

# Interop

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*The Promise and Perils of  
Highly Interconnected Systems*

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## CONCLUSION

# The Payoff of Interop as Theory

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**H**ow are we to manage the unprecedented degree of interconnectivity that has been created between and among people and systems in the digital age? This is one of the most significant questions of our age. Much depends on our ability to maximize the benefits of this unparalleled and growing level of connection and information flow while minimizing its potential risks. We need to get interop right as a matter of public policy, as we address big issues like sustainability and climate change. Interop is also important in the private sector as a matter of strategy, in terms of helping businesses thrive and innovate. The theory developed in this book is designed to help consumers, business leaders, policy makers, and the public at large to make more informed—and ultimately, better—decisions about the ideal level of interconnectivity among complex systems and their components, about what we want to get out of interoperability,

and about the breakwaters that should be put in place to make sure it stays at the optimal level.

The theory of interoperability outlined here can be used in four ways: first, as a framing device and an organizing principle—in essence, as high-level theory; second, as a description, to guide us in our understanding of certain phenomena, mostly to do with information and technology, in the age in which we live; third, as an effort to predict what the future holds and what debates will surround the subject of interoperability in years to come; and finally, as a normative device, one that should drive and inform the kinds of decisions policy makers ought to make in order to lead to the kind of good societies in which we all wish to live.

#### INTEROP AS HIGH-LEVEL THEORY

The theory of interop that we develop and test throughout this book draws together a series of seemingly unrelated events, innovations, and themes in such a way as to establish unexpected and revealing patterns. What, for instance, do the global economic crisis that started in 2008, health care reform, global climate change, and the emergence of the social web and cloud computing have in common? All have interoperability at or near their core, what makes them possible and what can make them dangerous. The study of interop helps us see the promise and the perils of highly interconnected systems in our increasingly globalized economy through the similarities and differences among these widely ranging examples.

As a theoretical framework, the study of interop sheds light on what tends to go right and what can go wrong with complex systems that rely upon a constant exchange of information, most commonly mediated by digital and networked technologies. Although some of the interop stories included in this book—such as the evolution of emergency systems, shipping containers, and bar codes—predate today's digital era, they have important relevance for interop in the current age. The implications of this theory of interop are highly relevant for the next generation of complex systems. After all, it was not possible for information to flow as quickly or as consistently across organizational and national boundaries even a few

decades ago. Nor have people and materials been nearly as mobile and interconnected as they are today.

One of the key insights offered by interop theory is the degree to which the proper functioning of systems that seem to be predominantly technical in nature—such as air traffic control systems, cloud computing, or the smart grid—depends on how well human beings and institutions can work together. Over the past decade, much thought and money have been spent making information and communication technologies more robust and improving the systems that rely on them. It is crucial that we advance our technological know-how and practices to ensure that our data are safe and our privacy protected. But the theory of interop also highlights that we have to think equally hard about the appropriate design of the fragile interfaces where technology, data, human, and institutional layers intersect if we want to harness the benefits of the unprecedented interconnectivity in the future. Examples such as emergency communications and health care information teach important lessons about what has worked and what has not.

#### INTEROP AS DESCRIPTION

Interoperability research does not only lead to an abstract theory; it also helps at a precise, descriptive level. The careful study of interoperability helps explain specific phenomena in a complex world. An understanding of how interoperability functions in the context of case studies reveals much about what makes complex systems work well and what leads to their failure. Our methodology has been to explore case studies where we imagine interoperability might be part of the magic behind a system's functioning, for good or for ill. These case studies have taken us from the worlds of information technology, commerce, and trade to health care, emergency response, and the related fields of energy and environment. These case studies are posted freely on the web, at <http://cyber.law.harvard.edu/interoperability>, for anyone to read. These are the raw data and collected stories that we have worked from in the pages of this book; we have woven these narratives into the frame of our argument. They also stand alone as rich

descriptions of how complex systems function and of where they can break down.

These case studies describe connections that are hard to see on the surface but that are essential to the functioning of our complex world. A look beyond the surface of everyday phenomena—such as digital music, bar codes on products, instant messaging, and shipment containers (the boxes in which goods tend to flow around the world, on large ships and on trains)—encounters the hidden links and information channels among systems, components, and applications. It also discovers how much their capacity to work together depends on a complex set of choices, made over a long period of time, by a large number of players. These players have typically included technologists, consumers, companies, legislators, courts, and others. To make things more complicated, many of these decisions have been made in an ad hoc, decentralized fashion—certainly without any grand interop plan to guide the way. Given this decision-making process, it is surprising how well many of today's systems work together and how interoperable our world has become. At the same time, many of the case studies also illustrate how hard it is to undo bad decisions of the past. The legacy problem and the problem of path dependency (which we observed especially in the library and e-health contexts) are reminders of how important it is to think about interoperability in a proactive, strategic fashion.

Interop helps us understand issues related to globalization and how our cultures differ from one another. A global perspective, as we look forward, can help expose culturally specific approaches to interoperability. China, for instance, with its enormous market size, has a particular set of strategic interests with regard to interop. Chinese government and private companies are developing independent standards for certain information and communication technologies outside the realm of the international standardization organizations described in this book. Chinese officials have seen the development of their own standards as a matter of potential competitive advantage, both in security and in the marketplace. Officials in the United States are beginning to see standardization and interoperability issues in a similar light.

