LAW:
AN INFORMATION TECHNOLOGY

John O. McGinnis
Northwestern University School of Law

Steven Wasick
Northwestern University School of Law
2012 Graduate
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* George C. Dix Professor of Constitutional Law, Northwestern University. We are grateful to Nelson Lund, Mark Movsesian, and participants in a faculty workshop at Northwestern University Law School for helpful comments on previous drafts.
† President, Fantasy Journalist, Inc.; J.D., Northwestern Law School
Introduction

Law has always been caught between two conflicting impulses. First, it aims to achieve ready comprehensibility, so that people can plan their lives around the norms of their community. Second, it aims to achieve flexibility so that it can take into account the wide range of factors that make for just and socially optimal results. The first aim tends toward simplicity and clear rules. The second aim tends toward complexity and open-ended legal standards.

Both functions of law involve information. To give notice of its mandates to the relevant community, law facilitates the flow of information from the governing to the governed. But law can also permit information to flow from the governed to the governing, as it incorporates new data from legal disputes, thereby potentially improving its content. A common law standard can mutate as judges apply it to diverse facts in a stream of cases. A legislative command also can change as the legislature updates a law in response to the altered circumstances of the world or changing preferences of their constituents.

Law is thus necessarily an information technology—a tool for information distribution to the world that may itself change though the infusion of more information from the world. And as with any information technology, its structure as well as its content is subject to transformation by the available information capacity, by what we might call the legal bandwidth of the era. In particular, the process of finding the positive law of a society reflects the surrounding information technology of a given age. As that technology is improved, law can be more easily found and its content fixed. Given
today’s continuing exponential revolution in information technology, change in the form of law is in the offing as well.

As the computational revolution reduces information costs, law can better achieve its twin goals simultaneously of informing the relevant community and being informed by the world. At the limit point of costless and completely effective legal search, law can be flexible and yet instantly discoverable. It can update on the information made available in legal disputes while simultaneously informing the community of the norms that will be applied to it. If one could put natural language questions about any legal issue and get a firm answer of what law is now and an accurate prediction of how it would change in the future, people could plan to fit their conduct to law even if law were complex and changing. Perfect information could substantially temper the enduring conflict between comprehensibility and complexity, between the competing demands for clarity and for flexibility.

As a result, with better and better legal search, more open ended standards become more attractive vis-a-vis determinate rules, other things being equal, because improved legal search can better predict the application of standards to particular cases. With less expensive and more autonomous mechanisms for gathering information, dynamic rules that are open to automatic updating by prescribed formulas also become more attractive compared to fixed rules that require explicit legislative reconsideration when the world, or knowledge of the world, changes. Dynamic rules can respond to changes in the world faster while also giving the community a clearer view of the mechanisms that will drive legal transformation, thereby helping citizens plan for the future.
This article offers a historical, theoretical, and practical view of law’s function as an information technology, analyzing its past, its present, and its future. Part I shows that law has historically attempted to reconcile the incorporation of information to make better social norms while also providing clear information to the community about the content of those norms. These two factors are in tension with one another. As the law incorporates more information from the outside world – generating more case law reports, for instance – it becomes harder to find a specific piece of information without some form of synthesis or indexing. Expansions in legal information therefore create additional demand for synthesis. Over history, the production of legal information and its synthesis have conformed to this push and pull pattern:

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<td>Proto-case logs (“Year Books”)/English Reports</td>
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<td>West National Reporter</td>
<td>West’s American Digest System, Law Restatements, Law Reviews</td>
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Blackstone’s commentaries and West’s American Digest System are in the same category as modern search engines because they all serve a similar purpose: they seek to reduce the body of case law to just those cases that are relevant to a particular issue. The difference between them is in the specificity of their categorization. Blackstone, being one man with access to a printing press, divided his commentaries into 110 separate chapters.¹ West Publishing, having a large workforce of legal scribes and taking advantage of new methods of mass production, was able to create a Digest that had

thousands of discrete categories.² The electronic legal search made possible by computers now allows the user to create the category of cases that she wants to synthesize, ending the limit to the number of different classifications.

The push to create more legal information and the pull of fashioning that unruly data into comprehensible rules has marked major disputes about the form of law throughout history, particularly over codification of the common law. For instance, in the late nineteenth century the famous legal theorist Dudley Field hoped to replace much of the common law with his codes to summarize and regularize the law into easily accessible rules for informing the community.³ The bar generally opposed this effort, with head of the American Bar Association arguing that the codes would prevent the development of law that occurs through adding new information provided by the continuous stream of case law.⁴ Such conflicts are the tragic conflict of right with right. They are inevitable in a world where legal search is expensive: law must make a trade-off between the clarity and ease of access inherent to rules, and the sensitivity to facts and open-endedness of common law standards.

Part II of this article shows how the continuing computational revolution, which is necessarily a revolution in all information technologies, including law, will help resolve this trade-off. It will move to reconcile law’s dual function in gathering information to make better norms and in informing the community of their content. We describe the current and likely future progress of modern computerized legal search. The exponential

³ For a depiction of this process and its results, see Dudley Field, Codification in the United States, 1 JURID. REV. 18 (1889).
increase in the power of machine intelligence is making legal search ever more effective and less costly. This improvement relaxes the tension between comprehensibility and open-endedness that has bedeviled law throughout the ages.

To describe how legal search can achieve this reconciliation, the article turns to information theory—a body of knowledge rarely applied to law. First, we characterize the efficiency of legal search through what information theory understands as noise. Search engines can be more or less noisy, depending on the quality of the information link between searcher and search engine. The less noise there is, the more effective the search engine.

The theory of information compression then shows how efficient legal search can become law itself. Information theory demonstrates that uncompressed information can be compressed in the form of efficient algorithms. For instance, a continuous string of 01 repeated endlessly may seem on the surface to contain a lot of information but in reality can be described by a simple algorithm that simply provides a rule of repetition. Case law similarly contains a lot of uncompressed and redundant information. What efficient legal search can deliver is law’s algorithm, compressing the uncompressed legal information as it provides answers to discrete legal questions.

Part III of the article describes the practical effects of increasing computational power: it will shift the optimal form of law toward legal standards rather than rules, and dynamic rules rather than closed rules. A legal rule has the advantage of clarity and comprehensibility over a standard, other things being equal. A classic example of a closed legal rule consists of a speed limit on a highway limiting cars to sixty-five miles an hour. It possesses a limpid meaning and provides clear notice of the norms to which
the community must comply. But this rule has disadvantages as well. Depending on the weather, highway conditions, and volume of traffic, a lower or higher speed limit might be optimal. “Drive at reasonable speed” would be a classic standard that could capture such factors in its application. But this standard has an Achilles heel: it fails to provide clear notice of the appropriate speed.

As increased computational power creates better legal search, standards, other things being equal, become a more plausible form of law. For instance, we can imagine in the not too distant future an app on the dashboard that would take account of the relevant factors of road, weather condition, traffic and the like—information that is itself gathered by the information technology of networked monitors-- and provide a recommended speed limit in real time, a prediction on the basis of previous cases about how judges would apply a standard of reasonable speed under particular circumstances. Computerized and dedicated legal search can thus ameliorate the problems of comprehensibility and notice that often make standards problematic.

As an alternative, the legislature could take advantage of our increased ability to create, analyze, and communicate information by implementing a dynamic rule. In the speed limit context, a dynamic rule would update the speed limit according to some fixed formula that took into account road, weather conditions and the traffic, specifying a speed limit for a particular time and place. The speed limit could be flashed on the dashboard by a government approved app. The rule would be less open ended than a standard, because judges could not update the formula. Nevertheless, it would still generate better results than a more static rule, because it would automatically change on the basis of
relevant factors. Both approaches would mitigate the enduring conflict between law’s twin impulses of comprehensibility and flexibility.

We end by discussing the relative virtues of standards and dynamic rules, because it is the choice between these forms of law that will become more prevalent in our era of ever more powerful computation. Dynamic rules set law’s algorithm in silicon, permitting changes in law to occur only in response to previously specified information. Standards permit judges to change the algorithm itself as well as applying the old algorithm. Thus, the primary difference between the forms is how much confidence we have in judicial decisionmaking. Even computers cannot eliminate the all-too human questions of authority and trust.

I. The Information Technology of Law – A Brief History

Throughout history, law has focused on two kinds of information objectives—informing the community of its norms and gathering information from the world about what those norms should be. The first objective is most associated with the top-down legal ordering as when the sovereign provides a written code of commands. The second is associated with a bottom-up form of information ordering, as when the common law applies broad principles to changing facts in concrete cases. Whenever law has a more distributed form of ordering, however, the legal community tries to make a synthesis of decisions into more comprehensible rules. But because of limits to information capacity this synthesis is imperfect. Thus, throughout the history of the West, there is a tension between top-down and more distributed forms of ordering.
In this Part, we begin by considering the differences between top-down and distributed ordering that structure legal information. While almost any legal system has aspects of top-down and distributed ordering, we can better perceive the mix by defining the polarities. Then we provide vignettes in legal history of law’s attempts to perform its two information functions of informing the community and informing the content of legal norms with facts from the world. We discuss how the legal community has tried to use the information technology of its time to synthesize the data from more distributed ordering to make more comprehensible rules. But we end by showing that despite attempts at synthesis, historically the two information functions of law have conflicted as the people have battled over whether law should be codified or permitted to develop though more bottom-up methods of adjudication, like the common law. Such conflict was inevitable given the limited information capacity of the technology of previous eras.

A. Top-Down versus Distributed Forms of Legal Ordering as Information Structures

There are basic two ways for law to organize information: (1) a centralized, top-down approach and (2) a distributed approach. Legal information is centrally organized when there is a limited number (or even only one) place where information about the law is collected and disseminated. The paradigmatic example of this approach is a comprehensive legal code that seeks to provide clear and reticulated rules for all regulation. In contrast, a distributed approach relies on several decision makers who

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6 Id.
7 See id. (using America’s regime of environmental regulations as an example).
create and interpret the law. The best example of this approach is our system of common-law, which is built upon the accumulated decisions of many judges.\(^8\)

To be sure, almost all legal systems have aspects of both kinds of ordering.\(^9\) For instance, adjudicators still have to apply a code, however reticulated, and their applications influence the course of law.\(^10\) In a common law system, judges generally begin with accepted formulations of principles that have been handed down to them from history even if not from sovereigns. But even if legal systems exist along a spectrum of top-down and distributed ordering, the dichotomy is useful in understanding how the structure of law relates to its two information functions of informing the community and being informed by the facts of the world.

A key strength of the top-down approach (and a key weakness of distributed decision making) is that it reduces the informational cost of learning about the law.\(^11\) It is generally easier to understand a set of specific rules than a body of case law which applies general principles to a myriad of facts.

However, this benefit of a top-down approach must be balanced by the benefits of distributed decision making. Distributed decision making takes advantage of distributed intelligence, which exists “as dispersed bits of incomplete and frequently contradictory pieces.”\(^12\) Using distributed intelligence is particularly valuable when the information sources used to make a decision are not centrally located. This distributed information is what Friedrich Hayek called “the knowledge of particular circumstances of time and

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Hayek’s formulation provides a very good description of the type of information that must be dealt with in a court of law.

With common law, we rely on judges to apply and even to create law that is adapted to “particular circumstances of time and place,” each case being somewhat different from anything that has come before. Ideally, the judge combines the unique information presented at trial with information gained from previous legal cases (precedent) to create a legal opinion. In the process, an additional data point is created that others can now work off of. This process has been the essence of common law systems since its origin in England.

There are two key factors in the structural effectiveness of a system of distributed intelligence. First, is the number of data points, such as the body of case law. As more case law is added, each with its own particular facts and circumstances, the structure of the law takes a finer grain, and it becomes easier to place the particular facts of a given case in the context of earlier decisions. The second factor in effectiveness is the ability of individuals within the system to access these data points. Inaccessible data points are useless to the decision maker.

The multiplicity of data points and citizen’s ability to comprehend these points as a guide to conduct are in some tension. As case law expands for instance, it becomes more difficult, absent technology, for any individual to obtain the collection of case law

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13 Id. at 521.
14 SCOTT SHAPIRO, LEGALITY 199 (2011) (using common law as example of bottom up or distributed decisionmaking).
15 See Emily Sherwin, Judges as Rulemakers, 73 U. CHI. L. REV. 919, 924 (arguing that adherence to precedent works to constrain potential judicial biases that arise out of the details of individual cases).
that precisely relates to their case. Expansions in case law therefore create additional demand for synthesis.

B. The Development of Law as an Information Technology

The tension between distributed and top-down forms of the law is mediated by technology. Humans are both creators and creatures of technology. Everything we do is vitally connected with the tools we develop, and the law is no different. Law itself is a tool and an information technology, but its effect and effectiveness depend on the larger domain of material technologies in which it nests. Legal production is different if it is situated in the technology characteristic of the age of agriculture, the industrial age or the computer age. Here we offer a brief survey of Western lawmaking that show how intimately technology was connected to the creation and practice of law. The technology of an era both empowered and constrained law’s capacity to fulfill its information functions of providing notice and being informed by the facts taken from the world.

Law in the western tradition began in Greece, where the law was carved on a series of stones called stele. These stele were publicly displayed, so that all could see the law. Indeed, it was taken as a given that the law must be quickly accessible and visible to all citizens or else it had little utility. The technology of the time, a world not only without a printing press, but without paper in the modern sense, radically limited its ability to inform the public of system of complex rules or create structures of distributed information which could help change law through gathering information.

