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BREAKING DOWN DIGITAL BARRIERS

When and How ICT Interoperability Drives Innovation

by Urs Gasser *and* John Palfrey

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The Berkman Center for Internet & Society, Harvard University
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EXECUTIVE SUMMARY

Interoperability, like openness, is something that we generally think of as a "good thing" in the context of information and communications technologies (ICTs). One of the reasons why we tend to like interoperability is that we believe it leads to innovation, as well as other positive things like consumer choice, ease of use, and competition.

In this study, we have done a deep-dive on three cases — DRM-protected music, Digital ID, and Mashups in the Web services context — as well as cursory reviews of other narratives with a goal of understanding a range of views on how interoperability comes to pass, what is optimal in terms of interoperability, how interoperability relates to innovation, and how we ought to approach achieving greater interoperability.

Our research suggests that these inclinations about interoperability are on the mark in a general sense, but that the picture is filled with nuance. Interoperability does not mean the same thing in every context. Interoperability is not always good for everyone all the time. And the relationship between interoperability and innovation, while it likely exists in most cases, is extremely hard to prove.

There is no one-size-fits-all way to achieve interoperability in the ICT context. There are a range of approaches that have relative merits depending upon the circumstances: efforts within a single firm to interconnect products or within firms; collaboration between or among two or more firms; standards processes, including open fora and ad hoc cooperation; and a wide range of roles for governments, most of which are ex post rather than ex ante modes of regulation. In various contexts, one or more of these approaches may be the best suited to accomplishing the goal of interoperability and the relevant subsidiary goals (Not surprisingly, European attitudes toward the mode of accomplishing interoperability are quite different from American inclinations.).

Our conclusion is that interoperability generally supports innovation in the ICT context, but that the relationship between the two is highly complex and fact-specific. We conclude also that the best path to interoperability depends greatly upon context and which subsidiary goals matter most, such as prompting further innovation, providing consumer choice or ease of use, and the spurring of competition in the field. We conclude further that the private sector generally ought to lead efforts in interoperability, with the public sector ready either to lend a supportive hand or to determine after the fact whether the market has failed in a way such that state action is the best means of rectifying the problem. In many instances, a blended approach — involving one or more approaches concurrently — may be optimal. We recommend a process solution for considering which approach or approaches makes the most sense in a given context.

We also highlight the issue that sustaining interoperability – not just establishing it in the first instance – is a key place to focus attention. Our case study of mashups points to the concern that the most informal arrangements in the context of Web 2.0 functioning as a kind of operating system may lead to problems in the future if not stabilized in some fashion.

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INTRODUCTION

Interoperability Challenge

Over the past few years of working on the puzzle of interoperability in Internet-related systems, we have spoken to literally hundreds of people. Never once has someone made the case that "interoperability" is a bad thing. And each of those people, when asked, believed that interoperability generally drives innovation in this space. In a paper published in 2005 by the Berkman Center and sponsored by IBM and Oracle, our colleagues argued that interoperability is the first guiding principle of what it means to establish an "open ICT ecosystem."[1] Our initial bias – in favor of interoperability and its connection to innovation – was plain coming into this project, and, more or less, vindicated by what we learned. The picture that emerged from our research, though, was more colored by nuance than we anticipated going into our study. There is much in the way of insight to be gleaned from those nuances.

The innovation made possible by interoperability carries broad benefits for societies that come to foster it. Consumers benefit, to be sure: interoperability leads to innovation that results in technology systems that work together more easily, with less hassle, and ensures that they have more choice when they are making a decision about what to buy or to use. The innovation that comes from this sort of interoperability is good in that it means jobs and higher rates of productivity in many economies around the world. And it is good because it means a more level playing field for competitors to develop yet more innovative things on top of the innovation that came before – it makes for "generative" systems, as Jonathan Zittrain has argued.[2]

The challenge that we take up in this paper, and the accompanying case studies, is to go much deeper into the issue of interoperability in this context and its relationship to innovation. Our goal is to push past the rhetoric about how good interoperability is as a general matter and toward specific values that interoperability brings with it, values that are themselves sound public policy goals. We ask – and seek to answer – hard questions about the kinds of interoperability that lead to the kinds of innovation that societies ought to care about; how these kinds of desirable interoperability is accomplished in the first place; and how it can be maintained over time once it has been achieved.

These are hard questions for a variety of reasons. First, we encountered a wide range of views as to what "interoperability" itself means. It means something quite different to different people, in different industries but even within industries and within firms. Interoperability turns out to be a complex, dynamic concept along a spectrum. There are degrees of interoperability, complex technological issues, complicated economics with stakeholders who often do not have perfectly aligned incentive structures regarding interoperability. The law only amplifies the complexity involved. The law points in various directions and seems to have an ambiguous relation to interoperability.

Objectives, scope and method of the Study

Objectives

We began this project with three main goals. First, we set out to gain a deeper understanding of what might be described as the ICT interoperability ecosystem. We have worked through a high-level overview of different definitions of interoperability in the area of information and communication technologies. We offer a working definition that might be helpful in multi-faceted and multi-stakeholder policy discussions at the intersection of technology,

market dynamics, and law. We sketch the current state of play regarding interoperability based on three case studies (Digital Rights Management, Digital Identity Systems, and the subset of Web services known as mashups). From there, we extract general principles and patterns while we also acknowledge differences among them. The case studies set the stage for mapping and discussing in more general terms the basic drivers and inhibitors of ICT interoperability that we put forward in this White Paper.

The second goal is to address the normative question of what the possible benefits and drawbacks of ICT interoperability are. We place particular emphasis on the relationship between ICT interoperability and innovation, and other ancillary benefits such as competition and consumer choice, in digital environments. Insights derived from the three case studies inform and guide the discussion about the impact of different degrees of interoperability on different types of competition and innovation. We seek also to explore related societal values that may be implicated by these cases and the potential for interoperability. We contrast the potential benefits with the potential drawbacks of ICT interoperability. These possible drawbacks include concerns about security, reliability, homogeneity, privacy, accountability, and in some cases accessibility of digital content, and so forth.

Third, and in many ways the hardest goal, we set out to provide an overview of the different ways in which increased levels of ICT interoperability can be achieved and sustained, map these approaches, and evaluate them based on a number of proposed benchmarks.

Scope

The scope of our study is to understand the dynamics of interoperability in the information and communications technology space, with a particular view toward its relationship to innovation. We have looked at many issue areas in the course of this research, though our focus has primarily been on three areas in detail: DRM, Digital ID systems, and Web Services. Within Web Services, we have dedicated the written case study to the emerging area of mashups. In addition to these focus areas, we also looked closely at (though have not written up as cases here) other issue areas within the ICT arena where interoperability has been a major topic. These secondary areas of interest include the widely publicized matter of document formats for word processing applications and the like; other aspects of the digital media space outside of DRM struggles, such as digital video formats and digital data carriers; eCommunications such as instant messaging and content on mobile devices; and other aspects of the Web services environment, such as content syndication. Based upon these cases, we have extracted general principles from the case studies where we think stable, reliable patterns emerge.

We have adopted a practical orientation with regard to approaches towards ICT interoperability. In each instance, we have explored a wide range of possible options. In our written work here, we have not addressed the most theoretical or remotely possible approaches.

Methodologies

We have adopted multiple methodologies in reaching the conclusions in this study. First, we undertook a number of explorative case studies and three in-depth case studies exploring ICT interoperability in the areas of DRM music distribution, digital ID systems (centralized and user-centric), and Web services. Second, we conducted several dozen in-depth interviews with experts in various disciplines and with various backgrounds over the course of a year and a half. Third, we convened two multi-stakeholder expert workshops, one in Switzerland and another in the

United States. Fourth, we conducted an extensive review of academic literature, policy reports, submissions by ICT companies, industry initiatives, and a series of theoretical frameworks and concepts. Last, we sought to take into account relevant quantitative data, where available. We made a particular effort in this regard in the DRM case study. Given its paucity in most instances, we have drawn our conclusions primarily on the basis of qualitative research.

We have self-consciously conducted this research project as a partnership between scholars at university research centers based in two countries, the United States and Switzerland. We have sought to blend the approaches and insights to be gained from two different perspectives, separated by culture, tradition, and a great deal of land and water. On this topic and many others, the European and American viewpoints start from different places. We have endeavored to blend the two in this work.

