, bundle as much as you want, as long as elements are also available in unbundled form. A user, or other service provider, can then substitute elements. (This approach must be distinguished from that for traditional cable TV. There, a vertical system exists, i.e. it is the island system that is an option for providers.)

Suppose a cloud links to some outside (or internal) element of storage 1 and 2. It can offer each as part of a bundle. But, when it is using the public internet in creating its services it

must also offer it on an unbundled basis at a price of its choosing, so that the user can take Storage 3 in the alternative. This generates competition on the user level for storage.



Graph 13

To conclude the discussion of interoperation: Cloud-based next generation media will include gatekeepers with market power in an important sector. In such situations there is a need to protect diversity and competition through the protection of interoperation. Such interoperation can be protected, when it is not forthcoming through market forces, by just two principles, where the cloud is interoperating with the public internet.

1. Ability of a cloud user to access other elements through the public internet
2. Unbundling of elements

With those two rules, one can establish pretty much a system of interoperation and interconnection for a cloud-based media system. There is no need for price regulation; nor for uniform technical standards; nor for international agreements on protections of consumers, children, political speech, etc.

7. Establishing a National and Global Commission on Next-Generation TV

The emergence of Cloud TV raises numerous questions. To repeat the points made in the beginning of the report, a strong argument can be made that questions cannot and indeed should

not be resolved in advance. The dynamic developments in technology and entrepreneurship should not be constrained. But it can also be argued persuasively that there should be some general principles that would assure free flows, reduce market power, and reduce fragmentation. If those issues are not addressed in a timely fashion, they will crop up as the new efforts emerge, and will then slow things down as they get resolved.

Alternatively, developments may forge ahead and will create realities that are detrimental to a competitive and open system, yet hard to undo anymore. Here, an example was the emergence of radio broadcasting in the US, or of private TV in Italy. In both cases, significant wildcatting created dysfunctional systems that took years to unravel.

And a third negative outcome might be that other countries will take an initiative in shaping the future of the new medium, possibly for reasons of their domestic politics and industrial policies, that will force others, including the US, into unfavorable directions or isolation, and might create globally fragmented media systems.

Contrast this with the internet, where dynamic innovation became possible on the base of a consensus core, while that core was evolving, too.

This suggest an approach that lies between *ex-ante* and *ex-post*. It would be to search early for a set of broad technical and policy principles, and have these concepts debated and refined in parallel to technological and entrepreneurial innovation, neither in advance nor behind. And this means getting prepared now, while such innovation is taking place.

Concretely, there is a need for an organized effort of thought leadership. And therefore, this report proposes the creation of a high-level expert advisory and study commission to study and make recommendations. Such a committee would be similar in concept to the FCC's Advisory Committee on Advanced Television Services empaneled by the FCC in 1987 to assist the FCC in establishing Advanced Television, (the "Wiley Committee"). Its recommendations led to the digital TV that has now emerged. Even in those parts of the world where other standards were adopted, many of the concepts behind the US recommendations were incorporated in other parts of the world.

The advisory commission would

1. Identify the issues of next generation of online-based television, consider options, and make recommendations on broad principles for such a system.

2. Identify the infrastructure needs of an online based TV system, and make recommendations if warranted.

The group would be composed of technologists, policy analysts, economists, regulatory and copyright lawyers, media managers, NGO representatives, content creators, and various stakeholders.

A national committee would be best appointed by the FCC. This would shorten the distance between advisors and decision makers. But the procedures involved would create delay. Alternatively, the National Research Council could appoint such a board, though that would most likely generate a more academic effort. Still another alternative would be for a university or consortium to take the initiative. Related efforts in the technology field are being undertaken, as described in the Appendix, by ATSC and NAB (North America), DVB (Europe); NHK (Japan) and FobTV (international). These are important initiatives, but they focus on the narrower standards issues, which, as has been argued, are only a small part oft he emerging set of issues. Furthermore, these efforts are primarily those of the traditional TV broadcasting and TV set making industries. But the set of industries involved in a cloud environment is much wider. And still wider is the range of interests in a society and economy dealing with its major media system.

A report should be delivered 1 year from the commission's appointment, with interim reports forthcoming periodically. Its budget will add up to about $500,000.

To conclude: a new type of TV is emerging that will be significantly different in its rate of technical and entrepreneurial innovation, and consequently in the nature of media industries. More fundamentally, this affects the content styles and genres that constitute culture and political discourse. It may be early now, but it is a short time before such cloud TV emerges as the central medium, and then it might be too late to affect its systems and structure. Let us think today about tomorrow, and not tomorrow about yesterday.