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18 On the nesting of specific technologies in a larger technological domain, see generally W. BRIAN ARTHUR, THE NATURE OF TECHNOLOGY: WHAT IT IS AND HOW IT EVOLVES (2009).
20 Id. at 275.
But life did not change as much for year to year in the ancient world and society was not as complex as it later became. The stele is a legal technology adapted to a world of technological stasis. Subsequent political theorists, like James Madison, sharply distinguished this kind of legal information production from that needed in the more fluid modern world, noting that unlike law chiseled in stone, modern laws had to be open to updating and even repeal. Law’s need for adaption puts an emphasis on its capacity to be opened-ended enough to adapt to new information.

Roman law took advantage of the technological invention of the codex, which was an important historical step in the long historical arc of reducing information costs. A codex was a series of pages bound together in a volume in contrast to a scroll which is a single continuous page that must be unrolled to be read. Because of a codex’s separate pages, the codex allowed easier access to information than the scroll by permitting easier indexing and search. It therefore permitted a more expansive rendition of law—a far more complex code of conduct than could be contained on the stele of ancient Greece. It was still in essence a top-down structure but a far more reticulated one than had existed before. The Roman use of written law came to its apex with the publishing of Justinian’s Corpus Juras Civilis, a sweeping codification of the entirety of Roman law. After being essentially lost, this code was rediscovered in Italy during the eleventh century and went on to form the basis of civil law in continental Europe.

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21 2 Annals of Cong. 1666 (1790). (Remarks of James Madison) (“Our acts are not like those of the Medes and Persians, unalterable. A repeal is a thing against which no provision can be made.”).
The origins of the common law system lie elsewhere, in England. There, the Roman law existed alongside a common law system based on precedent and prior case law.\(^\text{25}\) The common law was built up first through student-kept notes on cases, which began as early as 1292.\(^\text{26}\) Again this advance in legal technology depended on material technological change from the ancient era.\(^\text{27}\) The cost of paper had fallen sufficiently so that it was possible to memorialize more and more details of cases. These case notes, called “year books,” built up to the point that the need for abridgement and synthesis developed. This was first done in 1470, by Nicholas Statham, baron of the exchequer under Edward IV.\(^\text{28}\)

The forms of legal knowledge changed again as legal information was put within a new domain of material technology—that of printing.\(^\text{29}\) As movable type allowed for cheaper and faster printing, more and more case law reports came into existence, creating again a greater need for synthesis.\(^\text{30}\) William Blackstone created the masterwork of early legal synthesis with his *Commentaries on the Laws of England*, first published in 1765. The *Commentaries* were important to legal technology for two key reasons. First, Blackstone extolled the common law as being every bit the equal of the centralized Roman law codifications.\(^\text{31}\) His advocacy struck an early blow for the importance of distributed decision making. Second, Blackstone’s work was comprehensive, spanning


\(^{26}\) *Id.* at 17.

\(^{27}\) *ELIZABETH L. EISENSTEIN*, *THE PRINTING PRESS AS AN AGENT OF CHANGE*, 90 (1979) (describing how the lower cost of paper made further indexing possible).


\(^{29}\) *EISENSTEIN*, *supra* note 27 at 103-105.


\(^{31}\) Berring, *supra* note 2 at 16.
four volumes and 110 chapters, permitting a powerful synthesis of information that accumulated over centuries.

Despite these advances, systems of synthesis still were not available that rapidly made recently decided law available to subsequent decision makers. The Supreme Court is notable in its early years for neglecting precedent.32 Hodgson v. Bowerbank,33 for instance, was a case which declined to apply the portion of the Judiciary Act of 1789 to permit suits among aliens. Marshall’s opinion does not cite Mossman v. Higginson,34 a case from 1800 that had covered the same ground.

The difference in the use and reliance of precedent between the early Supreme Court and the present day is partially a story of information technology. Justice Marshall’s access to case law was far below that available today, or even in the late 1800’s.35 Case reporters of American law did begin to appear in fits and starts soon after the country’s founding.36 However, these case reporters were far from comprehensive, as the editors enjoyed wide editorial license to include or exclude cases.37 The quality of the reporters also varied greatly.38 There was even a “reporter of reporters” which cataloged the various reporters and attempted to assess their quality.39

Without being informed of recent precedent, a judge fulfills only half of the potential benefits of distributed intelligence. He creates a new data point for others to

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33 9 U.S. 303 (1809).
34 4 U.S. 12 (1800).
36 Berring, supra note 2 at 18.
37 Id.
38 Id.
rely on, but does not take advantage of the data points that came before, thereby lowering the overall quality of the system.

John B. West, who in 1876 founded the West Publishing Company in Minnesota, regularized the reporting of precedent. He created the West National Reporters, a series of books that grew to cover legal precedent in every state. The growth of the West Reporters was driven by two advances. The first was the practical idea to combine the reporting of several large states into one book. This allowed West to publish weekly updates of case laws and a full reporter book every year, as opposed to official reports which could sometimes be five years or more out of date. The second advance was adapting mass production techniques to the legal industry.

An examination of the 1901 West pamphlet “Law Books by the Million” shows how technologically driven the National Reporter system was. It was a product of the age of steam and steel no less than Blackstone was a product of the age of the printing press. In the span of 25 years, John B. West had created a legal information factory: hydraulic binding pressers, sixteen advanced model linotype machines, and a quarter-mile long vault containing 2.5 million pounds of metal type sheets, all powered by an in-house boiler room. This industrialization of legal publishing reduced the costs and increased the availability of legal information. West made individual case decisions available for only a quarter, far below the $5 to $10 typically charged by official state reporters, radically reduction legal information costs.

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40 West Publishing Co., Law Books by the Million (1901).
41 Id.
42 Id.
This explosion in information was not met by universal approval.\footnote{See Ross E. Davies, \textit{West's Words, Ho! Law Books by the Million, Plus A Few}, 14 \textit{Green Bag} 2d 303, 304 (2011).} In a speech given in 1902, Pennsylvania Chief Justice James Mitchell spoke of the pre-West legal culture:

[t]he legal world had not yet surrendered to the manufacturer and the bookmaker, nor would any publisher have dared, even if he could truthfully do so, to send out, as more than one does now, boasting circulars that he makes law books by the million.\footnote{James T. Mitchell, \textit{Historical Address, in Addresses Delivered March 13, 1902 and Papers Prepared or Republished to Commemorate The Centennial Celebration of the Law Association of Philadelphia, Pennsylvania: 1802-1902} 13, 15 (Law Ass’n of Phila. 1954). This was quoted by Davies, supra note, 43 at 308.}

The idea of publishing a comprehensive record of case law was also opposed by commercial interests that stood to lose business to the new enterprise. Several competing concerns offered highly edited reporters, publishing only the “important” cases.\footnote{Berring, supra note 2, at 21.} These selective reporting systems lost the commercial battle. Despite Justice Mitchell’s views, lawyers have consistently shown that when it comes to information, they want more. In time, the West Reporters themselves would become the more selective source when compared to electronic databases, and again the more selective source would lose the battle.

In order to deal with this massive increase in legal data, the West Company did two important things. First, it standardized the reporting of individual cases by publishing all cases in its own proprietary form. With West, reading cases was the same in any jurisdiction, and under any topic.\footnote{\textit{Id.} at 22.} As Berring noted, “[r]esearch skills were made fungible as research became a mechanical process.”\footnote{\textit{Id.}}
More importantly, West introduced the Key Topic system. It first appeared in volume twenty of the Northwestern Reporter, which covered cases for 1884. This system contained four hundred main topics that were then further broken down into subdivisions.\(^\text{48}\) This was the critical innovation from West publishing. It gave lawyers the ability to identify a discrete topic that was relevant to their case and then pull up a heretofore unavailable amount of case law on that topic.

Outside the West Publishing Company, the increase in case law prompted other attempts to organize the law. One of these attempts at synthesis was the Restatement of the Law project. Originally, the Restatements were meant to replace the messy expanse of common law.\(^\text{49}\) Instead of citing to case law, a lawyer would instead cite to the Restatement. Like the would-be competitors to West’s Reporters, this attempt to distill the common law down to discrete principals failed to supplant the flexibility and comprehensive value found in the mass of case law. However, like law reviews, which were developed a generation before, the Restatements did succeed in providing a new data point of persuasive authority.

Although West Publishing Company solidified its position in the legal world during the century after its founding, from today’s perspective we can notice three key limitations. First, although it was more comprehensive than any other commercial case log, the West National Reporter did not include every opinion. West only published those opinions that the courts wanted to have published. Second, the Key Number system, while detailed, could never actually cover every possible topic created by legal events. As a result, lawyers trained to use the West system would feel pressure to wedge


\(^{49}\) Berring, *supra* note 2, at 23.
the facts from their case into arguments that could be developed from within the Key Topic system.\(^5^0\)

Finally, (through no fault of West) during the National Reporter era there was no equivalent of the Digest system for sources outside of case law. This gap made it hard for lawyers and judges to draw upon non-legal references and secondary sources in briefs and opinions. An examination of turn of the century Supreme Court cases, and even cases from the 1950s, show few references to secondary sources such as law reviews, treatises, international law, and non-legal sources.\(^5^1\) As we will see, these limitations disappear as law comes within the domain of computational technology with its exponentially greater capacity to gather and categorize data.

\textit{C. The Tension Created by Limits of Information Capacity}

Before the advent of the computer age, law two’s information objectives—creating clear notice to the community and updating though taking account of the facts of the world—were in tension. A code could give clear notice of rules, but did not provide the same opportunity as the common law to take account of facts to inform its broad principles. The flexibility of the common law gained additional advantages as the world became less static with the advent of industrialization.

The major debate throughout American history about the form law should take reflected this enduring tension. From the beginning of the Republic, movements arose to codify matters that had been previously been decided by the common law. One of the


main advantages touted for codification was the clarity and access to information that codification would provide.\textsuperscript{52} To be sure, the debate was also pitched in terms of democratic enactment of a code by a legislature as opposed to control by judicial elites. William Drayton stated that the “letter of the law” was needed to protect the people from becoming the slaves of magistrates."\textsuperscript{53} But even such complaints about the potential tyranny of judges were related to the information technology surrounding the law at the time. In world with such weak reporting of recent precedent, magistrates necessarily had a lot of discretion.

The debate endured throughout the nineteenth century. The most powerful exponent of codification was Dudley Field, who proposed that legislatures adopt his so-called Field codes. Field emphasized the information advantages of codes. According to Field, codification would make the law accessible to layman, lawyers and judges, thereby reducing the costs of finding the law.\textsuperscript{54} Field was a sophisticated legal theorist. He acknowledged that no code would determine all the cases and no set of rules could foresee all future contingencies.\textsuperscript{55} Interpretation would still be required to apply even well-defined and comprehensive rules, and thus glosses on the law would be generated. But he thought that more code would lead to more clear results than the alternative.\textsuperscript{56}

If Dudley Field emphasized the advantage that top down approach to law had for informing the community of legal norms, his great opponent, James Coolidge Carter, a

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\textsuperscript{52} See Gordon Wood, Empire of Liberty 403(2009).
\textsuperscript{53} Wood, supra note 53, at 408.
\textsuperscript{54} Grossman, supra note 4, at 154. Field also makes other arguments for codification that are related to information capabilities. He states that codification will help clear up lawyers’ bookshelves, and make legal research easier: two problems resolved by modern technological advances despite retention of common law.
\end{flushleft}
leader of the American Bar Association, emphasized the advantages that a distributed form of legal ordering had for reaching better social results. According to Carter, the common law was better at reaching justice in an individual case, because its broad principles were better able to capture the customs of society. As result, the common law was also better at legal development, adapting the law to changed circumstances. Like Field, Carter was a sophisticated advocate of his favored approach. He recognized that it created uncertainty, but argued that it was worth the price.

Again, as in the debate at the beginning of the Republic there were undercurrents of populism versus elitism. The common law, it was argued, made more work for lawyers and gave more power to judges. But again tension is not unrelated to conflict between certainty and flexibility in a world of limited information. At the time before computerized search, more flexibility in the law was a direct boon to the income of lawyers, because it was largely their knowledge of practice and precedent that was necessary to find plausible answers to legal questions in the interstices of the common law. One commentator at the time observed that “every practitioner knows that when a hard case arises, the law books are ransacked from the time of the Norman Conquest and the court blindly applies any absolute precedent that may have been found by diligent counsel.” Indeed, in the nineteenth century men who were capable of complex calculations in their head were called “computers.” Just as those men performed the

59 Masferrer, *supra* note 56, at 388.
60 Subrin, *supra* note 57, at 319.
calculating function reserved for the computers in our day, lawyers necessarily performed much of the functions of computerized search today.

Thus, the long debate between the virtues of the common law and codification dramatizes the tension between top-down and distributed decision making, between law’s two information functions. As the debate went on through the decades, sophisticated advocates understood that it was about a tradeoff between law’s potential for certainty and its capacity for discovery. What was not so appreciated was that this tension was to a great degree a reflection of information scarcity. Computation systems at the time were simply not capable of ongoing, accurate synthesis of the growing number of discrete legal data points, particularly as they multiplied in a more complex and litigious society. We now turn to developments that are beginning to radically alter the world of information technology and so beginning to resolve this historic tension.

II. Creating Law’s Algorithm

In this section, we show how lowering information costs can transform the nature of legal search and reconcile law’s conflicting impulses to gather information from the world and provide information to the community. First, we discuss the beginnings of computerized search—the search that promises this reconciliation—showing how it improves fundamentally on the deficiencies of previous legal search. Then we describe the driving force behind this improvement—Moore’s law—an entrenched tendency of the information age that suggests such improvement will continue. We also describe how legal search is likely to progress though the use of increasing computer power. Finally,
we use information theory to show how the lowering information costs can help search create positive law from distributed information.