1 MAPPING THE INTEROPERABILITY ECOSYSTEM

Definitions of interoperability

Overview of definitions

Neither the extensive review of definitions in the technology, business, policy, and legal literature nor the thorough investigations within our three case studies have revealed a uniform or generally acceptable definition of ICT interoperability. On the one end of the spectrum, we have found definitions that solely focus on technological aspects, while broader frameworks on the other end distinguish and define interoperability very broadly and at various levels, including, for instance, legal and "political" layers. The analysis of many definitions along this spectrum leads to the conclusion that interoperability is a very context-specific concept. Rather than aiming for a single, one-size-fits-all definition, it seems more promising to carefully consider the terms' specific contours in each case up for discussion, but otherwise to operate pragmatically with a rather open working definition.

Importantly, such a pragmatic working definition of interoperability is not limited to a technological understanding of interoperability, because the "human factor" matters a great deal as almost all contributors to this research project have emphasized. Further, a working definition of ICT interoperability should not introduce biases as to how to best achieve interoperability at any given level (e.g. technical, legal, …). Moreover, it should reflect that interoperability, in our view, is not a binary concept, instead encompassing different levels or degrees along a multidimensional spectrum. Finally, a working definition would ideally be permeable for different views and needs of different stakeholders.

Definition of interoperability: stakeholders' views

At the definitional core of the multi-layered and multifaceted concept "ICT interoperability" is what we might describe as the ability to transfer and render useful data and other information across systems (which may include organizations), applications, or components. Throughout our research, this working definition needs to be "enriched" by adding context-specific definitional elements and is given life by the viewpoint of a variety of stakeholders. Typical stakeholders in a digital ICT environment include users, content providers, distributors, platform providers (for

instance, Internet access providers), and vendors of products and services (including but not limited to software and hardware, online social networks, search engines, devices, components, etc.).

As mentioned above, it is important to understand that the working definition needs to be concretized for each context and use case separately. For instance, for Digital ID users, interoperability concretely means being able to sign into one program or web site and having their personal information seamlessly and securely transferred as needed to a variety of merchants and service providers. The recording industry, content providers in the music DRM area, sees interoperability as being able to sell their content securely through a variety of online channels and have it play on many approved devices, not just the iPod or Zune. Web service and mashup platform providers, to take another example addressed in our research, rely on seamless data transmission and easy extension and integration of data sources by users and small developers.

Clearly, various stakeholders often have different perspectives on and divergent incentives with regard to interoperability, ranging from promotion of Internet neutrality (relying on existing open standards as a platform) to negotiating with various online service providers for special features, preferred bandwidth, or access to customers (acting to facilitate large innovators who can afford to pay at the expense of their competitors). In particular, some seek to internalize the benefits it produces, while others want to profit directly or indirectly by enabling others to innovate

With this working definition and its specifications in different research areas in mind, we can now turn over to a rough sketch of the current state of affairs when it comes to ICT interoperability in the DRM-protected music space, the Digital ID ecosystem, and the Web services universe.

State of Play

Overview of three Case Studies

Our research centered on three core case studies. We have based our conclusions upon what we learned in this course of researching these cases, as well as through ancillary cases that we have explored but did not write up in as complete a fashion. The careful reader will discern substantial differences in approach and depth of the three inquiries, which can be attributed in part to the relative maturity of the case material and in part to differences in the mode of research conducted by the two partner institutions.

Case Study #1: DRM-protected Music Distribution (led by University of St. Gallen)

In the DRM case study, we investigated interoperability both in the context of the offline and online distribution of (digital) music and mapped the rather complex interactions among key players in the digital music space, their business incentives, technological challenges, and the changing legal environment. Our stock-taking in the area of offline distribution tracked the music industry's attempts to implement copy control technologies on CDs as a response to the widespread availability of CD burners since 2002, which resulted in lower interoperability for consumers, as many protected CDs did not work on certain devices such as portable and car CD players. Partly in response to consumer complaints, major labels recently announced that they would abstain from using such technology on CDs in certain markets while still employing copy-protection technology in other parts of the world. In the meantime, the lack of interoperability has also been addressed by courts and consumer protection authorities in Europe.

DRM interoperability issues have also emerged in the online music market. While standard setting bodies and industry consortia — as well as in some instances individual companies through liberal licensing practices — have worked towards DRM interoperability, the online music ecosystem is (still) characterized by a relatively low degree of interoperability as a result of business decisions by major players to keep their DRM ecosystems and platforms closed. Most prominently, Apple, as the owner of the market-leading iTunes Store, has generally refused to license its FairPlay DRM system to its competitors. Consequently, its products and music services only support DRM-protected content if it is encoded with Apple's closed DRM system. For example, music purchased from the iTunes Store and protected by its FairPlay technology can only be played on iPods, Apple's own portable music players, but not on competitors' products. Likewise, Microsoft has established a closed ecosystem with the linkage between its portable player Zune and the corresponding online Zune Marketplace by use of a variant of the Windows Media DRM. Arguably, Microsoft revisited its approach to interoperability, as this design of a closed ecosystem contrasts with its previous PlaysForSure initiative which aimed for a high degree of interoperability between devices and services of different players.

More recently, online music services have emerged that allow permanent music downloads in an unprotected format, such as, for instance, Amazon's music store launched in September 2007. Further, some of the major music labels announced that they would make parts of their music catalog available to online stores in an unprotected format for a premium. Arguably, these developments are a response to interoperability concerns voiced by users and illustrate the market dynamics in the field of DRM interoperability – a market that at least in Europe is increasingly shaped by the interventions of courts, consumer protection authorities, and even legislators. Most prominently, for example, the revised French IP Code mandates the disclosure of information necessary to build interoperable DRM systems and applications, and other European countries might follow suit.

Case Study #2: Digital Identity Systems (led by Harvard Law School)

In the Digital Identity case study, we looked at three basic and partly overlapping models currently in use to communicate user identifying information: user-centric, in which the user remains in active control of how her own data is used; federated, in which multiple trusted sources can authenticate and provide information about users (e.g., faculty vs. student vs. staff), potentially without identifying the particular user personally; and centralized, in which one or more sites separately collects and stores personal information from users. There have been and continue to be numerous mutually incompatible attempts at streamlined and effective Digital ID systems, ranging from Microsoft's CardSpace (user-centric) to the open-source Shibboleth (federated) to Google Accounts Authentication (centralized). People in limited contexts can make use of each of these systems, but most sites on the Internet require their own username and password.

In part because interoperability of these various solutions is low at present, there has been relatively little adoption either at the level of online service providers or by individual users. However, there are positive developments. Most major stakeholders have come to the conclusion that interoperability will enable both service providers and individuals to usefully participate in these Digital ID systems, thereby fostering adoption of each of their solutions. The open-source Higgins Trust Framework seeks to enable interconnection among these systems, and the Liberty Alliance, a consortium of major industry players, has committed to open and interoperable standards in the area. Furthermore, Microsoft in particular has contributed to some prominent open-source projects to allow them to inter-

operate with its preferred solutions. Against this background, there appears to be relatively little role for government involvement in this area at the moment. If the corporate and community actors continue to move in a cooperative direction towards interoperability, enhanced benefits of Digital ID and corresponding opportunities for innovation will emerge. However, the technology is not yet mature, the stakeholders have a long way to go to achieve substantial interoperability, and defections or changes of attitude can always derail the current, promising trajectory.

Case Study #3: Web services: Mashups (led by Harvard Law School)

The Web services case study concerned a relatively immature area where widespread interoperability has enabled broad innovation in the form of mashups. Some mashups are complementary to or grafted onto existing business models, others are businesses in and of themselves, and many are made by nonprofits or individuals for the benefit of the public. Those who have produced Web services have by and large been quite open to mashups, often facilitating them through open Application Programming Interfaces (APIs).

