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THINKING ABOUT THINKING MACHINES: IMPLICATIONS OF MACHINE INVENTORS FOR PATENT LAW

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ABSTRACT

Advances in artificial intelligence, particularly in the field of evolutionary computing, are producing computers with increasingly complex problem solving capabilities. Borrowing principles of evolution, molecular biology, neurology, and human cognitive science, technologists are evolving computers into "thinking machines" with the potential to perform creative and inventive tasks. Thinking machines have already demonstrated the ability to play instrumental roles in developing patentable inventions in areas such as drug discovery, robotics, and mechanical design. As computer capabilities continue to expand and costs of computing continue to fall, machines will perform the majority of the work in the invention process and originate novel solutions not imagined by their human operators, transforming the invention process in ways not easily accommodated within the current U.S. patent system. In this paper we identify key areas of impact within the U.S. patent system and make recommendations on how to meet the challenges of a "thinking machines" paradigm of invention.

The "thinking machine" paradigm is characterized by the replacement of the human with the computer as experimenter. Features of this paradigm include the automation of trial and error testing; the substitution of brute force computation for human intuition; the decreased cost and increased speed of producing inventions; the divisibility of the invention process into discrete abstract tasks distributed over multiple machines; and the blurring of boundaries between traditional concepts of invention, inventor, and instruments of invention. These new features will yield inventions on a scale and of a nature that the patent system is not currently equipped to accommodate at either a conceptual or practical level. Thus, the existing patent laws and supporting legal doctrine need to be re-examined, and rules for patentability, patent scope, and patent infringement adjusted, to accommodate this new paradigm of invention.

This paper identifies some key issues for participants in the patent system to consider in thinking about thinking machines and the challenges these machines will pose for the patent system. We demonstrate the main areas in which the new paradigm will impact the patent system, including conceptual challenges to notions of inventor and invention, challenges in the application of statutory tests such as novelty and non-obviousness, and logistical challenges due to volume and rapid technological change. We then provide an assessment of some recent patent office initiatives and legislation targeted at

addressing challenges to the patent system and some recommendations on how to adjust the patent system to accommodate the new paradigm of invention.

I. INTRODUCTION

Using techniques derived from understandings of evolution, molecular biology, neurology, and human cognitive processes, technologists are evolving computers into "thinking machines" capable of performing creative and inventive tasks. These thinking machines are producing results that are competitive with those of humans. Thinking machines are producing results that correspond to existing patents or produce what would qualify today as patentable inventions.[1] As computer capabilities and capacities continue to expand, and computing costs continue to fall, machines will perform the majority of the work in the invention process and will originate novel solutions not imagined by their human operators.

Features of the new thinking machine paradigm include: the automation of trial and error testing, the substitutes of brute force computation for human intuition, the decreased cost and increased speed of producing inventions, the divisibility of the invention process into discrete abstract tasks distributed over multiple machines, and the blurring of boundaries between traditional concepts of invention, inventor, and instruments of invention.

Although the scientific and business applications of thinking machines for invention are receiving growing attention, little thought appears to have been given to the legal implications, particularly in the area of patent law. In this paper we suggest that the growing use of computers to augment human capabilities and replace human operators is transforming the invention process in ways that are not easily accommodated within the current patent system. We identify key areas of impact within the U.S. patent system and make recommendations on how to adjust the patent system to meet the challenges of the new paradigm of invention.

The changing nature of the invention process poses challenges for the players and rules that together comprise the U.S. system governing the protection of inventions (the "Patent System"). Legislators and judges must decide whether, and how, to adapt the existing statutory framework governing inventions to new technological possibilities and changing market conditions. Patent examiners and practitioners must struggle to manage a flood of potential new inventions and to apply traditional tests of patentability to a transforming invention process. Inventors and market participants seeking to use or develop related technologies must navigate cautiously through existing intellectual property boundaries.

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[1] *See* JOHN R. KOZA ET AL., GENETIC PROGRAMMING III: DARWINIAN INVENTION AND PROBLEM SOLVING 5-7 (1999) (providing examples of instances in which genetic programming has produced results that are competitive with the products of human creativity and inventiveness).