A. The Beginning of Computerized Legal Search

Following the introduction of written law and the creation of legal indexes, the introduction of computer aided legal search was the next great legal information transformation. Computerized legal search began in the mid 1960s when the Ohio State Bar Association tried to create an electronic system to sort through legal opinions. That system became the foundation for the Lexis legal search system, which was introduced to the public in 1974. Westlaw was offered soon after, but it was of limited utility, since it did not allow researchers to search the full text of legal opinions. During this same time, the Lexis system was handicapped by comprehending a less than complete database of case law.

At first there was only limited access to even this fledgling computerized search. Lexis and Westlaw were both initially only available on minicomputer terminals. These terminals typically occupied a separate room within a legal office or library. Starting in 1979, Lexis offered searches on their custom built UBIQ desktop computers. Having ready access to electronic databases was the first step in allowing lawyers to make legal search a routine part of their information gathering process. In that same year, Westlaw eliminated its biggest limitation by allowing search of the full text of cases, rather than

63 F. Allan Hanson, From Key Numbers to Keywords: How Automation Has Transformed the Law, 94 LAW LIBR. J. 563, 573 (2002).
64 Id.
66 Id.
just head notes.\textsuperscript{67} The next year, 1980, Lexis expanded its legal database so that it covered all 50 states and most federal cases, matching the database Westlaw had developed.\textsuperscript{68} By 1980 the improvements at both Lexis and Westlaw made electronic search into a credible replacement for many traditional forms of acquiring legal information.

Indeed, from 1980 to 1995 legal search experienced massive growth. This was the main period of market penetration for legal search.\textsuperscript{69} After 1995, most of the growth came from additional services, rather than adding more customers.\textsuperscript{70} Several of the services added to legal search since 1980 have been critical additions.

For instance, in 1992, Westlaw became the first legal search engine to allow for natural language search. Lexis followed one year later. Natural language search allowed people to search without knowing how to use Boolean search terms. Unfortunately, the hardware and software available at the time did not allow the search to be very accurate.\textsuperscript{71} Despite the limited initial effectiveness, natural language search, as it is refined, will have fundamental implications for legal search and ultimately the form of law.

Both search engines integrated Shephard’s citation checking services into their case results in 1981.\textsuperscript{72} In 1997, Westlaw developed its own proprietary citation checker, Key Cite.\textsuperscript{73} The integration of these services allowed researchers to instantly assess whether the opinion they were looking at was still good law. During the late 1990’s,

\textsuperscript{68} LexisNexis, \textit{supra} note 66.
\textsuperscript{69} Interview with Clemens Teipek, Ian Koenig, and Steve Mann of LexisNexis, December 14, 2011.
\textsuperscript{70} \textit{Id}. \textsuperscript{71} \textit{Id}. \textsuperscript{72} LexisNexis, \textit{supra} note 66. \textsuperscript{73} Berring, \textit{supra} note 51, at 1700.
Lexis and Westlaw first allowed users to access their products through the internet, greatly expanding the accessibility of legal search.\textsuperscript{74}

Legal search added features, increased coverage and offered increased accessibility as the cost of computerized search dramatically fell in real terms. In the 1970s, a search for the phrase “trial by jury” on Westlaw could have cost as much as $5000.\textsuperscript{75} A similar search today on Westlaw Next would cost only $60.\textsuperscript{76} While this represents a tremendous reduction, looking at the cost effectiveness of Westlaw or Lexis alone overlooks perhaps the most important change in the cost of legal search: the introduction of free legal search by services such as Google Scholar and FindLaw.\textsuperscript{77} On either of these sites, researchers have access to decades of case law, all fully searchable. Google Scholar even links cases by citation, so that a researcher can easily see all of the cases that have cited to a particular opinion.

Given the increase in accessibility, breadth, and cost-effectiveness of legal search, we would expect to see empirical changes in how legal documents are created. One change we might expect is an increase in the number of citations in opinions and briefs, reflecting the ease with which additional case law is acquired. Two studies have shown this exact phenomenon. A study of California Supreme Court opinions shows that the number of citations doubled from 1973 to 2003.\textsuperscript{78} Federal Appellate opinions increased their citations at a similar rate, going from 13.8 per opinion in 1975, to 27.2 in 1993.\textsuperscript{79}

\textsuperscript{74} LexisNexis, \textit{supra} note 66.  
\textsuperscript{75} Hellyer, \textit{supra} note 68, at 286.  
\textsuperscript{76} Ronald E. Wheeler Jr., \textit{Does WestlawNext Really Change Everything? The Implications of WestlawNext on Legal Research}, 103 \textit{LAW LIBR. J.} 359, 361 (2011). WestlawNext would charge additional amounts ($15 per document) for examining the contents of the search result.  
\textsuperscript{77} \url{http://www.findlaw.com/casecode/}  
\textsuperscript{78} Hellyer, \textit{supra} note 68, at 294. Hellyer concludes that legal search has not increased the court’s access to legal knowledge because the amount of citations per word of an opinion has decreased. We think that citation density is a poor measure to judge of the effect of legal research. Increased access to legal
Computerized legal research has also led to tremendous improvements in the accessibility of secondary sources and non-legal sources. Lexis added its Nexis service in 1980, allowing customers to search journalism articles. By 2000, LexisNexis was adding 8.7 million documents to its database every week. Lexis and Westlaw also added law reviews and secondary sources to their databases. Given that legal search engines have increased the availability of secondary and non-legal sources, one might expect to find increasing citations to such sources. The empirical research appears to show this. A study of Supreme Court cases from 1950 to 1995 showed a large spike of non-legal sources starting in 1991.81

Developments in legal search since then have increased the availability of secondary sources. In 2004, Westlaw introduced a feature called ResultsPlus to its search engine. ResultsPlus automatically gathers secondary sources that may be relevant to a search query and displays them in a sidebar next to the regular search results.82 WestlawNEXT went even further with the introduction of database independent search.83 Rather than having to specifically seek out information in secondary sources, WestlawNEXT automatically displays the relevant secondary sources, not in a sidebar,
but as a complete category of results displayed in the same format as the case law results.\footnote{However, in assessing the effect of legal search on these sources, it is important to remember the goal of any individual attorney is winning the case, not presenting the most wide ranging argument. Legal search can allow an attorney to quickly find the legal opinion that makes his case. In this way, legal search could depress the use of argument by analogy, which in turn might depress the use of secondary sources. Regardless of their eventual insertion into briefs or opinions, the important fact is that legal search makes the information available.}

Thus, even the beginnings of computerized search have had dramatic effects, overcoming each of the defects we noted in structure of search that West Publishing previously created in the late nineteenth and twentieth century. First, a wider variety of opinions can be searched because of the ease of putting information online. Second, lawyers can search through categories of their own choosing, created by their own works, rather than depending on preset categories. Third, secondary literature can be searched and this search can be seamlessly integrated into searches for law. Perhaps most importantly, free computer search engines are now emerging—a first step to democratizing legal search and making even complex law available in real time to the citizen.

\section*{B. The Future Improvement of Computerized Legal Search}

\subsection*{1. Moore’s Law and Powerful Natural Language Search}

Given the dramatic changes that the introduction and improvement of legal search has already created, it is important to explore how legal search will likely develop, before discussing how these changes will affect the form of law. The main driver of continuing legal search improvement is Moore’s law. Moore’s law is a technology trend identified
by Intel co-founder Gordon Moore in a 1965 article. In the article, Moore noticed that
the number of transistors on an integrated circuit had roughly doubled every year over the
previous seven years. With uncanny consistency, the exponential growth Moore
identified has continued over the past 46 years. But even this trend understates the
stability of exponential growth. Inventor Ray Kurzweil has demonstrated that
exponential growth in computing predates Gordon Moore’s prediction by a full 70
years. He found that the electro-mechanical devices used to compute the 1890’s census
experienced year to year exponential growth, as did the electronic relay and vacuum tube
based computers that followed. After 120 years of consistent exponential growth, the
safe bet is that this growth of some kind will continue. Current research has already
identified specific techniques that will extend Moore’s law for at least 10 more years.

Since very substantial growth in computational power is likely to continue for the
foreseeable future, the question for future legal search is how to take advantage of this
additional processing power? In our view, computers will take advantage of the new
processing power to deploy advanced algorithms in order to accurately decipher natural
language questions. Two recent technological advances outside law are harbingers of

85 Gordon Moore, Cramming More Components onto Integrated Circuits, ELECTRONICS 114 (Apr. 19,
1965).
86 From 1965 forward, the rate of doubling was closer to once every 24 months. This improvement,
however, understates the overall improvement in integrated circuits, as it doesn’t account for the increased
speed of the transistors, improvements in chip architecture, and declining costs of the integrated circuit in
real dollar terms.
88 Id.
89 All exponential trends must end eventually of course, and there are theoretical limits to the computational
ability of matter. However, current computers are nowhere near those limits. See id. at 34.
90 Intel, Intel Developer Forum 2008,
http://download.intel.com/pressroom/kits/events/idffall_2008/PatGelsinger_keynote_transcript.pdf (last
visited Aug. 15, 2012); PhysOrg, 15 Moore’s Years: 3D chip stacking will take Moore’s Law past 2020
Hodgin, New research suggests Moore’s Law will not cease around 2020, TG Daily (Dec. 10, 2008),
http://www.tgdaily.com/trendwatch-features/40515-new-research-suggests-moores-law-will-not-cease-
what the future of legal search will entail: IBM’s Jeopardy! playing computer Watson, and Apple’s virtual assistant Siri.

To enable Watson to play Jeopardy! Watson has basic language rules programmed within it. Watson also possesses over 100 separate modules with their own unique algorithm, each of which would individually try to determine the correct answers to questions on the show (technically of course, according to the rules of Jeopardy! it finds the correct questions to answers). Watson is also constituted by a separate layer of algorithms that balance the results suggested by the competing modules in order to find the right answer.

Since the modules would not always agree on an answer, Watson does not generate one definitive answer, but instead generate several possible answers, each with its own probability of being right. During Jeopardy, Watson attempted to answer a question only if the probability of the top ranked answer reached a certain threshold.

The specialized modules in Watson have a natural analogue in the specialized sections of the human brain. Like Watson, the answers stemming from human minds are thought to emerge from the harmonization of these different sections. Indeed, after learning about the process by which Watson determines answers, Ken Jennings, the

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93 Id.
94 Id.
96 “The ultimate consciousness product occurs from those numerous brain sites at the same time and not in one site in particular, much as the performance of a symphonic piece does not come from the work of a single musician or even from a whole section of an orchestra.” Antonio Damasio, Art and Science Peer into the Mind, DISCOVER MAGAZINE (July 7, 2011), http://discovermagazine.com/2010/dec/17-art-science-peer-into-the-mind/article_view?searchterm=damasio&b_start:int=2.
famous game show champion, remarked that “the computer’s techniques for unraveling Jeopardy! questions sounded just like mine.”

Watson defeated Ken Jennings and Brad Rutter (Jeopardy!’s all time money leader), in February of 2011, more than doubling the scores of the human contestants. IBM is currently adapting Watson’s natural language abilities to create a system for improved medical diagnosis. IBM also states that deploying Watson’s technology in the legal field is one of its future projects.

Like Watson, much of the genius of Apple’s Siri lies in deciphering the meaning of language. Siri is a virtual assistant that is built into Apple’s iPhone 4S. It responds to simple natural language commands such as requests for weather reports. It can also transcribe and send text messages and can even make restaurant reservations. Unlike Watson, however, Siri must accomplish these tasks using the computation available on a smartphone, rather than a supercomputer. The key advantage that Siri has, and the reason it is so important to the improvement of natural language algorithms, is its immense user base from which Siri and its subsequent iterations can learn. Apple is currently storing the raw data of each Siri interaction in a massive computer database in North Carolina. Its engineers will be able to mine this database to correct Siri’s errors and add new capabilities for understanding.

99 IBM, supra note 93.
101 Id.
103 Id.
By improving the level of accuracy and breadth of response, technologies like Siri and Watson change the very nature of search. As Gary Morganthaler, an early backer of the technology behind Siri, put it, the future of search is “not a million blue links, but one correct answer.”

Given the future importance of understanding natural language, it is not surprising that both Lexis and Westlaw are making serious efforts to improve their natural language searches. Westlaw felt confident enough in its technology to make natural language search the default search choice in Westlaw Next. Lexis’ new search product “Lexis Advance” will include an upgraded natural language search. The goal of this search is to understand the semantic value of the search query, rather than just trying to find the exact words being searched for. If working properly, this search should be able to pull up a result that doesn’t contain any of the words that were used in the search, but is nonetheless on topic.

However, while legal search companies are making large strides in this area, the big breakthroughs are likely to initiate in other fields and then be transferred to law. Legal search will improve through picking up the more general search features, because the market for general natural language search is so much larger than that for legal search. Once a company such as IBM, Apple, or Google has created the proper algorithms, there is very little marginal cost in applying those algorithms to legal

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105 Interview with Clemens Ceipek, Ian Koenig, Steve Mann, LEXISNEXIS, (Dec. 14, 2011).
106 Id.
As a result, the improvements in general natural language understanding will quickly be brought to bear on the problem of legal search.