Given current market incentives, momentum at present drives toward continued interoperability, but some possible issues lurk in the background. It is on these potential future issues that we have trained our focus. In particular, terms of service and licenses of different Web services may conflict or interact in unfavorable ways, and interoperability in general leaves the door open for spam, phishing, and other applications that undermine privacy and security. Agreement on standards among stakeholders, and in particular standardized license and service contracts, has the potential to mitigate these difficulties. Finally, there is the potential for a more or less strong government role in maintaining interoperability, but authorities must tread carefully to avoid undermining their goals through unduly burdensome regulation.

Learning from Case Studies, Workshops, and Interviews

As we reflect on these case studies and what we heard from the corresponding workshops and interviews, several threads of commonality and difference emerge, as well as a few themes that may apply in analogous circumstances.

- **Interoperability can be achieved by multiple means.** In the case of mashups, for instance, we note that a single firm, Facebook, has thrown open its virtual doors, via an API, and has enabled others to develop more than 5,000 applications, some of which are purpose built, upon its platform. The Facebook API, despite its popularity and the current buzz surrounding it, is dwarfed in terms of the amount of usage by those offered by larger firms such as Google, Amazon, and others. In the case of DRM, both standards bodies and industry consortia have promoted interoperability, while individual firms have played roles both in favor of and against further interoperability. In the case of Digital ID, a heterogeneous set of efforts are underway, some of which are promoting interoperability. There is, in each instance, the possibility of government intervention to force interoperability as well, either before or after certain events take place to prompt such interventions.

- **These means are not equivalent in terms of the interoperability to which they lead. But predictions as to which type of approach will lead to which type of interoperability are hard to make.** There is not an obvious set of lines that connect means of achieving interoperability and specific outcomes. We focus instead on the extent to which the approach to interoperability can affect the likelihood of stable interoperability continuing in the optimal form. The more open, inclusive processes of accomplishing interoperability, once established, are more difficult to disrupt than those processes managed by a single firm, so are more likely to promote stability

of interoperability. This conclusion, though, is derived from discussions with participants who fear a certain outcome, rather than evidence that instability tends to come to pass as a result of a single approach or another.

- **Empirical evidence of the link between interoperability and innovation is elusive, but anecdotal evidence is plentiful.** We set out with a preference to demonstrate the link between interoperability and innovation in the ICT sector through sound economic analysis. We found insufficient data, short of launching a major empirical study, to help support or undercut such an argument. We found no shortage, in each of the case study areas and in our secondary cases, of one-off examples of innovation derived from interoperability to support this linkage. We conclude that this anecdotal evidence, and the absence of much evidence to the contrary, is sufficient to support the claim of a link in general between interoperability and innovation. More specific claims, related to the many IT subfields for instance, would need to be grounded in a careful, case-by-case analysis.

- **Time, maturity of the space, barriers to entry, and complexity of relationships are key factors.** In order to determine which type of approach to take to interoperability in order to maximize innovation, it matters a great deal to what extent the relevant market is mature, where the technologies and usage patterns fall on a time spectrum, and how many players are implicated. In very new settings, such as mashups, the decision of a series of single firms to promote interoperability with their systems may lead to a quick spike in innovation – but this approach may not, over time, continue to be stable enough to ensure that innovation continues, especially if key players decide to participate in rent-seeking behavior. The current state of Web services innovation is to a large extent contingent on the absence of substantial barriers to entry or transaction costs, which are more prominent in Digital ID and especially in DRM. In a more mature setting, such as DRM, where battle lines have been more explicitly drawn and multiple factors are in play, a more complex set of solution may be required to promote innovation. And in a setting such as Digital ID, the existence of an enormous range of relevant players calls for a varied set of approaches to interoperability to achieve higher (if not optimal) levels of innovation.

- **The role of the state is to promote private sectors solutions ex ante and to intervene only in appropriate cases, when markets fail in certain ways.** We found scant evidence that the state is likely to be a key player in prompting interoperability in support of innovation ex ante, other than in support of private sector efforts and by holding out the possibility of intervention in future if individual actors cross legal lines, such as competition laws or intellectual property laws or licenses. This is true largely because technological development is likely to outpace the speed with which government actors can react. However, recent French legal amendments and court cases attempting to correct a perceived market failure have the potential to impact interoperability in DRM. Part of the difficulty in government involvement is trying to define what would constitute a market failure that would invite state action. France's decision that DRM is such an area is controversial; arguably, the United States has taken the opposite approach by allowing few and narrow exceptions to the Digital Millennium Copyright Act's anti-circumvention provisions. It would be problematic to suggest that a market situation in which interoperability is not achieved is a market failure, because as we have concluded, interoperability is not an unqualified good and should not be seen as an end in itself. And trying to analyze whether a particular firm's action has hindered or fostered innovation as such is extremely speculative, given the lack of good quantitative measures of innovation. Most participants in our research process, especially those from industry, argued that the role of the state as either not needed at all or only in the role of a back-stop. We have noted in

the context of the case studies several possible regulatory approaches that may be appropriate in some circumstances. We can only emphasize that any substantial or intrusive government intervention should be considered carefully on a case-by-case basis, because it has the potential to freeze technology, raise costs, or otherwise stifle innovation if used inappropriately.

Forces at Play: Drivers and Inhibitors

Technology

Our three case studies make plain the complexity of ICT interoperability from a technological perspective. Interoperability occurs at a range of levels in the ICT stacks. There is no single technical architecture that invariably leads to interoperability. The digital identity case study, for instance, demonstrates that key players are pursuing at least three types of digital identity systems, each with a distinct structural focus.

Market actors have taken a number of approaches to achieving technological interoperability (as distinct from legal interoperability or market-based partnerships) in the ICT space. The most straightforward one is unilateral openness. For instance, a Web services provider like Facebook or Google voluntarily creates an open API that allows many others to interoperate with their services without the need for further approval or cooperation. The opposite approach is reverse engineering, as when RealNetworks through their Harmony technology attempted to make its DRM scheme compatible with the iPod over Apple's vigorous objections. Somewhere in the middle is widespread intellectual property licensing, which Microsoft has done with their PlaysForSure initiative in licensing Windows Media DRM to several online music stores. These approaches to technical interoperability have the advantage of time to market and the ability to make improvements in technology systems without a great deal of coordination among many firms. Such relatively informal approaches differ from more formal approaches, such as the development of open standards. As we discuss further below and in the individual case studies, open standards develop far more slowly and take far more coordination than these unilateral or bilateral approaches, but present the opportunity for greater interoperable ecosystem sustainability.

The contrasting experiences from attempts to create open standards in DRM and Digital ID are illustrative. In DRM, some stakeholders have created a Rights Expression Language (REL) that is open to all, namely ODRL. However, neither Apple nor Microsoft has endorsed this standard, and it also faces a patent infringement suit brought by the creators of a proprietary competitor, XrML. While creating an open standard can facilitate interoperability, it will only do so if market positions and the legal background induce the relevant stakeholders to use it. In Digital ID, on the other hand, the SAML standard has been widely adopted by many parties, and additional standards from the Higgins Trust Framework and the Liberty Alliance show great promise for allowing different Digital ID solutions to interoperate seamlessly.

Market incentives

Our research has confirmed our working hypothesis that many of the companies that have a stake in ICT technologies operate on marketplaces with strong network effects. Companies like Apple, Microsoft, or Facebook, to name just three, face the challenge of developing and adjusting their respective competitive strategies over time in order to profit from network externalities. The strategic choices of these companies, as our research suggests, have a profound impact on the question of whether the particular firm contributes towards higher degrees of ICT interoperability or not.

In the DRM music case study, for instance, we illustrated how Apple has come up with an innovative piece of technology (iPod) and a technology-based service (iTunes Store) for online music distribution and consumption that has offered users substantial advantages over existing systems. Apple evidently believed that it was strong enough to create a sufficiently large network on its own. Consequently, Apple chose to market a non-interoperable technology over which it has retained strong proprietary control, thus contributing to a low level of interoperability on the online music market. Microsoft, in contrast, at least originally applied a different strategy by offering a proprietary technology (Windows Media DRM), but worked together with allies (PlaysForSure initiative) to make the network larger and to profit in this way from positive feedback and network effects.