This paper identifies some of the key issues for participants in the Patent System to consider about thinking machines and the challenges these machines will pose for the Patent System. We begin with an overview of features of the "intelligent" technologies driving the paradigm shift. We then move along a spectrum from conceptual to practical issues raised by the new paradigm that are likely to have a significant impact on the Patent System. We start with conceptual challenges to notions of 'inventor' and 'invention' around which justifications for granting patents and tests of patentability have developed. We then examine the potential difficulties in applying existing statutory rules for patentability to an automated invention process, and go on to consider logistical challenges to the system for examining patent applications and administrating patent grants. Through this analysis we demonstrate how the new paradigm will impact the patent system and identify where the major areas of impact are likely to be. After exploring the consequences of the new paradigm, we provide an overview of current responses to changing invention technologies and recommendations on how to adjust the patent system to accommodate the challenges of the new paradigm. We conclude with further food (chips!) for thought.

II. FEATURES OF "INTELLIGENT" TECHNOLOGIES

The new paradigm is characterized by the use of computers and robots to automate the synthesis and testing of hypotheses in various media and formats. Thinking machines have become an indispensable part of the invention process in a wide range of areas. Research on the frontiers of physics, chemistry and biology, and even fields like sociology, anthropology and archaeology, is becoming increasingly dependent on computation, resulting in a merging of science and computer science during the discovery process.[2] The expansion of computational capabilities and the discovery of new applications promises even more pervasive and material changes to the invention process in the future as computer science becomes integrated into daily tools and activities and even household appliances are imbued with adaptive learning capabilities.[3]

[2] *See* George Johnson, *All Science is Computer Science*, N.Y. TIMES, Mar. 25, 2001, § 4, at 1. "In fact, as research on so many fronts is becoming increasingly dependent on computation, all science, it seems, is becoming computer science. . . . In the course of this augmentation of the scientific mind, the volume of data that needs to be analyzed has increased from a trickle to a torrent, with physicists and biologists making the heaviest demands." *Id.*

[3] *See* Stephen S. Cohen et al., *Tools for Thought: What is New and Important About the "E-conomy,"* 13-14 (Feb. 27, 2000) (unpublished manuscript, BRIE Working Paper #138), *available at* http://econ161.berkeley.edu/OpEd/virtual/technet/Tools_for_Thought.html. "From cash registers and cell phones to hotel doors, elevators, and pacemakers, embedded microprocessors are transforming our world from the inside by adding features of intelligent behavior to potentially all our products." *Id.*

A. *Falling Cost of Invention*

A key enabler of the thinking machine paradigm is the exponential increase in computer performance for a given expenditure. For the past thirty years computer processing power has doubled in speed for a given cost roughly every 18 months.[4] This trend, known as Moore's law, is expected to continue for at least a few more generations of technology, and by some estimates computers will have ten million times the processing power in 2010 than they had in 1975.[5] The market price of computing power has decreased even as the power has increased, falling more than ten thousand-fold in a single generation.[6] At this pace of growth in computational capacity and cost decline, scientists in the future will be able to tackle problems in hours that would have taken previously existing supercomputers thousands of years to compute.[7] Intel Corporation, for example, which controls about eighty percent of the market for computer chips, has continued to introduce faster chips to market at regular intervals and to offer its products at lower prices forcing competitors are forced to follow suit with cheaper and/or better technologies.[8] Lower chip prices feed into lower prices for computer systems. Even as existing technologies begin to hit their natural limits, new technologies with higher growth trajectories, such as carbon circuits, continue to emerge.[9]

As a substitute labor force, computers often offer significant cost savings and certain performance advantages over their human counterparts. Thinking machines are relatively tireless, are not subject to minimum wage or maximum hour protections, and have the ability to focus continuously on their task, no matter how dull or difficult. Computer agents have already made inroads in the fashion industry where fashion automatons are promoted as "models without attitude."[10] Recent movies have featured digital actors, opening in

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[4] *See* Peter Leyden, *Moore's Law Repealed, Sort Of*, WIRED, May 1997, at 166 (stating Moore's Law is a rule of thumb first proposed by Gordon Moore, founder of Intel, that has been borne out by the U.S. experience in the computer industry).

[5] *See id.*

[6] *See id.*; *see also* Jack Triplett, *Computers and the Digital Economy*, *at* http://www.digitaleconomy.gov/powerpoint/triplett/s1d003.htm (containing a price index for computer equipment from 1958 to 1998 demonstrating marked decline in computer prices).

[7] *See* Eric Blom, *Technology's Dark Side*, PORTLAND PRESS HERALD, Nov. 5, 2000, at 1C. According to Bill Joy, co-founder of Sun Microsystems and co-author of the Java programming language, computing ability will improve "a million million times" during the next few decades, allowing scientists to tackle problems in hours that would take thousands of years to address with current supercomputers. *See id.*

[8] *See* Chris Gaither, *Intel Selling Two-Gigahertz Chips*, N.Y. TIMES, Aug. 28, 2001, at C4.