2. The Practical Effects of Accurate Natural Language Search

These new algorithms and additional computing power will likely improve legal search in two broad phases. The two phases are broken apart by the function of the lawyer. In Phase I, the lawyer spots the issues and looks to the search engine to identify the relevant cases. In Phase II, the search engine itself will identify the issues implicated within a given set of facts, and then suggest the case law likely to be on point for the issues it identified. This second phase will cabin and may someday effectively eliminate the role of the lawyer in legal research. Since the second phase is likely to be at least 15 years away, this article will focus on the ramifications of the first phase of legal search improvement.

Legal search engines during Phase I of search improvement will build upon the process that lawyers use to interact with search engines by adding the capability of accurate natural language understanding. Legal search engines have incorporated a natural language search option for twenty years, but its effectiveness has been limited. Unlike keyword searches, where the search engine simply scans for the keywords in documents, natural language search attempts to understand what the search query is

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107 Improved algorithms may also migrate over from the field of legal discovery search. The need for automated search in that field may be even greater than the need within the case law search field. The cost of a thorough discovery search can often exceed the value of the case. The leading journal on e-discovery issues has specifically advocated that lawyers co-operate in developing improved artificial intelligence as a necessary component for future legal cases. See A Project of The Sedona Conference Working Group on Best Practices for et. al., The Sedona Conference Best Practices Commentary on the Use of Search and Information Retrieval Methods in E-Discovery August 2007 Public Comment Version, 8 Sedona Conf. J. 189, 212 (2007).
asking for. As an example, if you searched for “boat accidents” using a keyword search engine, the search engine would simply look through documents to find those that contained the words “boat” and “accident.” Documents might then be ranked higher if the words appeared more often or closer together. A natural language search would try to understand the search query on a more fundamental level. For instance, the search engine could pull documents that dealt with a “ship” accident or a “sailboat” accident, knowing those words were synonyms for the word “boat.” More sophisticated algorithms would be able to understand longer, more complicated natural language queries that included verbs and adjectives, but this level of understanding is still in its infancy.

Today, despite the some advances in semantic understanding, legal search engines still work as a searchable index. Lawyers searching the index play a guessing game, trying to come up with the magical combination of terms that will get the search engine to return the relevant case law. The guessing game takes time, energy, and money. In Phase I of search improvement, legal search engines will eliminate the guessing game by understanding, at a human level, the legal question being posed. Instead of typing in a search term like “conspiracy /s (cover-up getaway escape) /p join!” the lawyer will simply ask “find case law where the court discusses whether helping to cover up a conspiracy means you are responsible for the acts of the conspiracy.”

It is unlikely that these search engines will be able to find the one case that is most on point. Instead, following Watson, the search engine will likely use competing algorithms to “score” each possible case for how well it lines it with the search query, and come up with a short list of the top ranked cases. The algorithm could then also take into account non-language related factors, such as whether the opinion was heavily cited.

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108 Interview supra note 106.
to or searched for. Westlaw Next is actually already implementing this feature, altering its search results depending on how often a case has been downloaded or highlighted.\textsuperscript{109}

When natural language understanding and case ranking algorithms are implemented, the search engine will operate, essentially, as an Automated Legal Encyclopedia (“ALE”). Legal encyclopedias like American Jurisprudence (“AmJur”) and Corpus Juris Secundum (“CJS”) ideally work like a good legal researcher. If a lawyer has a question on how the statute of repose works in the state of Illinois, a look at that topic section in the encyclopedia should give him a good overview of the relevant case law, just as a legal researcher would do if they were given a research task. While legal encyclopedias often work exactly as planned, they are far from perfect. The two key flaws in legal encyclopedias are dated citations and inflexibility.

Many of the cases cited in the legal encyclopedias are far too old to make it into a strong legal brief. In such encyclopedia as AmJur, CJS, or their state law equivalents, citations to cases from the 1800’s are far from rare.\textsuperscript{110} An ALE search will not have this limitation. The database it is based on will be refreshed whenever a new case is published. When a lawyer gives the computer a topic to research, the computer will access that database and use it to compile a fresh list of cases that are on point for that topic. Essentially, the encyclopedia topic is recreated with every search. This development will eliminate the problem of case law that has been overturned or is simply stale.


\textsuperscript{110} See e.g. 6 Am. Jur. 2d Assignments for Benefit of Creditors § 60; 74 C.J.S. Railroads § 585.
By creating each research topic from scratch, the search engine will also overcome another flaw of legal encyclopedias: lack of flexibility. Legal encyclopedias are very detailed, often having four or more levels of sub-headings under a single topic. No matter how detailed, however, no encyclopedia can possibly have a heading for every available combination of law and fact. If the particular case law that the lawyer is looking for is not contained in the encyclopedia, then it serves as merely a jumping off point for further research on an issue. An ALE will be able to provide customized results that highlight the exact cases that the lawyer is looking for. A lawyer using ALE search will therefore have instant access to the case law that is in his favor. ALE search will also be able to pull up secondary sources that can support the case law and contextualize the legal issues in the case.

C. Information Theory and Advanced Legal Search

ALE search will represent the next installment in the push/pull relationship of case law growth and increased legal synthesis that has taken place throughout legal history. However, its effects will be more profound than any previous step in the history of legal technology. In fact, the capability of ALE legal search could develop into the law itself. To understand why this will be the case, we examine how legal information fits into the framework provided by information theory.\textsuperscript{111} Despite the potential synergy between information theory and law, there has been a surprisingly small body of scholarship on this subject.\textsuperscript{112}

\textsuperscript{111} For an underappreciated explanation of information theory as a potential framework for understanding law, see Martin Shapiro, \textit{Toward a Theory of Stare Decisis}, 1 J. LEGAL STUD. 125 (1972).

\textsuperscript{112} For examples of legal scholars using concepts from information theory, see e.g. Barton Beebe, \textit{An Empirical Study of U.S. Copyright Fair Use Opinions, 1978 – 2005}, 156 U. PA. L. REV. 549, 596 (2008)
There are two concepts in particular that apply to our thesis: the signal to noise ratio and the algorithm theory of information content. Information theory is both conceptual and mathematical. In this early application of information theory to law, we do not seek to apply information theory to law in a rigorous mathematical sense. Instead, we look to how the concepts suggested by information theory have application to law and legal search.

Claude Shannon founded information theory in 1948, when he published his article “A Mathematical Theory of Communication.”113 Among other things, Shannon showed that the maximum amount of information that can be reliably carried through a signal is limited by the amount of noise in the channel.114 In telecommunication, this noise would show itself as the hisses and pops that inevitably accompanied a signal and altered the message that was transmitted.

Shannon showed that if you really needed to be sure that the message you were sending was received accurately, despite the noise, the only way to do this was to make the message redundant.115 The greater the amount of noise, the more redundancy had to be built into the signal. By requiring more redundancy, which takes time and energy to produce, noise reduces the potential of a system to communicate. 116

A message sent through a telegraph wire illustrates the uses of redundancy. The noise in the wire could alter the signals sent so that the letter “a”, sent at one telegraph station, is received at another station as the letter “b.” A natural amount of redundancy in  

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(criticizing fair use doctrine as syntactic rather than cybernetic feedback); see also Randy Barnett, The Virtues of Redundancy in Legal Thought, 38 CLEV. ST. L. REV. 153 (1990) (explaining how redundancy in law leads to both increased jurisprudential certainty and discovery).

114 Id.
115 Id.
116 Id.
the English language provides a counterweight to such errors.\textsuperscript{117} For instance, you might be able to understand when we write words without vowels. However, while such communication can potentially be more efficient, the lack of redundancy would make the message more vulnerable to noise.\textsuperscript{118} For instance, if a telegraph operator sent the word “where” down the telegraph line and noise turned the “r” into a “t”, there is a decent chance that the receiver of the message will understand “whete” to have been a scrambled version of the word “where.” In that case, there would be no loss of information, despite the noise. However, if the word “where” is sent without any vowels as “whr” and the “r” is turned into a “t”, leaving the word “wht”, the receiver will likely view the message as the word “what.” Because of the lack of redundancy, the same amount of noise has now caused a loss of information.

To ensure that a message is received accurately, a sender can go beyond the redundancy inherent to language and add repetition. For instance, picture a young salesperson in the 1870’s meeting an unfamiliar business contact. The salesman knows that his manager has met with this contact before, so he telegraphs a question, asking his manager to describe the contact’s character. If the manager was concerned about noise in the transmission, and wanted to be sure the salesperson got the right message, he could incorporate redundancy by sending the message “bad bad bad.”

But redundancy is broader than simple repetition or additional letters. For instance, let us change the above scenario slightly. First, we will change the telegraph system so that there is no longer any noise in actual wire signal. Any message sent will

\textsuperscript{118} Id.
be the exact message delivered to the other side. However, we will also change the salesperson into someone who has a very limited grasp of English. In this scenario, the manager would likely feel the need to be redundant, just in a different way. He might write with a semantic redundancy, “bad evil liar,” in the hopes that the salesperson would recognize at least one of the words as negative.119

This same sort of noise occurs in legal search. The noise is the lack of intellectual convergence between the searcher of law and the search engine responder. Legal search fights this lack of intellectual convergence through redundancy. Since the legal search engine does not have the intelligence to actually understand legal search queries the way a human being would, legal search is used to download massive amounts of case law. For instance, legal search can bring up all cases where the discovery rule is mentioned, but not all the cases where the rule is applied in ways applicable to particular fact pattern. Like the manager writing to his salesperson, the legal search process is predicated on the hope that some of the cases produced line up with the understanding of the questioner.

Intelligent search engines will allow us to reduce the level of noise inherent to this process. Instead of returning hundreds of cases of marginal importance, a search will return a few, highly relevant cases. Seen through the prism of information theory, the legal information system will have improved its ability to communicate. Naturally, this improvement in capability should lead to changes in how the law is created and disseminated. Legal actors will not have to spend a great deal of energy looking through irrelevant case law, and will instead either focus their energies on crafting better arguments or simply reducing the cost of their services.

119 For a fascinating example of how African tribes overcame this kind of noise in drum signals, see GLEICK, supra note 63, at 22-25.
As noise is wholly eliminated it will have a dramatic effect: the legal search engine will become the law itself. To understand why this is the case, we must understand a different part of information theory: the algorithm theory of information.

This theory was conceived by Gregory Chaitin.120 Mathematicians wanted to understand how much information was carried within a given message. What Chaitin determined was that the proper way to measure the amount of information contained in a message is to determine the smallest possible algorithm that could describe the message.121 For instance, think of the binary string “01” repeated one million times. In order to transmit that information, it is not necessary to send one million copies of the “01” string. Instead, the information could be captured in the shorter and simpler message “repeat ‘01’ one million times.” The amount of information contained in “01” string, therefore, is actually rather small. On the other hand, for a truly random string of numbers, there is no way to compress the message into an algorithm. Instead, the entire message must be sent. The information contained in a random string of numbers is therefore exactly equal to its length.

The English common law, as it existed before synthesis, can be viewed as being in a random or “uncompressed” form. Since there were no guideposts, determining what the law was on a particular issue would require going through each case in the case law records. Synthesis, such as that provided by Blackstone, provided a series of algorithms that compressed the information contained in the case law. Blackstone would state that the law on issue “X” stems from the decisions in cases “A”, “B”, and “C”. West Publishing’s Key Digest system had a similar effect, but had the additional benefit of

121 GLEICK, supra note 63, at 332.
providing an exponential leap in the number of algorithms available to the legal researcher.\textsuperscript{122} However, these algorithms were still inevitably limited, since they could not capture every legal scenario. Thus, these summaries and digests were rough approximation of the law, rather than the law itself.

Modern legal search refines the process Blackstone and West began. By allowing researchers to design their own queries, legal search opened up an infinite amount of potential algorithms. As described above, however, this communication signal is currently reduced by the noise inherent in the lack of intellectual convergence between sender and receiver. If this noise can be severely reduced to the point that legal search becomes highly accurate, then this problem goes away.\textsuperscript{123} The question of “what is the case law on the discovery rule in X situation” will not be scattered among random case numbers, or found in legal encyclopedias, but will instead be entirely contained within the phrase itself (placed into a legal search engine). Since the researcher will be free to pose any question of law to the search engine, then the search engine itself will effectively become the law.

We use the term “law” here the same way Justice Oliver Wendell Holmes did when he said “[t]he prophecies of what the courts will do in fact, and nothing more pretentious, are what I mean by the law.”\textsuperscript{124} We are speaking positively, not normatively –about what the law is, not what it should be. And Holmes’ term “prophecies” is here very relevant. So long as human judges decide the law in the future, what the law is at

\textsuperscript{122} See Berring, supra note 51, at 1693.

\textsuperscript{123} A critic may counter this proposition by pointing out that the noise between the legal search engine and the researcher can never be completely reduced, since the intellectual convergence between the two parties can never be complete. This is true. However, the same can be said of a researcher and a legal encyclopedia. It will never be the case that the researcher’s understanding of the topics in the encyclopedia line up perfectly with the author’s understanding, but we accept that they can be close enough to allow for efficient communication.

\textsuperscript{124} Oliver W. Holmes, The Path of the Law, 10 Harv. L. Rev. 457, 460-61 (1897).
present is always only an informed prediction. But if is the best prediction available, it is in effect the law until the judges make their decision. There is no better way for citizens to plan their lives than to follow the best prediction of the law. Thus, the algorithm becomes the law until judges add data that changes the algorithm.

It might be objected that law is more complicated than mathematics and therefore the algorithm analogy is inapt. In any legal area there are conflicting decisions. Thus, the argument would run, no algorithm can compress all the decisions into a predictive algorithm, because some of the decisions conflict in a variety of ways. But this objection does not undermine the usefulness of information theory to capture compression that computation can bring to law.