Similarly, the Digital ID case study has revealed that the incentives of ID solutions providers to aim for an interoperable infrastructure might change from case to case based, in part, on a company's respective market position. Currently, however, our study suggests that several of the key players are similarly positioned as far as the ID market is concerned, thus sharing a strategic interest in a larger total market on the one hand and an agreed set of specifications on the other hand. Initiatives like Higgins or, to a lesser extent, Microsoft's CardSpace indicate that we are likely to move away from competition *for* the market to competition *within* the market, with increasingly reliance on common ID standards.

Strong network effects also characterize the Web services market. In the Mashup case study, we used the example of Google Docs to illustrate how Google's strategy regarding the degree of openness of its APIs may change over time depending on the development of its market position relative to its competitor Microsoft. Similarly, once Google lost the bidding war for a partnership with Facebook to Microsoft, it launched its OpenSocial API with every major social networking player *except* Facebook, thus seemingly leading to two rival camps of social network APIs. Had Facebook made a different choice, there would have been a greater chance of a universal social network API according to some observers, although Google's incentives would have been changed by an alliance with Facebook. In any event, the layout of the market landscape in these cases has a significant impact on the technical interoperability that results. A market player may initially be interested in making its API more readily available to enlarge its market control or increase the branding of its name. A well-established firm, in contrast, has fewer incentives to support other players in a similar manner.

From these and several other examples, we conclude that the basic incentive structure on markets with network effects does not necessarily or automatically lead towards higher levels of ICT interoperability among organizations, systems, or components. Rather, the individual companies' competitive strategies vis-à-vis the positive feedback effects on network markets are critical in that respect. The question of what competitive strategy is adopted, in turn, largely depends on firm-specific factors such as current market position, technological capabilities, and IP portfolio, among others. These are largely dynamic factors that often call for an adjustment of strategy over time, which might in turn also change the firm's attitude towards interoperability between its products or services and those of its competitors and — in some instances – even those of its former allies. Consequently, network market dynamics may play either way in favor or against higher levels of ICT interoperability.

Role of law

The state of play regarding interoperability in the case studies we have examined is not only the result of technological development and market forces, but is also shaped by the legal and regulatory system. Our research indicates that general laws such as competition law, consumer protection law, contract law, or tort law on the one hand and legal provisions that specifically address interoperability issues on the other hand have an impact on the ICT interoperability landscape. Specific laws have been identified in the context of DRM-protected music interoperability in particular, where the French IP Code mandates the disclosure of interoperability information to competitors under certain conditions. The reverse-engineering provisions aimed at enabling interoperation between components represent another example of this type of "specific" legislation.

At a more granular level, our case studies have demonstrated that especially general laws might work bi-directionally in the sense that the same body of law can either be used to achieve higher levels of interoperability or to hinder it. Intellectual property law is illustrative in this regard. In the mashup context, for instance, we discussed that poorly scrutinized and rather opaque software patents may impede the progress of mashups, since it is increasingly difficult for web service developers to predict the potentially devastating liability risks for patent infringements. The use of patent law to hinder — or at least increase the expense of — the development of interoperable technology was also observed in the DRM case study (ContentGuard controversy). In contrast, IP licensing by single companies, in bilateral co-operation, or in multi-player settings, are important forms of private coordination in which IP law has been used to contribute to higher levels of interoperability as we have documented in the case studies and learned from conversations with various stakeholders.

Two other themes that have emerged across the areas we have studied are worth noting here. First, legal uncertainty may inhibit ICT interoperability. In the Digital ID study, for instance, we noted that uncertainty with regard to the liability exposure of the involved players may have had a chilling effect on the establishment of an interoperable Digital ID ecosystem. Further, legal uncertainty regarding liability for copyright and patent infringement plays a significant role in both the mashup and DRM context, as previously noted. Second, the use of law as a force to create a level playing field may become increasingly relevant, especially in the European context. Competition law arguments, for instance, have been made on both sides of the Atlantic — with varying success — to force dominant players to allow interoperation with their products. Consumer protection law is also increasingly "en vogue" to tip the balance in favor of ICT interoperability.

From a broader perspective, we conclude from our findings that a truly market-based approach to ICT interoperability, as often advocated by industry representatives, represents more a strictly rhetorical move rather than a fact-based argument. While there is no truly blank slate in that sense, our research also suggests that no coherent legal approach to interoperability has emerged. Where specific legislation has been enacted, it can arguably be seen as an ad-hoc response to highly-visible interoperability cases like, for instance, Apple's exclusive link between the iPod and the iTunes Store. This type of ad-hoc intervention deserves particularly careful consideration since it tends to be driven by political interests rather than a thorough examination of the complex interoperability issues at stake or a cost-benefit-analysis of the envisioned government intervention.

2 ASSESSING ICT INTEROPERABILITY

Potential Benefits

Interoperability is not an end in itself. Society benefits from interoperability because it is, much of the time, an effective means to others ends. One such policy goal that has been at the core of our research initiative is innovation. As discussed in the next section, we conclude from our analyses and conversations that increased levels of ICT interoperability generally foster innovation. But interoperability also contributes to other socially desirable outcomes. In our three case studies, we have studied its positive impact on consumer choice, ease of use, access to content, and diversity, among other things. The following paragraphs provide a brief overview of our findings.

Innovation

At a general level, two straightforward examples illustrate how interoperable systems in the ICT space can lead – and, in fact, have led – to massive amounts of innovation. The first one is *the Internet* as such, which can be seen as the ultimate interoperable design to which more and more non-interoperable networks and systems have converged. The second example is *e-mail*, *the* killer application of the early Internet. Neither e-mail protocols nor the concept of e-mail were restricted to a limited set of players, and their designs were broadly interoperable. The results are extraordinary in each instance. (Of course, the productivity gains and widespread innovation were accompanied by the downsides of interoperability – worms, viruses, spam, and other unwanted activity that many parties have tried to control with limited success.)

With these two compelling narratives in mind, we tried to explore in greater detail, using more specific examples, whether or not interoperability fosters innovation – and if so in what ways. In each of our case studies, we conclude, largely based on qualitative analysis and anecdotal evidence, that interoperability is likely, though not certain, to drive increased innovation. We have not found, however, empirical proof of a causal relationship between interoperability and innovation in these three areas, partly due to a lack of data on this question.

Three frameworks might be helpful to better understand how higher levels of ICT interoperability might result in increased innovation.

- One model of innovation is presented in Jonathan Zittrain's article, "The Generative Internet." In tracing the Internet's evolution and developing the concept of the generativity, our colleague documents the importance of having ICT platforms that remain open and permit the various users of the infrastructure to make creative developments on top of it. He defines generativity as a central feature of the existing Internet and, more generally, as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences."[3] To the extent that interoperability is not only a feature, but also a prerequisite of an open ICT ecosystem as we noted in the outset of this report, it contributes to the generative power described by Prof. Zittrain. We've seen several examples for this type of innovation in the context of our Digital ID case study, where an interoperable ID infrastructure is expected to enable new types of Web services-based systems that require seamless authentication and payment.

- A second, related model of innovation may be seen in the work of Eric von Hippel. Von Hippel examines "horizontal innovation networks" where innovation occurs not within a traditional firm but is carried out by users of the product. Von Hippel maintains that it is possible that innovation may be sustained by users alone where «(1) at least some users have sufficient incentive to innovate, (2) at least some users have an incentive to voluntarily reveal their innovations, and (3) diffusion of innovations by users is low cost and can compete with commercial production and distribution.»[4] One example of such innovation in the area of our case studies is the social networking site Facebook. Since it opened itself up to outside applications, it has attracted more than 5,000 of them, with about 100 more added each day on average, as discussed in the Mashup case study. Another example is Yahoo Pipes, which provides a community space where programmers can mix, match and share mash-up code.