[9] *See* Kenneth Chang, *IBM Creates a Tiny Circuit out of Carbon*, N.Y. TIMES, Aug. 27, 2001, at C1 (stating that IBM researchers have, for example, created a logic-performing computer circuit within a single molecule that could lead to a new class of smaller and faster computers that consume less power than current computers).

[10] *See, e.g.*, *Hard Look Story*, THE OBSERVER (London), Nov. 7, 1993, at Life Sec., p. 16

fairly close proximity to contract disputes among Hollywood actors, script writers and the studios employing them,[11] and robotic life guards utilizing computer-vision applications have already made life saving assists.[12] Unlike human workers, computer agents cannot move from employer to employer, and this lack of volitional mobility makes it easier for companies to protect trade secrets and appropriate the benefits of investment in worker (or robot) skills and training.

In addition to their speed, a significant advantage of computers is their ability to handle and store huge amounts of data relatively cheaply, and the complementary ability to search and retrieve information from large databases. As the costs of storing data fall and the speed of retrieving data increases, data mining techniques and other methods of computer simulation and testing are providing an increasingly cost effective avenue for experimentation and discovery.

B. High Volume of Discoveries

The combination of growth in computer processing power, increased storage of information, and declining computing costs has contributed, and will continue to contribute, to a higher volume of discoveries.[13] This growth in volume has been accelerated by new techniques for defining and solving questions of human interest. Rapid advances are being made in reducing concrete, real world problems into machine solvable form and using machines to solve increasingly open-ended, higher order (i.e., less structured and pre-parameterized) problems.[14] Moreover, once an efficient algorithm has been identified, the same program structures and/or solutions can often be applied to solve a variety of complex problems in related and unrelated fields (e.g., genetics and drug discovery, or motor and circuit design). The ability to identify similarities in the underlying structures of many complex problems

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(relating the story of Jenny Shimizu a tattooed and pierced former motorcycle mechanic turned model whose 'bad girl' looks were changing the face of fashion).

[11] *See* Megan Turner, *A New Generation – Pacino's Next Leading Lady is Right off the Circuit Board*, N.Y. POST, Aug. 17, 2000, at 51 (noting the Screen Actors Guild's concern over digital actors as they threaten to strike); Karen Kaplan, *The Cutting Edge: Focus on Technology; Old Actors Never Die; They get Digitized*, L.A. TIMES, Aug. 9, 1999, at Bus. Sec., C1 (discussing the efforts of a production company to create a digital clone of arlene Dietrich who past away in 1992, and noting the presence of digital actors in such movies as "Contact", "Forrest Gump" and "In the Line of Fire"); Patti Hartigan, *Digital Actors*, CHICAGO SUN-TIMES, June 20, 1999, at Show Sec., p. 6 (referring to digital actors as "synthespians," and noting that both "The Mummy" and "Star Wars: Episode I The Phantom Menace" featured digital actors).

[12] *See* Jeremy Hay, *Anti-Drowning System*, WIRED, July 2001, at 70.

[13] *See* Blom, *supra* note 7, at C1.

[14] *See* RAY KURZWEIL, THE AGE OF SPIRITUAL MACHINES 82-83 (1999) ("Increasingly, we will be building our intelligent machines by breaking complex problems (such as understanding human language) into smaller subtasks, each with its own self-organizing paradigm.").

and to decompose complex problems into a series of discrete mathematical sub-problems can lead to time and cost savings and broader applicability of results. This would allow a greater leveraging of the benefits of machine generated solutions and a more efficient use of information.[15]

Computers can also enable new forms of experimentation by simulating complex systems. Simulations can be performed rapidly for large numbers of variables, enabling rapid data synthesis and testing. Moreover, the information generated by the simulation can be used to develop a better understanding of the system. Computer discovery is recursive and combinatorial, each result providing a stepping stone for multiple new results. As the database of information grows, the number of novel connections between variables increases, and therefore the potential for new discoveries increases, providing scale economies of inventions.