Such diverging regional interop approaches are also visible in a comparison of everyday experiences. Consider, for instance, the dissimilar ways in which we in Western countries and our friends in Asia deal with different electrical plugs. In China, the solution to this annoying interop problem is not an adapter but, rather, a pragmatic, multiplug design of the power outlet itself, built into the wall. Or take the example of a contactless, interoperable smart card, called Suica (the Super Urban Intelligent Card), that is used to pay the fare on trains in Japan. This nicely designed card works outside of trains, too; the Suica is increasingly accepted as a form of e-money for purchases in stores, at kiosks, and in taxis. Meanwhile, in the United States, we carry around wallets stuffed with different credit cards, swipe cards to allow us various forms of access, and separate customer loyalty cards from our drug store, our grocery store, and the place where we get our coffee in the morning.

These examples from Asia suggest another lesson from our research: interoperability, in virtually every context we have studied, is in constant flux and is occurring at differing rates around the globe. Rapid technological progress combined with highly dynamic market forces will continue to create new interoperability challenges and at the same time change the character of old problems. But the problem side of the equation is not the only thing in flux. The ways in which we address interoperability challenges may change over time as well, because we will learn from our own successes or failures and will also be inspired by different approaches from other parts of the world.

This theory and these case studies may be most immediately relevant to those who work in the industries and areas examined in the specific cases, such as computing and the web, libraries, and health care information systems. The implications are easiest to see in the context of information technology companies. The importance of an interoperability strategy is obvious to those who work at Apple, IBM, Microsoft, or Oracle, in the high-tech world. Increasingly, the next generation of big information technology companies are betting even more on strategies of interoperability: Facebook, Google, and Twitter are all building enormous businesses by

developing, and sharing wide access to, highly interoperable platforms. The same is true of companies all around the world, many in Europe and others in the fast-growing markets of East Asia.

But these issues are highly relevant to policy makers and consumers, too. The job of setting policy in the digital era increasingly calls for a deep understanding of interoperability and how it affects a broad range of legal and policy outcomes. It is an issue of competitiveness and of national security. And for consumers, the level of interop that people demand has a powerful effect on the decisions companies make as they design their products and services. Higher levels of interoperability can be great for consumers in terms of convenience, but it can also pose risks for security and privacy, as we have seen in the cases of Google's Buzz and Facebook's Beacon products.

#### INTEROP AS PREDICTION

Interoperability theory helps company executives and government policy makers by enabling them to make better predictions. The study of interop helps decision makers look ahead as they try to anticipate the results of their actions today. For instance, a large technology company may want to know whether it makes more sense to allow free access to and connection with core systems, opening them up to other developers (as Twitter and Facebook have done on the social web), or whether traditional strategies of exclusion are a better way to go. In the online world at least, the increasingly common answer seems to be that high levels of interoperability lead to better results for individual companies, for the industry at large, and for consumers.

But a well-designed interop strategy, as we have seen time and again, must also get the degree of interoperability right. It is essential to realize that high levels of interoperability can lead to further problems, often related to security and privacy, homogeneity, and lock-in. It is important to craft interop strategies that take advantage of what we know to be the major advantages of highly interconnected systems while working hard to design systems that mitigate its several potential downsides. Interop theory can help guide this design process.

Smart interop strategies adopted by tech companies, as well as sound interop choices made by users and regulators, will help harness the benefits of digital interconnectivity while avoiding its risks. But the most challenging interop problems often stem from the sheer complexity of the systems we want to make work together. For instance, it is very hard to envision what a successful interoperability strategy for the next generation of air traffic control systems will or should look like, because there are so many stakeholders around the world and so many different technologies involved. The same is true of international financial markets, where it is very hard to model the effects of the most highly interconnected systems and the most complex financial instruments. Viewed from this angle, our studies highlight the urgency and importance of sound interop strategies design to handle complexity at a global scale. Our theory demonstrates how users, companies, and governments should expect to come up against limits of how effectively we can predict outcomes in the most highly interoperable, complex environments—a major trade-off that we must realize we are making as we continue the process of deep interconnection.

#### INTEROP AS A NORMATIVE MATTER

Finally, the close study of interop helps determine what we, as societies, *ought* to do in certain circumstances. The study of interop can inform decision making about what the most promising approach might be to any given new interop problem. Interop theory helps us consider how we might solve the problems that we expect to face in the near future. The health care debate and the need to preserve human knowledge in a digital era, for instance, are two pressing issues that will require governments, companies, and consumers to have a firm understanding of interop issues. The emerging architectures of cloud computing, the smart grid, and the Internet of Things also present intricate interop problems that we, as societies, will need to address.

At a granular level, this emerging theory of interoperability provides a framework for sound interop policy making and puts forth a process-oriented model for policy makers who are seeking to address interoperability

problems that have arisen or are likely to arise. Most of the cases we have examined here are not straightforward instances of clear lawmaking; they tend to involve cultural and societal factors that shape the responses by governments, and vice versa. These factors may influence, for example, the instruments a government may use in addressing a given interop problem. To generalize, European lawmakers have appeared to be more inclined to regulate interop *ex ante* than their US counterparts, whereas US lawmakers have tended to rely on market forces up front and to turn eventually to corrective *ex post* mechanisms as needed. Several of the most recent examples that we have studied, including e-health and the smart grid, suggest a possible trend toward convergence between the US and European approaches. Increasingly, blended approaches, where public and private actors work together to establish optimal levels of interop, play an important role on both sides of the Atlantic. And, as demonstrated by our examples from Japan, China, and beyond, such approaches, in addition to innovative strategies, are emerging around the world.

The greatest payoff from the close study of interop ought to be the manner in which it guides our decision making on some of the biggest questions of our increasingly global, interconnected, digital world. It should push us, as individuals and as societies, to acknowledge and address the costs and benefits of deep interconnection among technologies, data, humans, and institutions. We need to understand, too, the implications of the failure of complex systems to work together in optimal fashion. Fundamentally, a deep understanding of interop will help us as we work together, across our many roles and functions in society, to fashion the kind of world in which we wish to live.