- A third model of innovation that is relevant in the context of our research consists of incremental improvement on an existing product. This model, discussed for instance by Clayton Christensen, consists of incremental improvement on an existing product or service. This type of innovation builds largely upon prior knowledge and resources, and leverages existing competences. The technological changes involved in incremental innovations – as opposed to radical ones – are rather modest. By increasing the level of interoperability, the range of potential improvements gets broader because more systems, components, or applications can be combined to make improvements on ICT-relevant products or services. In our research, we have seen several examples of this type of innovation. An illustrative one was featured in the Digital ID case study, where we described how a call from a GPS-enabled mobile phone to a taxi company could automatically provide location and payment information (while such a service necessitates secure transfer of trusted information).[5]

Our case studies provide many examples of innovations that can be explained based on the three theories outlined above. However, we also acknowledge the argument that higher levels of interoperability may negatively affect certain *types* of innovation. Such a situation might occur, for instance, where a successfully interoperable system — by unleashing network effects — leads to very high switching costs for consumers, thereby potentially diminishing developers' incentives to invest in an entirely new technology, i.e., a *radical* innovation that would seek to replace the old one. Under such a scenario, innovators might only focus on incremental change of existing interoperable systems and thus foreclose opportunities for radical innovations — even if the alternative system would be superior. This effect might also help explain why, in certain situations, companies that originally disfavored interoperability

change their strategy when the market grows too large for them to satisfy: they may seek to prevent radical innovations by way of punctually increasing the level of interoperability among existing pieces of technology. While we have not been able to identify such a scenario in our case studies, negative "net effects" of interoperability on radical innovations have been observed in other parts of the ICT environment.

In conclusion, we've found many instances in which a higher degree of ICT interoperability has led to innovation and identified theoretical concepts that help to understand the positive relation between the two phenomena. At least with regard to evolutionary or incremental innovations, we have identified three theoretical concepts that help to understand the positive relation between the two phenomena. Whether or not high levels of interoperability usually also stimulate radical ICT innovations, however, remains questionable and subject to further research.

Competition

In our case studies – particularly in the DRM-protected Music report – we have also addressed the interactions among interoperability, competition, and innovation. Based on standard economic analysis, we concluded that increased interoperability is likely to foster innovation by reducing lock-in effects and lowering entry barriers. Interoperable ID systems, for instance, allow Internet users to switch between different ID providers, but also to choose more freely among businesses engaged in e-commerce (e.g. online travel agency), thus enhancing competition among them. Enhanced competition benefits users by reducing prices and by providing incentives for product and service innovation. Along similar lines, our DRM-protected Music study illustrates how higher levels of DRM interoperability might lead to a greater consumer base and, ultimately, induce new players to enter the market with innovative products and services on the one hand and motivate incumbent companies to improve their market position through product differentiation.

Interoperability does not, however, always lead to more competition. Interoperability could, counter-intuitively, lead to anticompetitive situations. For instance, certain unilateral or bilateral arrangements by firms that lead to interoperability and to greater innovation may promote a single firm or a few firms in a manner that is, over time, anticompetitive. We have noted this possibility most clearly in the context of the Mashups case study, as a prospective worry rather than as a certainty. The same holds true for standards consortiums that may manipulate the standard-setting process to achieve anticompetitive ends – although we have not identified an immediate risk in the three areas we covered.

Even in the general case where more interoperability leads to competition in the market this doesn't mean that the net effect is maximum innovation. According to one strand of economic theory, firms may have an even stronger incentive to be innovative in circumstances where low levels of interoperability would promise higher or even monopoly profits to successful competitors. As discussed in the DRM-protected Music report, this sort of (Schumpetrian) competition for the market sets incentives to come up with entirely new generations of technologies or ways of doing business (so-called "leapfrog competition") in order to replace incumbent players and achieve temporary dominance. Apple's strategy on the online music market might be seen as a case-in-point of this sort of competition for the market as a whole rather than for a share of it.

Based on a qualitative analysis, we conclude that a high level of ICT interoperability generally stimulates competition, which in turn fosters innovation in this space. Taking seriously economic theories that differentiate between

competition in the market versus competition for the market, we have not found concrete indicators in our case studies that would strongly support the argument that lower levels of interoperability lead to leapfrog innovation. However, due to the lack of empirical research in this specific area, one has to interpret these results cautiously and take them as tentative findings.

Autonomy, Flexibility, and Choice

We conclude that increased levels of interoperability in almost all circumstances we have explored tend to enhance user choice and autonomy. In interoperable ecosystems, users are more likely to choose among competitive and efficient options with regard to systems, applications, components, etc. that may be tested, mixed, and matched for specific purposes. For instance, an interoperable DRM music system would allow users to purchase music from their preferred online store and play it on any portable device they might own. An interoperable Digital ID infrastructure would ultimately allow users to switch hassle-free from one e-commerce platform to another, or to move from one virtual world to another. The Web services case study, too, is full of examples of enhanced user autonomy; again, one might refer to the ability to create its own applications and plug-ins where APIs are opened up.

Not only users, but also other stakeholders, may have greater freedom to make choices when the level of interoperability increases. Consider, for instance, content providers in the online music business that may run the risk of being locked into a gatekeeper-like distribution channel where an online music distributor builds up a dominant market position based on a non-interoperable DRM system. Or consider, for instance, the benefits of interoperable Digital ID systems for community-driven Web 2.0 companies.

Access, Diversity, and Openness

As we pointed out in the DRM-protected Music study, increased levels of interoperability are likely to reduce access barriers to digital content. Along the same lines, an interoperable Digital ID infrastructure is expected to increase access to online services of various sorts, including e-commerce platforms.

Our research also suggests a positive relation between interoperability and "diversity." Particularly powerful illustrations can be found in the Mashup case study, where we documented how open APIs have led to an unprecedented variety of applications. To the extent that interoperability contributes to the generative power of the Internet as described earlier in this section, we can expect diversity not only at the logical, but across all layers, including the content layer. The emergence of niche markets that serve the long tail as discussed in the DRM space is an illustration in this context.

Finally, interoperability is a crucial building block of an open ICT ecosystem that, if properly developed and maintained, is believed to foster innovation and growth. While interoperability is also possible within a closed system, the Web Services infrastructure and an interoperable Digital ID system are key components of such an open environment with the advantages outlined in the report of our colleagues that we have mentioned above.

Potential Drawbacks

Interoperability is not an unalloyed good. In certain instances, greater interoperability brings with it possible drawbacks. Our research has led us to conclude that these problems tend to be highly fact-specific and are often not

problems related to interoperability *per se*, but rather are related to what people do with the systems once they are made to interoperate.

Security

We encountered certain threat models in our three case studies associated with security risk in highly interoperable systems. The extent of these threats and their precise relationship to interoperability are unclear in most cases. Plainly, a system that has more points of open access to data, in the simplest formulation, might lead to the ability of more people to access these data or to inject bad code.

This security concern is not precisely a problem with interoperability, nor is it insurmountable. The fact that the systems can interoperate does not *per se* mean that more people have access to underlying data in a given system. It is theoretically possible that increased interoperability as between systems could lead to further vulnerability of the different components or systems if sound security measures are not taken. It is also the case that there are high security risks associated with systems that are not at all interoperable.

Privacy

The possibility, in certain situations, that interoperability might reduce individual privacy is among the most commonly voiced concerns about interoperability. It is true, on a simplistic level, that increased levels of interoperability may increase the number of players who could plausibly have access to personal information exchanged via an interoperable system. Each of our case studies – DRM-protected Music, Digital ID and mashups – involved fact patterns that suggest this might be the case. The digital identity context is the most obvious setting in which interoperability might lead to less user privacy: if technical and user controls are not well-established, the fact that an identification by a certain ID provider may be relied on by various other parties increases the risk of one of them misusing that data. In the DRM context, it has been argued that an interoperable standard may allow anyone who knows (or is able to discover) the standard to collect sensible usage data across platforms and applications. In both cases, the higher risk of technical failure is a consequence of the before-mentioned increased complexity of an interoperable framework. Against that backdrop, it becomes clear that it is not precisely interoperability per se that gives rise to increased privacy risks, but rather the specificities of its implementation. Even if one assumes that a technically waterproof interoperable solution cannot be achieved – an assumption on which commentators disagree — one can imagine organizational or legal tools, such as (European) privacy regulation, successfully addressing respective privacy concerns.

Homogeneity

Interoperability might lead to less diversity in innovation in the ICT space. A single platform, with which many systems interact, might become a de facto standard in such a way as to lead not to more kinds of innovation, but innovation constrained to what is possible on or within that platform. As with possible concerns related to security and privacy, it is not the interoperability per se that would lead to this homogeneity, but rather the conditions that might flow from the extent to which parties avail themselves of the interoperability. This concern was not borne out by the examples we studied closely, though we flag it as a possible drawback of promoting interoperability.