C. Distributed Computing and Network Production

Computers have an advantage over their human counterparts in the ability to share data efficiently. Discoveries can be shared with other computers almost instantaneously and at little cost. Advances in network compatibility and the ability to integrate different programming languages have facilitated the diffusion and expansion of innovative programming methods and processes. Improvements in search technologies on the web contribute to the diffusion of existing information. Computers can be used to bypass the language and geographical boundaries of scientific communities in order to increase the diffusion of ideas and thus the volume and pace of innovation.

Advances in distributed computing have made it possible to harness unused computer capacity to solve a given problem and to allow multiple computers to share common resources. Computers can share capacity, tasks, and data with each other quickly and efficiently, providing less costly ways of dealing with fluctuating demands for capacity, allowing more efficient use of data, and increasing the speed at which problems can be solved. Moreover, in an evolutionary computing system, increasing the number of computers that are contributing to the information pool can have benefits similar to those resulting from increasing the gene pool in the evolutionary development of a species.

D. Autonomy of the Computer

One of the distinctive characteristics of evolutionary computing is the ability to move beyond human-designed "top down" systems. There are already a number of results generated from autonomous problem solving by a computer without any material human intervention during the problem solving process that are competitive with human performance in solving problems in fields

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[15] *See* J.C. Smith, *The Charles Green Lecture: Machine Intelligence and Legal Reasoning*, 73 CHI.-KENT L. REV. 277, 279-80 (1998) (discussing the Church-Turing Thesis which states that all problems that a human can solve can be reduced to a set of algorithms, supporting the idea that machine intelligence and human intelligence are essentially equivalent).

such as computational molecular biology, computational chemistry, electrical engineering and robotics.[16] General Electric, for example, has successfully employed genetic algorithms in the design of jet engines, and its simulations have produced designs superior to those created by unaided human designers.[17] Companies, such as Bios Group, have used evolutionary computing techniques to solve manufacturing resource allocation problems, such as improving inventory control and optimal product delivery schedules.[18] Finally, Engeneous was able to boost the efficiency of a new fan for power-plant turbines by five percent using genetic algorithms that violated some of the expert system's design rules.[19]

As adaptive and related learning and feedback technologies improve, computers can increasingly be deployed at ever earlier stages of research and development to drive the discovery process and can be relied upon to sort through the results of the process through brute force computation, leading to a truly automated invention process. Research on "thinking" technologies is extending beyond the imitation of human qualities to empower machines to solve tasks and perhaps even to identify questions that may reach beyond human control and understanding.

E. Examples of Commercial Applications of Thinking Machine Features

Markets have been quick to respond to the commercial possibilities offered by thinking machine technologies, with advances in software moving rapidly ahead of understanding how to apply available intellectual property protections to such advances. Computers have already been integrated into processes for the design, testing and manufacture of sophisticated products such as engines and robots, and are widely used in biotech, biochemical, engineering and financial industries to simulate experiments and to sort and process experimental data. Recent advances in the mapping of the human genome by companies such as ArQule Inc., NuTec Sciences Inc. and Celera Genomics have been driven by advances in computational capabilities allowing researchers to make sense of huge data sets and to model complex gene and molecule structures. Siemens has opened up new frontiers for electrical engineers with the creation of an advanced software development tool that integrates "smart technologies" such as neural networks, fuzzy logic, and genetic algorithms to aid in the design of algorithms for pattern recognition,

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[16] *See* John R. Koza, *Human-Competitive Machine Intelligence, at* http://www.genetic-programming.com.

[17] *See* Ray Kurzweil, *The Virtual Thomas Edison*, TIME, Dec. 4, 2000, at 62-63.

[18] *See* Gene Bylinsky, *Look Who's Doing R&D: Big Corporate labs are cutting back on research when they don't see a quick payoff. But plenty of small companies are filling the gap*, FORTUNE, Nov. 27, 2000, at 232; Julie Wakefield, *Complexity's Business Model*, SCIENTIFIC AMERICAN, Jan. 2001, at 31-2.

[19] Stephen A. Landry, The Uses of Artificial Intelligence For Business and Its Potential Impacts 32 (April 7, 1997) (unpublished manuscript, Rensselaer at Hartford), *at* http://www.jwp.bc.ca/landry/ariforbic.doc.

process monitoring and control, time-series forecasting, image analysis, signal processing, and related applications.[20] Using funds supplied by Caterpillar Inc., the University of Wisconsin's Engine Research Centre has used genetic algorithms to "evolve" the world's most efficient truck engine.[21] In financial markets, companies such as the Prediction Company have utilized smart technologies for prediction and computerized trading of financial instruments.[22]

The widespread use of evolutionary computing in every aspect of product research and development (R&D), development and sales, the commercial success of machine discoveries, and the shift in R&D spending towards computational capabilities, is indicative of the growing role that thinking machines are playing in the invention process. The different features of intelligent technologies will enable an automated invention process that yields inventions on a scale and of a nature that the Patent System is not currently equipped to deal with at either a conceptual or practical level.