APPENDIX: Technological and Organizational Efforts Towards Cloud-TV

7.1 North America

The ATSC committee, in charge of developing TV standards, embarked on a next generation project ATSC 3.0. It reached several findings in its Next Generation Broadcast TV Report[27] of September 2011 and issued recommendations on:

- Improved audio and video codecs (HEVC) and transmission methods.
- "hybrid" services, in which over-the-air and online methods of content delivery seamlessly converge at the user's terminal device.
- New or extended applications ("usage models"),
  - content personalization
  - targeting features
  - more immersive presentation formats
  - advanced non-real-time content downloading services.

Cable Labs, the North American cable industry's R&D organization, developed the Open Cable Application Platform (OCAP) as a middleware system layer for consumer devices connected to cable networks.

7.2 Europe

- The European Union is funding a variety of next generation video projects with its FP7-IC program/ Information and Communication Technologies, which provides ICT funding of €9.1 billion for a while range of projects[28]

[27] ATSC. "Final Report on ATSC 3.0 Next Generation Broadcast Television" Sep 2011; Last accessed 07/09/2013. http://www.atsc.org/cms/pdf/pt2/PT2-046r11-Final-Report-on-NGBT.pdf

[28] Community Research and Development Information Service. " ICT - Information and Communication Technologies." 13.February 2012. European Commission. Last accessed on 07/09/2013 at http://cordis.europa.eu/fp7/ict/

- NoTube was a EU funded (6.15 mil) research project that ran from 2009 to 2012 to bring Web and TV closer together via shared data and semantic model.[29] [30]
- RE@CT is a 2011-2014 project with an EU contribution of € 3.5 mil that aims to improve the production of 3D characters and interactive characters.[31]
- IRIS (Integrating research in interactive storytelling) is a project funded from 2009 to 2011with an EU contribution of € 2.4 mil to enhance interactive storytelling technologies.[32]
- FascinatE aims to allows end-users to view, interact, and navigate around an ultra-high resolution panorama of a live event (e.g. a soccer match). The video and audio output (resolution, bit- and frame rate) adapts to suit different formats (e.g. smartphone, immersive panoramic display, etc.) and positions.[33] A scene will be captured with different types of camera and clustered around one or more viewpoints, rather than just using one camera for one whole scenery.[34]

In the UK, in 2012 the Ministry for culture, communication and creative industries put together "The Future of Innovation in Television Technology Taskforce" which was charged to figure out how to deliver sustainable UK economic growth through the convergence of creative, digital and IT activities.[35]

29NoTube "NoTube: bringing Web and TV closer together." 13.February 2012. NoTube. Last accessed on 07/09/2013 at http://notube.tv/2012/02/13/notube-bringing-web-and-tv-closer-together/

[30]Community Research and Development Information Service. "Networks and ontologies for the transformation and unification of broadcasting and the Internet." 13.February 2012. European Commission. Last accessed on 07/09/2013 at http://cordis.europa.eu/projects/rcn/89494_en.html

[31] Community Research and Development Information Service. "RE@CT - IMMERSIVE PRODUCTION AND DELIVERY OF INTERACTIVE 3D CONTENT." 23.December 2012. European Commission. Last accessed on 07/09/2013 at http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=interactive&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=101841

[32] Community Research and Development Information Service. "Integrating research in interactive storytelling." 24.November 2012. European Commission. Last accessed on 07/09/2013 at http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=interactive&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=89495

[33] "Future Immersive Experiences." *GeoInformatics* 14.4 (2011): 30-1. 29 Aug. 2012.

[34] "About the Project."*FascinatE*. Last Accessed 07/09/2013. <http://www.fascinate-project.eu/index.php/about/>.

[35] Goss, Patrick. "DTG and UK Government to assemble TV taskforce." *TechRadar.TVs*. September 6, 2012. Last accessed 07/09/2013. <http://www.techradar.com/us/news/television/dtg-and-uk-government-to-assemble-tv-taskforce-1095142>.

In Europe, TV standards are maintained by the DVB Project, an industry consortium; sometimes in collaboration with ETSI, the regional telecom standards body. The DVB group established**:**

*The working group CM-3DTV to create standards for 3D.[36] [37]

– The TM-CI-Plus ad-hoc working group in 2011 to produce a specification.[38] for Multi-stream support, IP-delivered content, TV set browser extensions, and access to TV broadcasts from computers.

- Standards for a "common core" of APIs for interactivity connected with television, known as GEM.
- Under development is a commercial module for Ultra High Definition TV[39]

- DVB-HHP middleware for consumer devices to connect to cable.

7.3 Asia-Pacific

The Japanese government supports domestic companies including Sony and Sharp in the joint development of super-thin OLED displays (organic light-emitting diodes.)