Reliability

Increased complexity of ICT systems may lead to decreased reliability. This possible drawback depends heavily on the approach taken towards interoperability. As systems grow in complexity, in ways that are driven by interoperability, flaws in these systems might be difficult to fix quickly. In some instances, flaws in one system, on which other systems have come to rely, may not be resolvable at all by the relying party. This problem might affect consumers, too, who find that they cannot call a single player to get a problem fixed, but rather need to call upon more than one. Consider the person who bought hardware from one vendor and software from another and Internet access from a third: she might well get bounced around from call center to call center as she seeks to solve a problem related to a service that relies upon all three working together. As systems that interoperate scale, the level of complexity may continue to rise.

This is one area where an open standards approach to interoperability holds out the most promise. In complex, interoperating systems, we ought to seek a means whereby problems can be solved by firms and for consumers as seamlessly as possible, without always having to come back to a single firm to fix an underlying problem. Open standards could mitigate, though not outright solve, this issue, insofar as problems might be solved collaboratively, with multiple stakeholders holding the right to a seat at the relevant table.

Accountability

The achievement of interoperability in the ICT space is often accompanied by an increase of complexity in the relations among private actors, especially in the context of industry-driven interoperability initiatives. Against this backdrop, the question of responsibilities and liabilities calls for increased scrutiny. In the identity context, for example, one can imagine a scenario in which the identification of a user is misused by a third relying party with whom the user has no contractual relationship. In such a scenario, the rights of the user with respect to the third party might be adversely affected. However, the example reveals that these concerns, again, are less a consequence of interoperability *per se* than of a concrete implementation, and that one might assume that careful contractual drafting (in this example: between the user and the identity provider) should avoid unintended and unnecessary liability exposure.

Accessibility

Looking at the aforementioned risks of decreased reliability and security in case of interoperability in the ICT space, concerns have been voiced that such developments could induce different players to withdraw from the online environment as such. In the DRM context, for instance, it was argued that content providers might decide to begin preventing access to their content if interoperability poses higher security risks than non-interoperable solutions (unless the distributor allays security concerns with its own guarantee). In that event, accessibility of content would decrease and the efficiency gains of online distribution (as compared to physical distribution) could not be realized.

Business models

Achieving interoperability, especially by pursuing government-led top-down approaches, adversely affects business models that are built upon the lock-in of customers. In this context, it has been argued with regard to DRM that a forced opening of Apple's FairPlay ecosystem to other parties would eliminate a fundamental characteristic of its business model and deprive the company of the expected rewards of previous investments. While especially incum-

bent players may therefore perceive (forced) interoperability categorically as a bad thing or may be obliged to change their business model, it is far from clear that the overall consequences of such an action are indeed worrisome, as we pointed out above.

Conclusion: Interoperability is a Sound Policy Goal

The benefits of interoperability in the ICT setting far outweigh its potential drawbacks in most situations. The drawbacks are more theoretical than they are certain to come to pass, whereas the innovation and other benefits of interoperability are obvious in this context. We conclude that interoperability is generally a sound public policy goal on the basis of this connection to enhanced innovation, among other salutary effects.

In each of the three case studies we have examined in detail, we have observed innovation that corresponds to increased levels of interoperability in digital environments. It is important to note that innovation can also occur where the level of interoperability is low, such as in the case of DRM, where we point to the innovations prompted by and within iTunes and associated technologies. As such, we find that interoperability can be, and often is, a driver of innovation, but interoperability is not a necessary condition for all kinds of innovation. It is also the case that there are kinds of innovation that cannot occur without interoperability.

Despite anecdotal evidence from our case studies that higher degrees of interoperability foster innovation, we have found no reliable empirical evidence that would support a general conclusion in favor of interoperability. From a theoretical viewpoint, interoperability can work in different directions (e.g. Schumpeterian competition argument). As such, we refrain from arguing that interoperability should be pursued as a matter of public policy in all cases. We instead recommend a case-by-case analysis to determine whether and how to achieve an optimal level of interoperability.

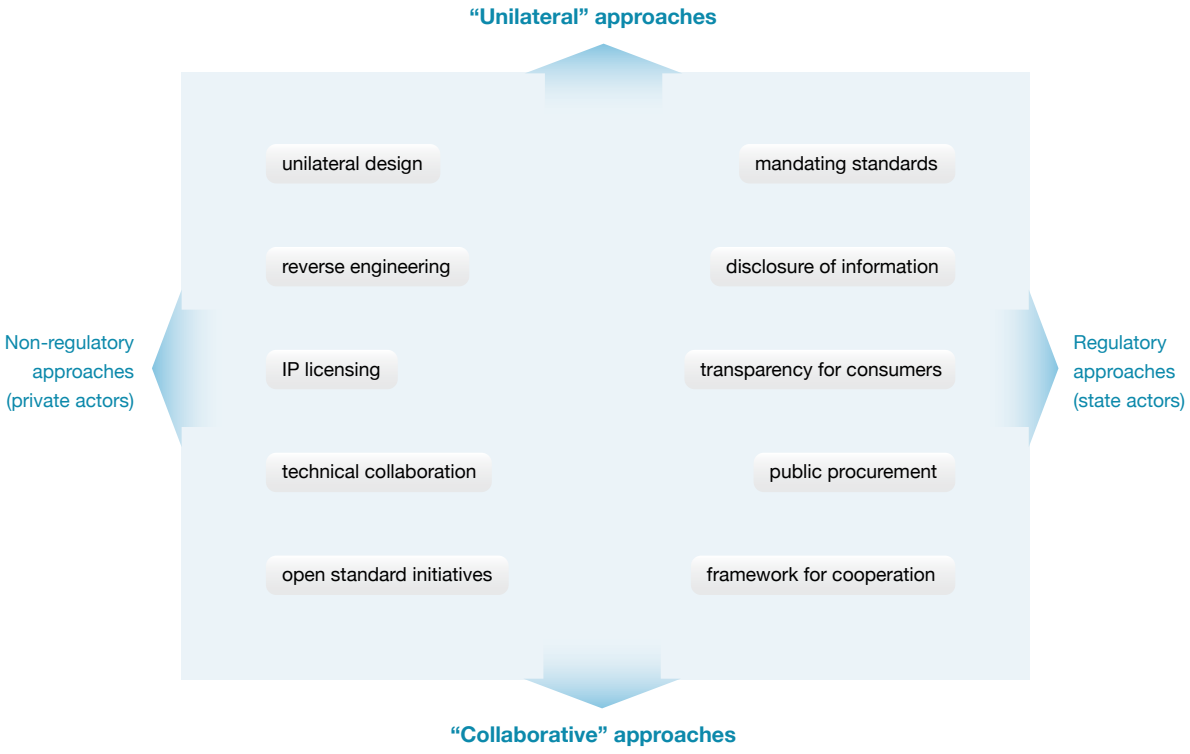
Our conclusion that the promotion of ICT interoperability is more often than not a sound policy objective is grounded in strong normative arguments. These normative arguments derive from the frequent correlation between interoperability and innovation, as well as competition, consumer choice, and ease of use. As such, interoperability should be promoted, where efficient to do so, not for its own sake, but because it tends to lead to other public benefits in the digital age.

3 APPROACHES TOWARDS ICT INTEROPERABILITY

Basic Framework

Overview of Approaches

One of the insights offered by this research project is that there exist a variety of approaches to interoperability. We have explored a number of relevant strategies and tools that can be used to work towards a more interoperable ecosystem. We have roughly distinguished between approaches taken by private actors on the one hand and an arsenal of interventions available to governments on the other hand. We will discuss particularly important approaches in the next section, but the following overview might give a sense of the broad spectrum of approaches, which range from "unilateral" to "collaborative" and are discussed in greater detail in our case studies.



Mapping the Approaches

We have not only explored the different ways in which higher levels of interoperability can be achieved prospectively, but also investigated what types of approaches have been used in the three topic areas of our case studies. The baseline is that usually more than one approach has been pursued with emphasis on private actor strategies, ranging from single firm design of interoperable products and services to collaborative efforts like standard setting. We refer to the accompanying case studies for a more detailed analysis, while predominant approaches and relevant contextual features can be roughly outlined as follows.