Algorithms can be statistically based and thereby sift the likely rule from a variety of rules that are more or less strongly supported by case law or other data points. One can think of this process as not different in kind from a regression analysis. Not all the data need to be on a line for a line to be fit to the data. Moreover, computers can be programmed to treat some decisions as having more generative force, because they are from higher courts or even because they are from more persuasive judges. These weights can be readjusted as the computerized service gathers more information about decisions in all areas of law, thus ever refining the weights it assigns decisions for their predictive value. Thus, in time machine intelligence can provide the probabilities of what the legal answer will be, just as the computer program that recently won at Jeopardy!

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125 For discussion of regression analysis, see Norman Nie et al., STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES 322 (2d ed. 1975)
gave the solution it deemed most probable to problems posed on that game show, but also displayed its confidence levels in a variety of plausible solutions.\textsuperscript{126}

III. The Move to Standards and Dynamic Rules

In this section, we consider how increased information capacity will affect the form of law. First, we show how the capacity makes standards relatively attractive compared to rules, because improved legal search can make the legal effects of standards more accessible to the community. Second, we show how it makes dynamic rules relatively attractive compared to static rules, because more information is available to automatically update complex rules. We end by a comparison of standards and dynamic rules, showing that the choice between them will often come down not to a question of technological capacity but human fallibility—how much trust we have in judges and other decisionmakers charged with applying the law.

A. Informational Capability and its Effect on the Rules vs. Standards Debate

In this section, we discuss how increased informational capability, and ALE search in particular, will allow us to take advantage of the many benefits of standards-based law. First, we outline the rules vs. standards debate in general terms. We then apply the informational capability framework to show how the use of standards-based law will be improved by ALE search because its greater capacity to find the law will both help the judiciary more rapidly mold more efficient standards and will help citizens more easily access the content of those standards. We close this section with two

\textsuperscript{126} See IBM, \textit{supra} note 93.
examples: an examination of Montana’s “reasonable and prudent” speed limit and of standards used to prevent tax avoidance. Both show the advantages of standards in the coming world of very low information costs.

1. Background of Rules vs. Standards Debate

Our analysis of the rules versus standards debate begins with a definition of what we mean when we say that a law is a “rule” or a “standard.” We define a rule, in its purest form, as “a directive to an official that requires him to respond to the presence together of each of a list of easily distinguishable factual aspects of a situation by intervening in a determinate way.”127 The prototypical example of a rule-based law is a speed limit which holds that a driver must drive at 65 miles per hour or less. In contrast, a standard “requires the judge both to discover the facts of particular situation and to assess them in terms of the purposes or social values embodied in the standard.”128 A standards-based speed limit, for example, would hold that a driver must drive at a “reasonable” speed.

In outlining these differences, we recognize that in the real world rules and standards rarely exist as perfect Platonic forms.129 It is possible to consider a rule that is sufficiently open to interpretation that it becomes a standard, or a standard that is so fixed in its interpretation that it becomes a de facto rule.130 We will leave it to others to define

128 Id.; see also Russell B. Korobkin, Behavioral Analysis and Legal Form: Rules vs. Standards Revisited, 79 OR. L. REV. 23, 30 (2000) (“under rules, outcomes are determined by the presence or absence of triggering facts that can be specified ex ante; under standards, outcomes require situation-specific factual inquiries and/or balancing of competing factors”).
exactly when a law crosses the rule/standards boundary. For this article, it is enough that some laws are more rule-like or standard-like than others. Those laws will contain the benefits and drawbacks of rules or standards to such degree as they are more like the ideal rule or standard.

We start first by discussing the fundamental benefit of standards, which is their ability to take advantage of distributed decision making. As discussed in Part I, distributed decision making is the process by which multiple parties converge on an optimal solution by each contributing a portion of the answer. While the creation of a rule often involves multiple parties in a legislature, once a rule is written it is supposed to be interpreted in more or less the same way as new cases are brought before the court. With a standard, the interpretation changes both because the facts of each individual case vary and also because each judge may have a different idea of the most efficient way the standard should be applied. While this process means the development of standards-based law is more chaotic, it can lead to a better legal framework in the long run through two processes of natural selection.

Of the two processes, one is conscious while the other is not. The conscious process of judicial natural selection is straightforward. The first judge to reach a decision on a given set of facts may make a good decision or a bad decision. If it is a good decision, it is more likely to be held up by higher courts on appeal. It is also more likely to be followed by sister courts within and without the jurisdiction. The reverse holds for a bad decision, which is more likely to whither on the judicial vine.

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131 See supra note 5; see also supra note 8.  
132 This assumes that the judiciary is more prone to making good decisions than bad ones. Without that assumption, this entire article is moot.
The other process of natural selection requires no ability whatsoever from the judicial branch. It occurs because bad decisions are more likely than good decisions to be re-litigated in the courts. 133 For instance, suppose a judge interprets a standard in an inefficient manner. The party that lost the decision will have more to gain from overturning it than the party that won will have to gain by defending it. 134 This dynamic means that parties that lose an inefficient decision will be more likely to take their future cases to trial. 135 Even if the subsequent decisions were to be decided by random chance, the increased pressure on inefficient decisions would cause them to be overturned with greater frequency.

While the benefits of distributed legal information are significant, the flip side to having all of this distributed information is that it makes it harder for lawyers, judges, and clients to understand and use this information. 136 This difficulty is a problem both ex ante and ex post. Ex ante, an actor subject to a law wants to understand what actions the law requires, so that he may avoid liability. 137 Instead of simply looking up a statute, as in the case of a rule, an actor subject to a standard would need to try and collect the relevant case law to figure out what the outlines of the standard are and how it applies to him. Ex post, an actor subject to a standard would have to go through the same process in order to try and determine the likelihood of success at trial. 138 At trial, the judge has the additional burden of trying to come up with the proper application of the standard to the particular facts of the case.

134 Id.
135 Id.
137 For an example of this kind of behavior at work, see Lucian A. Bebchuk, Ex Ante Costs of Violating Absolute Priority in Bankruptcy, 57 J. OF FIN. 445, 445 (2002).
138 Corbin, supra note 135, at 21-22.
Although there is a fascinating range of scholarship on the topic of standards and rules, Louis Kaplow offers the now canonical law and economic analysis of the benefits of rules versus standards. The first factor to consider is cost. Rules are generally more expensive to create, but then generally have lower enforcement costs going forward. Rules-based laws are more expensive than standards-based laws to create because of the greater level of care that must be taken when creating a rule. For them to perform well, we need to have a lot of information about all of their potential applications—information that standards gather over time. Rules must be designed carefully because they apply to a broad array of situations and are determinative as to outcome. They also tend to be hard to change or sticky, because it is costly for legislatures and administrative agencies to come to an agreement to change rules. However, once a rule has been promulgated, the costs of enforcement are less than with standards. The court system itself must incur a greater litigation cost when deciding standards because it must give content to the standard, which takes more energy than determining whether a rule has been violated. Moreover, the individual subject to a

139 Much of the scholarship frames the discussion within questions about the applicability of standards or rules to particular areas of law. See e.g. Clayton Gillette, Rules, Standards, and Precautions in Payment Systems, 82 VA. L. REV. 181, 201-203 (1996) (discussing how information asymmetries between group leaders and the public lead to the development of potentially inefficient rules rather than standards in payment system regulation, because the public is more likely to appreciate rules); see also Joel Reidenberg, Lex Informatica: The Formulation of Information Policy Rules Through Technology, 76 TEX. L. REV. 553, 568 (1998) (explaining how flexible standards regarding information security can be promulgated and ultimately embedded into privately designed computing networks by merely becoming industry defaults rather than through governmental intervention).


141 Id.

142 For a more complete discussion of the stickiness of legislative and administrative rules, see infra notes xx and accompanying text.

143 Id. at 570
The standard must incur a greater cost to learn about a standard, which is contained in dispersed case law, than to learn about a rule.\footnote{Id. at 571; contra Ian Ayres, Preliminary Thoughts on Optimal Tailoring of Contractual Rules, 3 S. Cal. Interdisc. L.J. 1, 8 (1993). Ayres describes the possibility that standards, by expressing the law in commonsense terms, may sometimes provide an individual with easier access to the law than a rule. \textit{See e.g.} Korobkin, supra note 127 at 34 (“[i]t would take little research for a lawyer to learn and communicate that the speed limit is 65 mph or that the speed limit is a ‘reasonable speed’ given road conditions”). In this example however, for the lawyer’s client in this case to be truly informed of his legal position under the standard the lawyer would need to do further research to identify case law where the “reasonable speed” standard was interpreted in cases where the facts were similar to the client’s situation. Because of this additional informational burden inherent in standards-based law, we hold that, typically, rule-based law is easier to derive information from.}

The second consideration for Kaplow is the likelihood actors will conform their conduct to the law. If actors are able to inform themselves as to the consequences of the law beforehand, they are more likely to act in accordance with the law. Under a system of rule-based law, the legal norm is stated before an individual has the opportunity to act, giving them the chance to inform themselves about the law and act accordingly. In a standards-based law, the individual is not able to know the exact outlines of the law until it is given content by the court. Individuals under standards would therefore know less about the law before acting. This lack of information would mean that individuals are less likely to conduct their actions in accordance with the law.\footnote{Kaplow, supra note 139, at 564.}

We fully agree with Kaplow that standards generally impose higher information gathering costs compared to rules, because distributed systems of legal ordering require more litigation to create legal norms and because information about the law is more widely distributed (in case reports, for instance), making it likely harder for citizens to know how their conduct will be affected by law.\footnote{As Kaplow noted, the exception could be if a rule was passed that was hardly ever litigated. In that case, the upfront cost of creating the rule would be greater than cost of litigated standards based, information-rich cases, since the cases would be so rare.} As we detail below, our thesis is that greater information capacity both reduces litigation costs of standards and makes it easier...
for citizens to conform to the legal requirements of a standard. By reducing these downsides of standards, it makes them generally more attractive than they were in a world of greater information scarcity.

If information costs help reduce the characteristic flaws of standards, they put into relief an important advantage that standards enjoy over rules. Rules are seen to suffer from the problem of over or under inclusiveness because it is impossible in advance to know all the possible situations to which a rule may apply. Over inclusiveness occurs when a rule is applied to a situation that it was not intended to govern. Under inclusiveness occurs when clever legal actors identify loopholes in the rigid structure of the rule. Standards, by being more complex than rules, are able to encompass a more complete range of possible actions and thereby avoid this problem.

Kaplow disagrees with this view of the relative complexity of rules and standards. He suggests that there is no inherent difference in the complexity of rules and standards (by inference suggesting that there is no inherent problem of over or under inclusiveness with rules). To prove his point, Kaplow posits an intellectual device, the “rule equivalent” to a standard. This rule would have the exact same factors as its equivalent standard. Through this device, Kaplow argues that the complexity of rules and standards is not inherent to their form, since they can both be just as simple or complex as each other.150

147 Frederick Schauer, Rules and the Rule of Law, 14 HARV. J.L. & PUB. POL’Y 645, 646 (1991); Kennedy, supra note 126 at 1689.
148 Kaplow, supra note 139, at 586.
149 Id.
150 If the concept of a “rule equivalent” were accepted, it would, in the end, prove too much, as it can be used to destroy the entire concept of a “rule” and a “standard”. For instance, you can imagine a standard that has developed into a long standing precedent, and this could be the “standard-equivalent” to a rule. You could then compare this to a rule that has been frequently modified, and find it is now the frequently changing rule that would be engaged in ex post decision making, while someone subject to long standing
We disagree with this interpretation, because to the extent that a standard has
discrete factors, that standard has become more rule-like. A true standard is inherently
more complex in its application than a rule, since the factors are given content in relation
to the specific facts of each case, and the number of possible facts in a case is infinite.
Thus, for instance the standard, “drive at a reasonable speed,” does not provide a fixed
value or hierarchy of the factors that determine reasonableness. This increased
complexity creates an informational burden on any individual trying to decide how a
standard will apply to the facts of their particular case. We will refer to this difference in
complexity as relating to the “substance” of the law.

In addition to this difference in the complexity between rules and standards, there
is a difference in the complexity of the “medium” through which standards and rules are
promulgated. The information within a rule exists in a single location. For instance, a
driver passing by a 40 mph speed limit sign does not need substantially to inquire how
various courts have interpreted what the term “40 mph” means. In contrast, the actual
embodiment of a standard exists in pieces of case law, which are scattered within the
jurisdiction where the standard was created (and even, through persuasive authority,
contained in the law of other states or nations). Such a distributed system is inherently
more complex than one with a single source.

precedent would be able to confidently predict the law ex ante. Furthermore, the concept of the “cost” of
promulgating the rule can be turned on its head as well. If the development of the “standard-equivalent”
only took place after a series of costly court battles, it could be said that it required a greater up-front
expenditure than the rule. And yet, if it remained precedent for a long time, it would have the low
enforcement costs of a rule. Kaplow seems to recognize the latter problem. See id. at 577. The “rule-
equivalent” device only proves the widely accepted point that in the real world rules and standards exist on
a spectrum, and any individual law likely has elements of both. See Korobkin, supra note 127, at 26 (“the
two types of legal forms are better understood, as a descriptive matter, as endpoints of a spectrum than as
dichotomous categories”).
Although we disagree with Kaplow’s view on complexity, this disagreement is not central to our thesis. From the perspective of Kaplow, our thesis would change from advocating the greater use of standards, to advocating the greater use of complexity, both in terms of substance and medium. We believe lower information costs generated by improved technology permit us to introduce more complexity in terms of substance either through the use of standards or dynamic rules that adjust automatically to different circumstances. Kaplow does not discuss complexity in the medium of law, but it is evident that that distributed law is more complex than centralized law. Our argument is that technology will allow citizens to more directly access scattered legal information and thus permit the greater use of standards which themselves encourage more use of distributed law.