Japan, as mentioned, also pushes 4K and 8K. In 2012, the ITU approved the NHK's Super Hi-Vision UHD 4K and 8K broadcasting standards. Japans government announced in February 2013 to launch commercial broadcasting in 4K resolution in mid-2013 and in 8K resolution in 2016.[40]

7.4 Global

In 2011, 13 leading world broadcasting organizations established a framework for cooperation to chart the future course of terrestrial television broadcasting. The first initiative

[36] "CM: 3DTV." *DVB*. Last Accessed 07/09/2013. <http://www.dvb.org/groups_modules/commercial_module/cm3dtv/index.xml>.
[37] "DVB Commercial Requirements for DVB 3D-TV," *DVB BlueBook A151.* July 2010. Last accessed 07/09/2013 at <http://www.dvb.org/technology/standards/a151_CR_for_DVB-3DTV.pdf>.
[38] "TM-CI-Plus." *DVB*. Last Accessed 07/09/2013. <http://www.dvb.org/groups_modules/technical_module/tmciplus/index.xml>.
[39] "CM-UHDTV." *DVB*. Last Accessed 07/09/2013. <http://www.dvb.org/groups_modules/commercial_module/cmuhdtv/index.xml?groupID=89>.
[40] Patrizio, Andy. "Report: China, Japan to Embrace 4K Resolution TV First." *Desktop Review.* Feb. 4, 2013. Last accessed 07/09/2013 at <http://www.desktopreview.com/default.asp?newsID=2088&News=China+Japan+US+4K+TV+Ultra+HD>.

was to form, in 2012, the task force on the Future of Broadcast Television (FobTV).[41] FobTV is run by a Management Committee that represents the founding members, with Mark Richter (president of the ATSC in the US) as Chairman.[42]

FobTV professes not seek to become a standard-making organization. The stated objective is to recommend broadcast technologies that can be adopted by existing standards bodies.[43] This is a fine distinction.

The goals of FobTV are:

- Development of future ecosystem models for terrestrial broadcasting taking into account business, regulatory, and technical environments.
- Development of requirements for next-generation terrestrial broadcast systems.
- Fostering of collaboration of DTV development laboratories.
- Selection of major technologies to be used as the basis for new standards.
- Need for standardization of selected technologies (layers) by ATSC, DVB, and the Association of Radio Industries and Businesses (Japan).

Other standardization efforts include:

- The Open IPTV Forum (OIPF), started in 2007, is a collaboration forum of different global industries and companies such as Sony, Samsung or Toshiba, which aim to develop the next generation of Internet Protocol television (IPTV) and harmonize diverse standards.[44][45]

[41]Luplow, W. "NGBT: Next-Generation Broadcast Television: Continued Rapid Technical Advances," ; *Consumer Electronics Magazine, IEEE*. April 2012. Last accessed 07/09/2013 at <http://www.nercdtv.org/fobtv2012/index.html>.
[42]"FobTV Home," *FobTV*. Last accessed Oct. 22, 2012. <http://www.nercdtv.org/fobtv2012/index.html>.
[43] "Developing a single global DTT standard," *DigiTAG Webletter*. April 2012. Last accessed on 07/09/2013. <http://www.digitag.org/WebLetters/2012/External-Apr2012.html>.

[44]Realwire. "Oipf and Hbbtv Collaborate on Testing of Common Technologies Crucial to Global Interactive Tv Deployments". September 7, 2012. Last accessed 07/09/2013 at http://www.realwire.com/releases/OIPF-and-HbbTV-collaborate-on-testing-of-common-technologies-crucial-to-global-interactive-TV-deployments.
[45] Lawrence, Ben, & Schierbaum, Thomas "New European Initiative merges Televisinon with the power of the Internet", *HbbTV*. August 27 2009 Last accessed on 07/09/2013 http://www.hbbtv.org/pages/news_events/pdf/HBBTV_PR_Final_20090827.pdf

- Hybrid Broadcast Broadband TV (HbbTV) is a European initiative that aim to harmonize the broadcast and broadband delivery of entertainment.[46]
- ATIS (Alliance for Telecommunications Industry Solutions) created a Cloud Services Forum (CSF) which unveiled in 2012 standards for multicast-based content distribution. It works on interconnection standards across clouds.[47]

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[46]Realwire. "Oipf and Hbbtv Collaborate on Testing of Common Technologies Crucial to Global Interactive Tv Deployments". Last accessed 07/09/2013. http://www.realwire.com/releases/OIPF-and-HbbTV-collaborate-on-testing-of-common-technologies-crucial-to-global-interactive-TV-deployments

[47] ATIS publishes new multicast distribution standard. (2012). Satellite Today, 11(32), n/a. Last accessed 07/09/2013 at http://ezproxy.cul.columbia.edu/login?url=http://search.proquest.com/docview/921496216?accountid=10226