	DRM	Digital ID	Mashups
Level of Interoperability	Low	Low but increasing	High
Primary Approach	Single firm (Apple, Zune), as well as broad licensing (PlaysForSure)	Single firm (MS, Google), as well as open standards (OASIS, Liberty)	Single firm (open APIs), as well as open standards (XML, SOAP)
Technological Maturity	High	Moderate	Low
Influence of Consumers	Low but possibly increasing (consider the record labels selling MP3s without DRM protections)	Moderate (major focus on consumers, but few consumers part of the discussion)	High (many mashups created by individual consumers)
Level of Government Involvement	Moderate/High (DMCA, EUCD, DADVSI, etc.)	Very low (maybe European privacy regulations, not much else)	Nonexistent
Ties to Related Markets/ Existence of Entrenched Incumbents	High – integral relationship with music industry, especially online music stores and physical music players	Low – some tie-ins with other products (GMail, Hotmail) but mostly with “e-commerce” in general	Low – few barriers to entry, no dominant players

Benchmarks

Each of the approaches that we have identified in our research – several more might be added – has its own features, including strengths and weaknesses or, in more economic terms, associated costs and benefits. One of the particularly tricky tasks is to evaluate them from a policy-oriented perspective and in an unbiased and balanced manner. In the three case studies we have explored different paths to assess the pros and cons of the various approaches, acknowledging the above-mentioned context-specific nature of the interoperability challenge. On an abstract level, we suggest the following three benchmarks, which need to be given life in each context and might be supplemented by context-specific evaluation criteria.

- **Effectiveness**: Each approach mapped above is likely to result in different levels of ICT interoperability and can be expected to play a distinct role in maintaining an interoperable ecosystem. The suggested effectiveness criterion evaluates the respective contributions and compares the available approaches that are considered in a given situation. Understanding interoperability as a means and not an end in itself, the evaluation of an approach's effectiveness would also consider to what degree the respective strategy tends to enhance competition in the market, foster innovation, or contribute to other policy goals such as consumer autonomy and choice. To be effective, a solution must also provide interoperability over time, not just in the first instance.

- **Efficiency**: In several instances, most prominently in the DRM and Digital ID space, we have seen that achieving and maintaining a certain level of interoperability comes with costs. The efficiency criterion seeks to measure the level of costs imposed on an affected player – companies, but also users and governments, among other stakeholders – for a given degree of interoperability and compare it with other means to achieve interoperability that are available. The costs of unintended consequences (some of them addressed in this paper under the heading "drawbacks of interoperability") also need to be taken into account.

- **Flexibility**: The ICT environment is a quicksilver technological environment characterized by a rapid rate of change. In order to be successful, a given approach to interoperability needs to be able to take into account important factual circumstances that characterize the environment in which it operates. Examples are the market's maturity, product and service maturity, the features of current and future business models, the needs of users, etc. Looking forward, it is particularly important that the approach is responsive to technological development to avoid technological lock-in.

Depending on the context of application, the three benchmarks might have different relevance or weight. One might imagine scenarios, for example, where interoperability serves such an important goal (consider, e.g., emergency number compatibility) that flexibility – at least in the short run – is considered to be less important than a high degree of effectiveness in the immediate term. In other instances like DRM, one might be badly advised to impose governmental standards given their relatively high costs and poor flexibility, despite the approach's potential effectiveness (see DRM-protected Music report).

Discussion of Selected Approaches based on Case Studies

Approaches by private actors

Most of the private actors' approaches towards interoperability outlined above are based on access to technology or technical specifications, and involve the licensing of IP rights or other contractual agreements (the most prominent exception being reverse engineering). Against this backdrop, our case studies have underscored the critical role that IP and IP incentive systems play in enabling interoperability in some contexts, while acknowledging IP law's bidirectional effects as discussed above. However, the degree of co-operation among different players and the corresponding licensing terms may vary considerably from case to case. The following paragraphs sketch three clusters of approaches to interoperability that are characterized by an increasing degree of co-operation.

- **Unilateral design and IP licensing**: We subsume under this first cluster all approaches that are marked by a comparatively low degree of collaboration between the two parties achieving interoperability. Unilateral design occurs when a market participant designs its products or services in a way that allows other players to offer interoperable products or services. In practice, IP licensing is particularly important, where interoperability is achieved by granting the contracting party access to technology, its specifications, and rights associated with its use. The range of possibilities in this cluster of rather "unilateral" approaches is still considerably broad: We have examined, in the context of mashups, companies making their APIs available to other parties in order to allow them to build interoperable services. In the DRM context, to take another example, Microsoft's PlaysFor-Sure initiative was shaped by its making the Windows Media DRM available to different online stores and device manufacturers.
  The effectiveness of a licensing approach to interoperability not only depends on the company's willingness to grant a license in the first place, but also to the concrete licensing agreement. The scope of and compensation for the license play a particularly important role. Generally speaking, IP licensing tends to be a cost-efficient way towards higher degrees of ICT interoperability, especially in cases where transaction costs are minimized by way of sophisticated and "streamlined" licensing procedures. As to its flexibility, the context-sensitivity of the licensing approach is high, as both parties of an agreement will carefully evaluate the characteristics of the concerned ecosystem. Also, IP licensing tends to be open to the development and adaptation of future technologies. The degrees of flexibility, however, may decrease with the widespread adaptation of a certain technology.

- **Technical collaboration**: Technical collaboration usually involves some form of IP licensing, but is often characterized by a degree of co-operation that goes beyond the mere granting of IP licenses. Often, technical collaboration is an approach to interoperability used by companies at different levels of the value chain that try to improve the user's experience of their respective customers by enlarging their usage possibilities. In the past, we have seen significant deals that fall within this category. For example, in the area of DRM, Microsoft and Nokia established a bridge between Microsoft's Windows Media DRM and the OMA DRM for wireless devices in 2005 that allows users to play certain DRM-protected music on their phones, PCs, and other devices supporting the Windows Media DRM-system.
  Technical collaboration shares many of the advantages of IP licensing. In our case studies, it has appeared to be a rather effective, efficient, and flexible approach towards increased levels of interoperability. However, one might also imagine scenarios under which the approach's advantages decline, for instance due to increasing

coordination and monitoring costs if the number of collaborators reaches a certain limit. Like other approaches, technical collaboration can also be misused to achieve anti-competitive ends that might not be aligned with the goal of an increased overall level of interoperability.

- **Open Standards**: Standards are generally characterized as a collaborative approach towards higher levels of ICT interoperability. Our case studies have mentioned several standard-setting initiatives in their respective contexts. One subset of standards are open standards — an approach to interoperability that has gained much attention in recent times, while its exact definition remains a subject of controversy as we mentioned in the DRM case study. In one interpretation, open standards require that (a) they are approved by formalized committees that are open to participation by all parties and operate on continuous bases, and (b) are made accessible to the public free of charge. Open standards have recently become the center of a heated debate in the context of open document formats like Open XML. Other examples examined in the case studies include the Open Digital Rights Language (ODRL) in the DRM context, and the technological standards XML and SOAP in the mash-up context.

  Open standards have a great potential for achieving high degrees of ICT interoperability. However, this approach also has limited overall effectiveness. Open standard initiatives are a purely voluntary effort, and anecdotal evidence suggests that companies with patent portfolios might easily interfere or even block such initiatives. Further, standard-setting processes are in many cases complex, time-consuming, and relatively expensive when compared to unilateral or bilateral approaches; arguably, their cost efficiency is therefore comparatively low. With regard to flexibility, open standards — given their voluntary, multi-party, and market-driven character — regularly take into account the characteristics of the specific environment in which they are intended to operate. However, an open standard is also by definition a snapshot of the state of the art at a particular point in time that might have a "freezing effect" and hinder the adoption of technological developments.