We have described the costs and benefits of rules and standards in order to lay a foundation for our thesis, which considers how society’s increasing ability to use information will interact with the form of our laws. We are not aware of any article that discusses the rules vs. standards debate from the standpoint of increasing informational capability. But given the centrality of exponentially increasing informational capability to our time, this dimension is now central to the tradeoff between standards and rules. The greater easing in finding the law made possible by better information technology will work to limit the downsides associated with standards-based lawmaking, thereby allowing lawmakers to take advantage of the many benefits of standards-based law.

2. How ALE Search Makes Standards More Attractive by Decreasing the Cost of Finding the Law
An Automated Legal Encyclopedia or ALE search reduces the cost of finding the law, reducing both litigation costs and the difficulty individuals have in conforming their behavior to standards—the two greatest drawbacks of regulating behavior by standards rather than rules. First, ALE search allows actors to understand standards-based law with less cost and greater accuracy. ALE search lowers the cost of legal advice by substantially cutting down the amount of time the lawyer needs to gather the relevant case law on the topic. Accuracy is improved by leveraging the superior processing power of computerized search. This improved accuracy gives the actor two of the key benefits of rules—knowing how to conduct himself to avoid litigation, and knowing where he stands when faced with litigation.

But ALE search also increases the ability of judges to utilize legal information when crafting their opinions, permitting more rapid and accurate application of precedent when creating standards. ALE search achieves these benefits by increasing the quality of the legal briefs presented to the court. Partially, the increased quality flows from the simple fact that a lawyer using ALE search is less likely to miss case law that is relevant to the proceeding. The greater improvement, however, could come from increased depth and creativity in briefs. Since the cost in time and energy of pursuing alternative legal theories is reduced, lawyers who have ALE search can take advantage of the opportunity to essentially brainstorm with the ALE. The lawyer can come up with a whole multitude of arguments for his client, the computer will quickly deliver the relevant case law, and the lawyer will be able to determine which avenues are fruitful. Gary Kasparov, the famous chess champion, has pointed out that a similar process takes place today with
humans and chess computers.\textsuperscript{151} Although computers today are far better than humans at playing chess, a human with access to a chess computer can work with the computer to perform better than any computer can alone.\textsuperscript{152}

The improved depth and range of legal briefing also makes it more likely that the first court to interpret a standard will make a legally efficient decision. With ALE search, the court is better exposed to relevant precedents in other jurisdictions along with pertinent information from secondary sources. With this information in hand, it is more likely that the first court decision will line up with the eventual consensus view, meaning there is less need for the court to reverse itself down the line. These developments make the process of legal natural selection, already a benefit of standards-based law, move faster.

One way of understanding the way that greater information capacity reduces litigation costs is that it improves the capacity of the judiciary. Hans-Bernd Schäfer argued persuasively that the capability of the judiciary should influence the rules/standards debate.\textsuperscript{153} His argument stems from the fact that standards require a highly capable judiciary to interpret properly, whereas rules are typically easier to interpret.\textsuperscript{154} Schäfer addressed judicial capability in the context of comparing judiciaries in developed versus developing countries, and argues that developing countries should lean towards creating rules in order to ease the burden on their fledgling judiciary.

\textsuperscript{152} Id.
\textsuperscript{154} Id.
systems. We believe this same dynamic applies to our own judiciary as it increases in capability over time on account of improved legal search.

For instance, the lower cost of finding the law allows quicker molding of established precedent. Of course, every decision creates precedent. The type of precedent we discuss here is a series of consistent decisions where the facts are very similar. Precedent of this kind is basically an organically created rule. Because it is a type of rule, the benefits of established precedent are similar to those of legislature-made rules. It can give actors a clear signal of the legal playing field, typically at a low cost, since a lawyer will often know of established precedent off hand, or be able to track it down easily. Established precedent also has many of the normal advantages of standards. First, there is no upfront cost to produce it. Second, and perhaps most importantly, even though such a precedent is “fixed”, it is still based on an underlying principle. This aspect of precedent allows it to be more adaptable to individual facts. In many situations, established precedent is the optimal form of law, combining the best of both rules and standards. Since precedent evolves from standards, the possibility of developing an established precedent is an argument for choosing standards.

However, a critical issue for the efficacy of precedent is the speed at which standards become established precedent. Typically, precedent develops in fits and starts. Before someone can truly rely upon it, several lower courts, or the relevant high court, must make a clear decision. If courts are able to turn standards into established precedents with greater speed, it would bolster the argument for choosing standards.

155 Id. at 119.
156 See Kaplow, supra note 139, at 578.
157 Id. at 612.
ALE improves the speed at which precedent evolves by reducing the occurrence of inconsistent decisions. Inconsistent decisions are a barrier in the creation of established precedent, because legal actors cannot rely upon a mixed group of opinions. ALE search reduces inconsistent decisions both within and between jurisdictions. By increasing the accuracy of legal research, ALE search reduces inconsistent decisions within jurisdictions by decreasing the likelihood of a court being unaware of important precedent, the omission of which could lead the court to make an “outlier” decision. ALE search also reduces inconsistent decisions between jurisdictions by increasing the quality of briefing that courts receive. If a court is hearing a case of first impression, a higher quality brief, full of the most relevant case law and secondary sources, makes it more likely that court will decide the case consistent with what eventually becomes the consensus view.158

We can compare standards-based law and rules-based law in the same way that we can compare a Ferrari and a Prius. A Ferrari is capable of very high performance, but unlike a Prius, it requires copious amounts of fuel to run its oversized engine. Standards-based law is similarly capable of very high performance, but compared to rules it requires much greater amounts of information to fuel the decision making process. It needs a

158 Another benefit of standards is that they may increase the quality of the judiciary. Standards do this by increasing the autonomy that judges have to decide the cases that come before them. Judicial systems where judges have greater autonomy, such as common law systems, have been shown to have lower levels of judicial corruption, and greater independence from other branches of government. See Frank B. Cross, Identifying the Virtues of the Common Law, 15 SUP. CT. ECON. REV. 21, 57 (2007). Unfortunately, ALE search may have a pernicious effect on the respect for the judiciary. Increased access to information has made, and will continue to make, the task of being a judge easier. Citizens already have access to statutes and other rules, and will likely soon have access to ALE search which presents relevant case law. If the task of judges becomes more determinative, the judiciary is likely to become less attractive to prospective judges. See Id. at 53 (“in French civil code nations judges ‘are at the bottom of the scale of prestige among the legal professions.’”). Increasing use of standards could have an important countervailing effect. The adjudication of standards will still require more judgment than the adjudication of rules, even after the introduction of ALE search. Shifting the balance of decisions towards standards will therefore help slow the decrease in judicial autonomy, which may help maintain the desirability of judicial employment and the independence of the judiciary.
large and growing database of previous decisions in order to flesh out the particulars of its legal structure. It also needs the ability to sort through this sea of information and fish out only that particular information that applies to each case. Thankfully, unlike gasoline, our ability to produce, store, and sort through information is increasing at exponential rates. We can and should design a legal engine that produces the highest level of performance, confident that its demands for ever more sophisticated uses of information will be met.

3. First Example: The Montana Speed Limit Experiment

As an example of how ALE might make a difference, it is illustrative to look at what happened with Montana’s standards-based speed limit. In 1995, Montana changed its daytime driving speed from 55 mph to “reasonable and prudent,” a classic standards-based approach. The new speed law was popular amongst residents, who appreciated the responsibility of determining the appropriate speed to drive. Residents also noted that the wide variety of road conditions in Montana made a fixed rule unworkable. Multiple attempts to repeal the standard in favor of a numerical law failed in the state legislature.

However, the law was not without problems. The Montana state court system soon faced a deluge of drivers eager to argue their citations. The problem of enforcement was also recognized by police officers, who admitted they had difficulty defining exactly what the standard meant. In 1999, the Supreme Court of Montana found

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160 Id. at 186.
161 Id. at 163-64.
162 Id. at 180.
that the standard was overly vague, and overturned it in a 4-3 decision. The court’s opinion emphasized that the standard left “the average motorist in Montana [with] no idea of the speed at which he or she could operate his or her motor vehicle on this State’s highways.” While the court could credibly make that statement in 1999, a similar ruling would find less support after the emergence of widely available ALE search.

With ALE search, any reasonably intelligent private citizen could obtain a list of relevant case law that described how “reasonable and prudent” applied to specific road conditions. If given a speeding ticket, they could compare it with cases where the conditions were similar. For instance, if the driver was given a ticket while driving in snowy conditions on a two-lane highway, the ALE could provide a list of cases that involved snowy conditions on a two-lane highway. This structuring of information would discourage drivers from bringing cases where they were clearly on the wrong side of the case law. A similar process would discourage prosecutors from pursuing cases where the driver was clearly on the right side of the case law. On the other hand, a driver who had not been considering fighting a citation might change his mind if a quick search through the case law showed that he was in a grey area. By bringing this case, the driver would help the development of the law by adding depth to the “reasonable and prudent” standard.

ALE search could also help with the problem of enforcement that police officers dealt with. A police officer on a rainy four lane highway would be able to get on the internet and perform an ALE search to pull up rainy, four lane highway decisions. This ease of access would allow him to avoid issuing citations that would likely to lead to litigation.

Indeed, given today’s information capacity, a market would eventually develop for a smartphone app that automatically combined GPS location, weather data, and court decisions into an estimated speed limit. Different companies could compete to provide the most accurate prediction, and even offer drivers insurance should the app prediction fail to provide the right speed limit.

Given all of this additional information, the distributed network of judges, prosecutors, police officers, and drivers would begin to converge on just what “reasonable and prudent” meant in different situations. A similar process occurred in Montana without ALE search. In the first full year after the law was enacted, speeding citations rose by more than 50%. The next year, however, citations settled down to a level only 25% above the amount given before the rule change. Given the increased speed of information distribution made possible by ALE search, this process would accelerate and ultimately move toward a lower level of citations, because the standard would better coincide with efficient driving speeds.

A standards based system combined with ALE search would not be perfect. No matter how accurate the ALE search is, the existing case law will never exactly match the conditions a driver or police officer confronts on any given day. However, the variegated nature of conditions highlights the problems with a rule-based system in the first place. Given certain conditions such as icy roads or heavy traffic, driving the speed limit can be dangerous. In contrast, on a perfect day, with a well maintained, modern car, the

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164 King & Sunstein, supra note x, at 179.
165 Id.
166 Many states have a “basic law” that requires drivers to drive at a speed no faster than what the conditions reasonably allow. See e.g, Cal. Veh. Code § 22350 (West). This creates a hybrid system where all speeds lower than the speed limit are judged by standards-based law, and speeds above the speed limit are automatic violations. Our argument is simply that there is no need to impose an arbitrary point to switch over to rule-based lawmaking when information is more readily accessible.
speed limit is likely to be too low. While the relative strengths and weaknesses of rules and standards will continue to exist, ALE search will minimize some of the weaknesses inherent to standards, thereby encouraging their use in the future.

4. Second Example: Tax Avoidance and Discontinuous Laws

Another benefit of standards-based law is that it helps avoid the problem of discontinuities. Rule-based laws create discontinuities because they set up artificial limits within the rule itself. If an actor treads one inch past the limit outlined in the rule he becomes subject to liability, even if there is almost no substantive difference in his actions versus one who went to the limit of the law. Here we provide an example of such a problem with rules in the area of taxation and show how standards become a more attractive alternative as greater information capacity helps citizens better predict how standards will apply.

Examples of discontinuities are pervasive in the tax code. One comes from the so-called “mixing bowl” transaction.\footnote{This illustration is taken from David A. Weisbach article Formalism in the Tax Law, 66 U. Chi. L. Rev. 860, 863 (1999).} Tax laws allow members of a partnership to contribute and withdraw money from a partnership tax free. The partnership is not taxed as a separate entity. The rule creates a loophole however: two people looking to exchange a piece of property could conspire to form a quick partnership, add their respective assets to the partnership, and then each partner could withdraw the other partner’s contribution without paying tax. But a direct exchange of the properties would have been taxable. To try to prevent a partnership transaction that is designed for tax avoidance, the tax law can
add an additional rule, such as a prescription against withdrawing property added to a partnership for a minimum period of time.\textsuperscript{168} 

The problem with adding this wrinkle to the rule is that whatever time period is selected will be artificial. The rule may require property to be held in partnership for two years, but the reality is that nothing magically occurs on the two year anniversary to make the partnership a real endeavor as opposed to a tax shelter. This artificial discontinuity creates economic inefficiencies.