Regulation-based approaches

As noted, we have also explored a range of approaches to enhance ICT interoperability that might be pursued by governments. They vary significantly with regard to the degree of specificity in which they address the interoperability challenge. On one end of the spectrum are approaches such as mandating standards or requiring the disclosure of interoperability information that are obviously very specific in nature. On the other end are more generic interventions like those aimed at increasing transparency or competition. Our research suggests that particularly careful consideration is needed when it comes to the former type of interventions, while the application of general laws and doctrines is much less problematic. The regulation-based approaches we considered in our case studies include the following ones:

- **Mandating standards:** Governments may decide to mandate the adoption of an interoperable standard on the part of industry players and choose among different forms along a spectrum: On the one end, the government might unilaterally determine the standard, on the other end, the government might merely set a timetable for industry players and require them to establish and implement a common standard. Between the two extremes, all manner of hybrid approaches are possible. Homeland Security Presidential Directive HSPD-12 — establishing a "mandatory, Government-wide standard for secure and reliable forms of identification issued by the Federal Government to its employees and contractors" — represents one example of such an approach as discussed in the area of Digital ID.[6] Further examples of government mandated standards for interoperability

include, as discussed in the DRM case study, the U.S. Federal Communications Commission's adoption of standards developed by the Advanced Television Systems Committee for implementation in digital television, or the British e-Government Unit of the Cabinet Office's that development of an e-Government Interoperability Framework.

The effectiveness of this type of approach to interoperability is usually very high. A government-mandated standard can even establish an interoperable system in cases where industry players are unwilling to do so, whatever their motives might be. Regarding the criteria "efficiency" and "flexibility", by contrast, the government-mandated approach is likely to perform poorly: Administrating, monitoring, and eventually enforcing a standard tends to cause considerable costs. Further, a traditional government-mandated approach usually leaves very little flexibility. Not only are governments generally ill-equipped to choose the most suitable standard, but also tend to operate under conditions that make it difficult to respond in due time to market developments or changes in technology.

- **Disclosure of interoperability information** (compulsory licensing): Another regulatory approach towards interoperability consists of the government mandating the disclosure of information that is essential to build interoperable systems, components, and applications. The terms of such a regime may differ along several dimensions, for instance with regard to the group of people entitled to ask for such information, the possible consideration for the disclosing party, compensation, or the sanctions for non-disclosure. In practical terms, the regulation may be implemented by way of a compulsory licensing of IP rights. This approach has most prominently been followed by the French legislature in the area of DRM with its modifications to the French IP Code in 2006. According to the French legislation, software publishers, manufacturers of technical systems, and service providers may contact a newly created regulatory body to request the disclosure of interoperability information.

  The merits of this approach depend largely on its concrete implementation, i.e., the particular design of the relevant disclosure rules. As to the effectiveness, for example, a direct relationship is likely to exist between the amount (and characteristics) of information to be disclosed, the number of parties granted access to the disclosure, and the level of interoperability that may be achieved. Similarly, the efficiency of such rules depends on their specificities. Taking the French regulatory authority that administers the disclosure system as an example, it remains uncertain whether the cost efficiency of that approach is higher than that of alternative approaches. The degree of flexibility also depends on the concrete design, but as a general matter disclosure rules can arguably be implemented in a way that takes factual circumstances into account (if the obligation to disclose is dependent, e.g., on market, product and service maturity). Finally, disclosure of interoperability information is very unlikely to create any kind of technological lock-in.

- **Transparency rules** (labeling requirements): In order to reduce potential information asymmetries, the government can use a rather traditional approach aimed at fostering transparency and mandate the disclosure of information concerning the characteristics of a certain product or service. Again, such regulation may vary in several regards, first and foremost in terms of the characteristics and optical appearance of the information to be disclosed. If one does not establish transparency rules by way of "specific" legislation addressing interoperability in a certain area, such regulation could be — and partially already is — implemented via consumer protection or (unfair) competition law. An actual example of the operation of such transparency rules in the context of

DRM is a 2003 French court case, where the court ruled that certain DRM-protected CDs should feature the following label: "Attention cannot be listened on all players or car radios".

As labeling requirements contribute to interoperability in indirect ways, their effectiveness is difficult to assess. Much depends on the actual design of the labeling provisions and how well they manage to avoid information insufficiency on the one hand and overload on the other. Recent research further suggests that information needs to be embedded in consumer decision-making processes in order to be effective. While there are monitoring and enforcement costs associated with labeling requirements, it is likely that overall efficiency performs better here than in the regulatory approaches outlined before. Finally, the flexibility of labeling requirements is high, given the indirect character of the approach and, therefore, the limited conflict with future technological developments.

- **Exercise market power in procurement decisions**: The government may favor interoperable products or services when undertaking procurement decisions and thereby provoke or support the market's tipping towards interoperable solutions. Of course, such an approach requires that the government possess substantial purchasing power in the relevant market. In the area of digital ID solutions, one could observe, for example, Finland's tax board implemented Liberty Alliance procedures in the process of improving the taxation e-collection process. The effectiveness of this approach is high only in instances where a government's procurement decisions have a considerable and lasting market impact, which in many areas of the ICT environment may not be the case (take, e.g., the example of DRM-protected music). The approach may turn out to be relatively inefficient in cases of trade-offs of the type where the government has to defer from choosing the offer with the (otherwise) best value in order to contribute to higher levels of interoperability. The flexibility of the procurement approach is comparatively low since the exercise of procurement power may create a technological lock-in on the part of the government (or else cause significant costs if the exercise of procurement power is to be repeated).

- **Competition law**: Interoperability may further be achieved based on an ex post-intervention grounded in competition law. Such an intervention is possible in many countries – although particular conditions may vary considerably — when the refusal of a certain powerful player to disclose interoperability information is considered to constitute an abuse of a dominant position. Most notably, Microsoft is facing antitrust suits in several countries that address interoperability between workgroup servers and (Microsoft's) Windows servers and PC's. In the context of DRM, Apple's refusal to grant access to iTunes' FairPlay system was examined by the French competition authority, which ultimately ruled in favor of Apple in 2004; several antitrust suits against Apple are, however, still pending.

  Antitrust interventions operate with considerable effectiveness when establishing interoperability in specific areas. However, these interventions run the risk — in view of the duration of the respective enforcement procedures — that they continuously lag behind market development. Further, antitrust measures generally entail significant costs for the government that is charged with monitoring and enforcing. On the positive side of the balance, however, it has to be noted that the fact-specific and narrowly tailored character of antitrust interventions generally ensures the flexibility of the approach with regard to the market, technological, legal, etc. environment in which it is applied.

In addition to the approaches outlined in this section, we have also examined what we might call "supplementing strategies" by governments such as funding of research initiatives aimed at establishing higher levels of interoperability, facilitating standards setting processes, or establishing public-private partnerships in the relevant areas. Several of these approaches are discussed in greater detail in our case studies to which we might refer here.

Conclusion: a process solution to interoperability

While there is no single, "silver bullet" means of achieving ICT interoperability, there are guidelines that can help determine the best way to achieve interoperability. What we recommend is a process for considering possible approaches, with a view toward an optimal approach to interoperability.

1) Identify what the actual end goal or goals are. The goal is not interoperability *per se*, but rather something to which interoperability can lead. The goal that we evaluate here is innovation and competition, but other goals might include consumer choice, ease of use of a technology or system, diversity, and so forth.

2) Consider the facts of the situation. The key variables that should be considered include time, maturity of the relevant technologies and markets, and user practices and norms.

3) In light of these goals and facts of the situation, consider possible options against the benchmarks we set forth in the section above: effectiveness, efficiency, and flexibility. Additional, context-specific evaluation criteria might be added.

4) Remain open to the possibility of one or more approaches to interoperability, which may also be combined with one another to accomplish interoperability that drives innovation. In many instances, a blended approach may hold the most promise from a public policy perspective (e.g. supporting standard setting processes by private players and using procurement power as a supplementing approach).

5) In some instances, it may be possible to convene all relevant stakeholders to participate in a collaborative, open standards process. In other instances, the relevant facts may suggest that a single firm can drive innovation by offering to others the chance to collaborate through an open API.

6) In the vast majority of cases, the private sector can and does accomplish a high level of interoperability on its own. The state may help by playing a convening role, or even in mandating a standard on which there is widespread agreement within industry after a collaborative process. In a very few cases, the state may need to play a role after the fact to ensure that market actors do not abuse their positions.

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