Picture a taxpayer that was engaged in a real partnership and had added assets to the partnership that had been kept in the partnership for one year. Under a rule based system where partnership assets must be kept for two years, pulling those assets out at the one year mark would create a 100\% chance of liability. If the law was based on a standard, the taxpayer would have to estimate the probability of being hit with a tax liability, looking at the time the assets have been kept in the partnership as well as other factors that the court would look at to determine if the partnership was merely created for tax avoidance. After looking through the case law, the taxpayer might determine that he had a 50\% chance of being hit with an additional tax liability if he pulled the assets out at the one year mark. For economic reasons, the taxpayer may feel that taking the 50\% chance of additional taxes is worth it, and pull the money out of the partnership. Or, the taxpayer may feel that pulling the assets out only makes sense if he had a 25\% chance of being hit with a tax liability. In that case, the taxpayer would only have to keep the assets in the partnership until the moment that his chances of liability reached 25\%. Unlike a rules-based system, which allows only one decision point (at the two year mark), a

\textsuperscript{168} \textit{Id.}
standards-based system allows an actor to continually re-evaluate his liabilities as the facts of the situation change.\textsuperscript{169}

The exact value of having a continuous, standards-based law versus a discontinuous, rules-based law to address this issue of tax avoidance is a detailed debate in which we will not engage. However, a clear disadvantage to having a continuous, standards-based law, where an actor can only intuit probabilities of a violation, is that the actor has to do some legal work in order to even understand what the probabilities are. It is an information intensive process: it requires combing through the case law on the issue in order to see how the standard has been applied. ALE search, by quickly identifying the relevant case law, will make this process easier and less costly. By accurately presenting all of the relevant case law, it will also increase the accuracy with which an actor will be able to determine the probabilities of a violation. Whatever the relative merits of a continuous legal framework, ALE search will help tip the balance in its favor, because ALE lowers the cost of assessing the probabilities involved in standards-based law.

\textbf{B. \hspace{1em} Dynamic Rules}

One of the reasons that we have argued for increased use of standards is that standards allow new information to alter the law after the standard has been implemented. New information is added from the facts of each case and the legal interpretations of other judges. This new information is used by judges to shape and change the interpretation of the standard.

\textsuperscript{169} Weisbach, \textit{supra} note 164, at 873.
In theory, rules could also be changed by legislatures or regulatory bodies in response to new information. In practice, however, rules tend to be sticky even if the face of changing circumstances that should modify them. Legislatures tend to be reactive to crises and thus may not update rules continuously as new information becomes available.\textsuperscript{170} Their crowded agenda often makes it difficult to find time to update rules.\textsuperscript{171} Finally, legislatures contain many veto points in the forms of committees and their chairpersons as well as legislative procedures, like filibusters, that can easily lead to gridlock and inertia.\textsuperscript{172}

For rules that are overseen by regulatory bodies, the main challenge to frequent change stems from the burdensome notice and comment procedures required before any changes.\textsuperscript{173} Regulatory ossification is now thought to be a pervasive problem of the administrative state.\textsuperscript{174} One possible solution suggested by our previous section on standards is for agencies to substitute regulation through adjudication under standards rather than rulemaking. Many agencies have the statutory discretion to choose between rulemaking and adjudication.\textsuperscript{175} Thus, just as common law standards become more attractive compared to fixed rules, so does a process of regulatory standards and adjudication. But currently the culture of administration favors regulation by rulemaking and thus this section seeks to offer suggestions for improvements in those rules.


\textsuperscript{172} Indeed in the U.S. Senate, legislators may successfully block legislation simply by signaling an intention to filibuster. See Catherine Fisk & Erwin Chemerinsky, \textit{The Filibuster}, 49 STAN. L. REV. 181, 186 (1997) (discussing the concept of a “stealth filibuster”).


\textsuperscript{174} See Barack Obama, \textit{Toward a 21\textsuperscript{st}-Century Regulatory System}, WALL ST. J. (Jan. 18, 2011), http://online.wsj.com/article/SB10001424052748703396604576088272112103698.html (explaining the need for an executive order to conduct a “government-wide review of the rules already on the books to remove outdated regulations”).

Dynamic rules can provide a solution to the problem of legislative inertia or regulatory ossification. Dynamic rules are rules that are tied directly to real world empirical data, so that they automatically update as the data they are tied to changes. Dynamic rules can therefore increase the ability of rules to change, but those changes would be based on new information altering the system, rather than on scheduled changes designed at one moment, using one set of assumptions and information. In addition to making rules more responsive, dynamic rules may also make it easier to fashion rules in the first place.

As with our arguments for adopting standards, our arguments regarding dynamic rules are based on technological change. While our theory on the improving case for standards is based on computer’s increasing ability to understand semantic values, our theory on dynamic rules is based primarily on the increasing ability of computers and electronic devices to create, store, and analyze data. At the end of 2011, the world was estimated to contain 1.8 zettabytes of electronic data. A zettabyte is a trillion gigabytes, or 1,000,000,000,000,000,000,000 bytes of information. This data stems from a nearly all-

176 For regulatory rules, one way to increase the rate of change would be to use “contemporaneous revision-planning.” Lynn E. Blais & Wendy E. Wagner, Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts, 86 Tex. L. Rev. 1701, 1733 (2008). Contemporaneous revision-planning involves determining the expected future course of revisions at the time of the initial rulemaking. Those future revisions would only fail to take place if regulators undertook the process of changing them. This framework would shift the bias of the rulemaking machine towards continual updates, rather than towards maintenance of the status quo. This process would help increase the rate of change, but does not increase the ability of the system to process and adapt to information. If the future-looking rules turn out to be inefficient or subject to regulatory capture, the same status quo bias that contemporaneous revision-planning was designed to get around would tend to keep those improper projections fixed in place.

177 We do not mean to suggest that dynamic rules will themselves not be subject to revision. Dynamic rules eliminate one element of uncertainty by responding to real world information. However, the framework of that response, or the algorithm behind the rule, would still need to be updated periodically.

pervasive collection system. Google has servers containing every internet page it has indexed, and is able to cross reference this information with its geographical data, data on search terms, and data on the physical location of millions of Wi-Fi enabled devices.\textsuperscript{179} It is not just corporations and governments creating this data, however. Deb Roy, a researcher at MIT, used a series of cameras in his house to record every moment of his newborn son’s speech development.\textsuperscript{180} In the process he created more than 20 times the data available in the printed catalogs of the Library of Congress.\textsuperscript{181} As a recent Popular Science cover article stated, we are living in the age of “Big Data.”\textsuperscript{182}

As pervasive as this system of data collection is now, it will increase dramatically in the future. As we discussed above, Moore’s law means that the cost of computing will fall exponentially, dramatically decreasing the computing cost required to create and store data. However, in addition to reducing the cost of computing, Moore’s law also exponentially reduces the amount of power needed for computation. Computing devices are now 100 billion times more efficient than computers in the 1950s, and power consumption continues to fall by a factor of 100 each decade.\textsuperscript{183} The result of this amazing improvement is that the power requirements of computing have dropped so low that computing devices can now be powered by background energy sources such as ambient heat and radio waves.\textsuperscript{184} For instance, researchers recently created a device that collects and transmits weather readings once every five seconds, powered by nothing but

\textsuperscript{180} Enriquez, supra note 174.
\textsuperscript{181} Id.
\textsuperscript{182} Id.
\textsuperscript{184} Id.
ambient radio waves.\textsuperscript{185} Cheap, self-powering devices like these will create empirical data at a rate far beyond what we experience today.

Several commentators have argued that lawmakers and regulators should take advantage of this data explosion by incorporating more empirical information into their decision making process.\textsuperscript{186} In theory, this insistence should be unnecessary for regulators, as regulators are obligated to revise rules in the face of new information, such as improvements in technology.\textsuperscript{187} In reality, requiring regulators to reconsider rules in light of new information has shown to be effective in improving the rate of change. For instance, regulations with mandatory review processes are more likely to be changed than those without mandatory review.\textsuperscript{188}

However, even mandatory reviews are unlikely to keep up with underlying conditions in a world with ubiquitous data collection. And it is difficult to frame rules to require legislators to undertake a mandatory review of subjects they would prefer to leave unaddressed. Rather than requiring legislators or regulators to look at empirical data, the use of dynamic rules could bypass regulators altogether by placing the collection and analysis of data at the heart of the regulatory system. Instead of setting up a fixed rule, or a schedule of rule changes, rule makers would create an algorithm. The algorithm could be fed information from existing sources of data (such as economic information from the BEA), or could be fed data from an information gathering system set up by the rule making body. As the data reflecting real-world information changed, the algorithm would alter the rule. Rule makers would be overseeing the regulating process, but the

\textsuperscript{185} Id.
\textsuperscript{187} Wagner, supra note 172, at 1727.
\textsuperscript{188} Id.
actual regulations would be processed and updated by the algorithm. This process would
fit with the trend of regulators moving towards “meta-regulation”: the regulation of the
regulation process itself.¹⁸⁹

As an example, picture a system of pollution regulation that involved lowering the
amount of mercury in coal plants. Regulators would start by determining the appropriate
amount of pollution allowance for the current day, using all the empirical information
available. Regulators would then write an algorithm that changed this level based on
certain factors. For instance, one factor could be the cost of reducing mercury pollution.
To determine what the cost of reduction is, a computerized bidding system could be set
up, wherein providers of pollution technology are free to submit bids for pollution
reduction services. If the bids on the system show that technology is outpacing the
estimates of technological growth, the law would automatically be changed to reflect the
new technology.¹⁹⁰

This system would have the effect of encouraging advances in technology. The
pollution control industry would have the confidence of knowing that if it could
collectively improve their product, the law would automatically change to provide a
market for that product.¹⁹¹ By participating in the bidding process, the individual
businesses would be changing the law by adding information to the rule making system.

¹⁸⁹ Douglas A. Kysar & James Salzman, Making Sense of Information for Environmental Protection, 86
Tex. L. Rev. 1347, 1357 (2007); Christine Overdevest & Brian Mayer, Harnessing the Power of
Information Through Community Monitoring: Insights from Social Science, 86 Tex. L. Rev. 1493, 1494
(2007).
¹⁹⁰ Any bidders in the system would need to be held to their bid.
¹⁹¹ Blais and Wagner point out that a similar mechanism would work using contemporaneous revision-
planning. Wagner, supra note 172, at 1735. Predicted revisions would give technology companies a target
to shoot for. Firms would have reasonable confidence that if they could produce a technology that
economically achieved pollution reduction at the target revision amount, then the target revision amount
would likely take effect. However, while this is possibly an improvement on regulations that would
otherwise have been in a default stasis mode, a dynamic rule could encourage even more innovation by
giving the industry assurance that improvements will lead to legal changes. On the other hand, if they are
unable to improve, a dynamic rule could prevent implementation of un-economical increases of regulation.
The more general point here is that dynamic rules make planning easier, because they reduce the uncertainty that is created by the difficulty that legislatures and agencies have in creating a schedule for updating their rules in response to new factual information.

By incorporating empirical data into the law, dynamic rules may also make the process of rule making itself easier. Currently, when creating a forward looking regulation, rule makers have to solve two types of problems: uncertainty as to what facts will exist in the future, and disagreements stemming from the political beliefs of the rule makers today. Dynamic rules can help to lessen the problem of future empirical uncertainty by simply allowing that uncertainty to exist as a variable in the algorithm. Two sides with diametrically opposing views about what is likely to happen in the future could happily come to agreement on a regulatory framework, both thinking that other will be proven wrong by future facts.

In addition to using information to modify regulations, it would be possible to create a dynamic rule that will only come into effect if future data supports its implementation. This type of rule making might not only reduce arguments based on facts, but by delaying the consequences of the law into the future, it could reduce the amount of pushback received from special interest groups.

The inaction over climate change is an example of a debate that could benefit from a dynamic rule tied to future empirical data. The debate over climate change is partly over principles (what burdens should we undertake on behalf of the environment), but is also driven by a disagreement on facts (is human activity changing the

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192 See David Gamage, Preventing State Budget Crises: Managing the Fiscal Volatility Problem, 98 CAL. L. REV. 749, 792 (2010). Gamage discusses how volatility in state budgets could be reduced by setting a target for revenues and then adjusting tax rates based on that target. Setting a revenue target helps remove budget disputes from the particular circumstances of the economic cycle in which legislators are debating.
environment, how quickly will technology advance to mitigate the damage, etc.). Instead of continuing to have a debate largely centered over facts, legislatures could craft regulations that are dependent on empirical facts as they exist five or ten years into the future. For instance, congress could set up a cap and trade system, but no price would be set on carbon for ten years. Once ten years passes, the price would be set based on a basket of empirical information, such as objective changes in temperature.

A technology element could be included as well. The algorithm could take into account a basket of renewable energy costs as a percentage of fossil fuel costs. Faster than expected breakthroughs in renewable energy technology could be a factor in reducing the fine for carbon emissions, based on the premise that these advancements will reduce the likely amount of carbon emissions going forward.

The use of a technology component shows how a dynamic rule could just as easily reduce the need for regulation, meaning that conservatives could have a reason to support it. Regulations could also become automatically less onerous if temperatures dropped, or new studies showed that climate change is a less serious problem than we assumed.

Dynamic rules could encourage a more market driven approach to industry regulation. Faced with an algorithm that will create future regulation, businesses may begin to change their behavior immediately. Unlike a set schedule of changes however, which everyone is aware of and subject to, a dynamic rule in essence allows different firms to “bet” on what regulations are going to be implemented. For instance, one firm may be of the opinion that technology advances will obviate the need for carbon pricing. That firm may choose to avoid any carbon mitigation strategy. A different firm might
believe that temperatures are likely to rise faster than expected and choose to pursue an aggressive mitigation strategy. Collectively, the individual businesses may settle on a level of interim regulation (before the delayed dynamic rule takes place) that is more optimal than the level that would have been reached if the regulators simply set it right out of the gate.

There are several examples of dynamic rules that are currently in effect, many with very successful results. One of the most important dynamic rules currently operating is the indexing of tax brackets to inflation. This was first done in the Economic Recovery Tax Act of 1981. Before this change, taxpayers experienced “bracket creep” when inflation pushed them into higher tax brackets while their purchasing power remained the same. This led to a period during the 1970s when tax brackets had to be frequently changed by Congress in order to keep pace with inflation.

By indexing brackets, Congress eliminated the need to revisit tax policy solely due to the inevitable increase of inflation. This aspect of the law has allowed Congress to focus on the true political disputes involved in taxation rates without having to also come to agreement on an empirical fact like the future increase of inflation. In contrast to the indexing of standard tax rates, Congress did not index the brackets for the Alternative Minimum Tax (“AMT”). The absence of indexing has led to repeated fights in Congress when AMT brackets require adjustment and greater uncertainty for taxpayers.

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194 *Id.*
Additional examples of successful dynamic rules come from the growing number of jurisdictions that are using congestion pricing for public roadways and parking spaces. Congestion pricing is a method of charging motorists a price to drive or park on a road that varies depending on how busy the road typically is at certain times.\textsuperscript{197}

Perhaps the most technologically interesting congestion pricing system currently being used is San Francisco’s SFpark parking meter system. The system uses sensors placed underneath parking spots to determine congestion for each block, and for each hour of the day.\textsuperscript{198} Each month, an algorithm dynamically adjust the price, raising prices in busy areas to reach a level that leaves at least one space open, and lowering prices in empty areas until those spaces begin to fill.\textsuperscript{199}

Although there were some congestion pricing systems that were implemented before the computer revolution, the ability to use automated systems to collect data, charge vehicles, and distribute pricing information, has vastly increased their utility. It is not surprising that successful schemes such as that in San Francisco only arose along with the ability to use automated pricing and toll collections. These congestion pricing schemes can provide a model for the more complicated task of creating dynamic laws and rules that change their applications with according to conditions and communicate those changes to legal actors.

\textit{C. Standards v. Dynamic Rules}

\textsuperscript{199} \textit{Id.}
In this last section we compare the two forms of legal rules that are likely to increasingly dominate the information age of American law—standards and dynamic rules. In the world of powerful information capability that is increasingly becoming ours, these forms of law have substantial advantages over laws that do not update on information. But how do they compare to one another? We believe that as information capacity increases, standards will continue to gain advantages even over dynamic rules in reconciling law’s twin objectives of informing of the community of norms and infusing information from the world to update norms. Nevertheless, dynamic rules may still be chosen on the basis of institutional considerations. Standards require a certain kind of trust—our willingness to entrust judges or other less democratically accountable decision makers with the capacity to make incremental, continuous changes in law’s algorithm that will ultimately reflect social preferences.  

This capacity of judges to use standards to make such incremental changes has advantages as information about the world may be relevant to changing law’s algorithm as well as to its applying its algorithm to facts. Thus, standards permit the judge to tweak the algorithm, not merely apply it. This capacity enables judges to take account of new information, potentially making better decisions along the lines we have described. But we may not trust judges with this kind of discretion, because we are afraid that the institutional advantages of greater information gathering will be swamped by the costs of ideological distortion by unrepresentative judges.

\[200\] See Shapiro, supra note x, at 335 (suggesting the structure of law represents a sophisticated “economy of trust”)
\[202\] For an explanation of various potential nonpolitical biases that might hinder judges as producers of efficient law, see generally Frederick Schauer, Do Cases Make Bad Law?, 73 U. CHI. L. REV. 883 (2006). However, it seems that greater information capacity would help judges overcome these biases. See Stefanie A. Lindquist & Frank B. Cross, Empirically Testing Dworkin’s Chain Novel Theory: Studying the Path of
Dynamic rules avoid this danger even as they do a better job of reflecting information in the world than more static rules. But even if they are better at integrating information than static rules, they do so in a necessarily more mechanical way than standards. The law’s algorithm is fixed by a rule, even if its results can vary widely with new information. Even a dynamic rule once set can be changed in our system only through legislative or, in the administrative context, through rule making. That process is generally more laborious and less spontaneous one that happens at longer intervals.203

The legislative or administrative responsibility for changing rules, even dynamic rules, gives legal change—changes in the algorithm itself—a more punctuated character. Thus, even if increasing information capacity helps transcend the tension between comprehensibility and flexibility by allowing us to continuously update on information, it cannot transcend the enduring institutional questions of authority. And that is how it should be. However great becomes machine intelligence, the question of whom we trust with authority to change law’s algorithm remains relevant even in age of greater computational capacity.

To be sure, as we have noted before, even rules require interpretation and judges can use this power to change the algorithm. But a judge is not authorized to change the rule and faithful judge does not do so.204 In contrast, a common-law like standard

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203 See e.g. Charles W. Joiner & Oscar J. Miller, Rules of Practice and Procedure: A Study of Judicial Rule Making, 55 Mich. L. Rev. 623 (1957) (explaining how even in the narrow field of judicial procedure, the complexity of society could not abide to wait for the legislature to update rules). Consider that Joiner and Miller were writing in 1957, and society has surely become even more “modern and complex” in the intervening decades.

204 See Frederick Schauer, The Convergence of Rules and Standards, 2003 N.Z. L. Rev. 303, 312 (2003) (arguing that standards and rules eventually converge somewhat through judicial interpretation and describing that a faithful judge will “soften the hard edges of rules”). This is not to be confused with outright changing a rule.
empowers even the faithful judge to change the algorithm by varying the weight of factors that determine how a standard is to be applied.

To understand this difference between standards and dynamic rules, it is useful to return to our primary example—speed limits. As we have discussed, a classic standard would be the command “drive at a reasonable speed.” As information costs fall, this standard becomes more plausible than rules specifying a particular speed limit. A dynamic rule, in contrast, would change the speed limit based on a calculation of factors—perhaps very complex but wholly specified. For instance, the dynamic rule could consider the road conditions, the traffic conditions, and the condition of the car at particular times. Its application would depend on some mathematical formula which would plug in different factual values for the various factors that make up the algorithm. The dynamic rule thus would possess many of the advantages of a standard compared to a rule with a specified speed limit, because it would vary the speed limit more efficiently. If an app was programmed with the algorithm and could monitor the information relevant to the conditions necessary to calculate the algorithm, drivers could still have ready knowledge of the rule, even if the speed limit were no longer fixed at a particular limit.

The difference between the standard and the dynamic rule governing the speed limit is that the standard would still allow judges to vary the mix of factors in determining what is reasonable, because they would make decisions to which the algorithm would need to adjust. In this case the algorithm would itself evolve with judicial decisions. Thus, these decisions might posit that there is a different tradeoff between road conditions and traffic in a particular place to get the same level of safety. In short, they
could modify the weight of the factors in the algorithm as well as apply the factors in the algorithm.

Thus, standards retain their advantages of capturing distributed information even vis-a-vis dynamic rules. They permit judges incrementally to gather information about the world to efficiently update the law. On the other hand, under the guise of changing factors to reflect new information about real world consequences, they might make a different decision about how much safety we desire. In doing so they might reflect a different tradeoff in values, such as that between lives lost and speed than that implicitly contained in the dynamic rule. Giving judges the ability to update an algorithm to better reflect factual information about the world also gives them the opportunity to change the rule to reflect their preferences.

This example illustrates the most important issue at stake in the difference between dynamic rules and standards. Standards remain superior even to dynamic rules in the ability to gather distributed information from the world. No legislature can perfectly foresee the future. Even with dynamic rules that take account of changing factors, the world may change in a way that makes another weighting of factors achieves the legislature’s original objectives. Thus, some factual change in the world—for instance the introduction of self-driving cars—may mean that the rule’s factors no longer capture the preferences implicit in the rule, because the rule applied in the new factual context comes to results that do not accord with our preferences even at the time we made the rule. If we had known about these changes at that time we would have had a different

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205 See Note, *The Elimination of Obsolete Statutes*, 43 HARV. L. REV. 1302, 1302 (1930) (discussing obsolete statutes, their ill effects, and the unfortunate result that such statutes must be deliberately repealed by the legislatures). For a more recent article on point, see Note, *Desuetude*, 119 HARV. L. REV. 2209, 2209 (2006).
algorithm in the first place. In the famous Italian novel, *The Leopard*, Tancredi, the nephew of the Prince, famously says “If we want to things to stay as they are, things will have to change.” So it can be with law: in a world that is changing, law’s algorithm must sometimes change if it is to maintain the same objectives and tradeoffs in values.

But in giving courts the ability to tweak an algorithm to achieve shared objectives, we also give them the ability to change the algorithm to serve objectives that are not as broadly shared. The question between dynamic rules and standards is whether the advantages of the greater capacity to update on information are outweighed by the greater danger of departing from preferences.

Thus, the decision to use standards or to use dynamic rules depends on a tension that will outlive the information revolution. It might be argued that this tension too can be tempered if we can create a system of adjudication that not only updates on information but does so in a manner that creates efficient algorithms. That promise lies behind the claim that the common law is efficient. We have previously shown that greater information capacity should help the forces of efficiency by giving judges better access to precedent and making litigation against inefficient precedents more likely to

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207 For a compelling example, see Christopher Jensen, *The More Things Change, the More They Stay the Same: Copyright, Digital Technology, and Social Norms*, 56 STAN. L. REV. 531, 531 (2003) (arguing that the advent of the internet has created such a disconnect between the public’s perception of copyright infringement and that of the law, that a reconceptualization of copyright norms must realign both public perception and legal rules in order to accomplish the goals of copyright policy).
208 See Rubin, supra note 132, at 51.
succeed. But the claim that common law tends toward efficiency is contested.\textsuperscript{209} In any event, not everyone agrees that efficiency should be the touchstone of all legal norms.\textsuperscript{210}

Despite the enduring questions of trust that standards create, the reduction of information costs and the attendant improvement in real time legal search will make standards more plausible than dynamic rules in areas where there is less concern about reposing trust in judges. Speed limits are again a good example. We are not generally afraid that judges will use a speed limit standard to go on an ideological frolic or express an idiosyncratic worldview. Thus, as information costs fall, standards will become more clearly better than rules, even dynamic rules, in any area in which we can trust judges to update according to the preferences of the community. The problems of notice and comprehensibility will be progressively overcome by the information revolution.

For areas where we want to keep judges and other decision makers on a shorter leash, dynamic rules will gain advantages in the information age over the more static rules in previous ages. Their openness to change within determinate bounds does allow for substantial updating on information and yet permits citizens to better plan around the foreseen consequences of the rules, because the updating depends on transparent factors. Within the constraints of trust and democratic accountability, they too reflect the legal form of our information age.

\textsuperscript{209} For an empirical study evaluating whether common law indeed tends toward efficiency, see Thomas J. Miceli, \textit{Legal Change: Selective Litigation, Judicial Bias, and Precedent}, 38 J. LEGAL STUD. 157, 166 (2009) (concluding that selective litigation will lead common law towards efficiency if precedent is overturned at random, but a large fraction of biased judges could disrupt this result).

Conclusion

Grant Gilmore famously divided American law into three eras. The Age of Discovery was marked by the new nation’s finding its own social norms and creating precedents that differed from Britain’s. The Age of Faith of the later nineteenth century forged a coherent set of rules from the precedents of the former age. The twentieth century’s Age of Anxiety reflected concern about the adequacy of these rules to reflect the law, in part because increasing the complexity of the world and the multiplication of precedents made it harder to find the law. Today we inhabit the Age of Information in which law can use the exponential increases in computational power to more readily and accessibly apply complexity in law.

Exponential growth is not very noticeable at first. An investment of a dollar that grows at 50% per year yields 38 dollars in the tenth. A person living through those ten years and looking only at the gross gains in value would hardly think anything was happening at all. Years thirty through forty, however, take you from $125,000 to over $7,000,000. The same growth rate becomes more noticeable simply because it is operating on larger numbers. If placed on a linear graph, the line charting this growth would start to turn dramatically upwards. This point is known as the “knee of the curve.”

We are likely in the knee of the curve when it comes to the growth of legal information technology. Looking back through the history of legal information, we see very slow changes at first. The practice of law in England changed little from the Magna


\[212\] Id. at 19-41.

\[213\] Id. at 41-68.

\[214\] Id. at 68-99.

\[215\] Kurzweil, supra note 88, at 10.
Carta until Blackstone’s Commentaries. Another two hundred years or so passed until West Publishing came up with a detailed, topic-based breakdown of the law. Ninety years later, we had the first electronic legal search. In the intervening thirty-seven years we have witnessed tremendous changes in how legal search is used. It has gone from an expensive, slow, limited process that took place on a single, fixed terminal, to something that can often be done for free using a cell phone.

There is every reason to believe this process will continue to accelerate. Moore’s law will continue to dramatically lower the costs of computation (in terms of money and energy), just as it has in the past. Legal search will also benefit from the technology industry’s interest in natural language search. By hitching its star to the improvement of search in general, and riding the wave of increasing computational power, legal search is experiencing a revolution in capability. We have suggested that law should respond to the improvements in information capacity to move towards a more flexible, nimble legal framework through either standards-based law or dynamic rules.

There’s an old Silicon Valley joke that goes “if GM had kept up with technology like the computer industry has, we’d all be driving cars that got 1,000 mpg and cost $25.” Unfortunately, the laws of physics prevent the car industry from improving the way computers have. Likewise enduring issues of trust—questions imbedded in human nature itself—prevent the law from improving at the exponential rates of growth that the technology industry achieves. Nonetheless, given that law is an information technology, the information revolution can substantially improve our ability to find the law and with that greater capacity can mold a law that better serves both its objectives of providing information to community and gathering information from the world.

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216 This quote is often misattributed to Bill Gates.