III. CHALLENGES TO CONCEPTUAL UNDERPINNINGS OF THE PATENT SYSTEM

The use of monopoly grants as tools for promoting economic objectives has a long history, both in the U.S. and abroad, and the current U.S. patent system is grounded in historically determined concepts of invention, inventor, and the process of discovery. Although the conceptual underpinnings of the U.S. patent system have proven to be remarkably robust to technological and social change, the new paradigm of invention poses unique conceptual challenges. In order to understand the nature of these conceptual challenges it is useful to begin with a brief review of the historical development of the patent system.

A. Evolution of the U.S. Patent System

The grant of some kind of monopoly right over an invention was used as a tool for promoting the discovery of new ideas as early as the third century B.C., when the Greek historian Phylarctos reported that the Greek city of Sybaris granted a patent for an article of cuisine, presumably a recipe, conferring a monopoly on the creator.[23] Although in medieval times patents were used by sovereigns primarily as tools for capturing revenues, some of these patents, particularly in regions that relied on textile production or mining, may have had a relation to innovation.[24] Patents were employed as tools of economic policy in Venice as early as the fifteenth century, where limited

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[20] *See* R. Colin Johnson, *Siemens rolls 'universal' development tool for smart technology*, EETIMES, July 20, 1998 *at* http://www.eetimes.com/news/98/1018news/rolls.html.

[21] *See* Mark Prigg, *Evolution of a Cleaner Engine*, THE SUNDAY TIMES (U.K.), July 23, 2000.

[22] *See* Wakefield, *supra* note 18, at 31-32.

[23] *See* GREGORY A. STOBBS, SOFTWARE PATENTS 3 (2d ed. 2000).

[24] *See* Ladas & Parry, Intellectual Property Lawyers, *A Brief History of the Patent Law of the United States*, *at* http://www/adas.com/patentl.html (last visited May 28, 2002).

monopolies were granted for inventions relating to the manufacture of silk and other textiles.[25] In the absence of a patent system for capturing the commercial returns from innovation, inventors in most of Western Europe had to rely on funds from wealthy patrons to support their work, a strategy that proved to be unworkable as markets grew and centralized control over markets (and hence the ability of patrons to internalize the commercial benefits of innovation) diminished.[26]

The British established a common law system of administering monopolies to reward creative effort in the late 1600s in response both to sovereign abuses of the right to grant monopolies and the desire to encourage industrialization.[27] The British Parliament passed the statute of monopolies in 1624, limiting the power of the sovereign to grant monopolies only for limited periods, for "manners of new manufacture," and only where such grants would not be "mischievous to the state" or "generally inconvenient."[28] Following the British example, the use of patents to promote social progress was later incorporated into the American Constitution.[29] As in England, the patent system in the U.S. was targeted primarily at establishing property rights in discrete physical embodiments of ideas that had some practical or useful significance, particularly in manufacturing, such as a steam engine or a new pulley system for lifting heavy objects, with a focus on improving social welfare through technological advancement.[30] Intangible assets received little formal attention or protection.

The first United States Patent Act, passed in 1790, confined the ability to award patents explicitly to high-level policymakers for new and important inventions.[31] Proving to be ineffective in the promotion of invention, due perhaps to the lack of objective criteria for determining patentability and patent scope, and lack of effective screening of discoveries, this Act was repealed and replaced in 1793 by a patent act that was shaped to a large degree by Thomas Jefferson.[32] The Patent Act of 1793 was based on a utilitarian system of

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25 *See id.*

26 *See* John Perry Barlow, *Selling Wine Without Bottles: The Economy of Mind on the Global Net* (unpublished manuscript) *at* http://www.eff.org/Publications/John_Perry_Barlow/HTML/idea_economy_article.html (demonstrating that interesting parallels can be drawn between medieval times and the current difficulties of small and mid-size companies to capture the commercial benefits of their software innovations, and the dominance and persistence of large controlling firms in the software industry).

27 *See* STOBBS, *supra* note 23, at 9-10.

28 *See id.* at 11-12.

29 *See* U.S Const. Art 1, § 8, cl. 8 ("To promote the Progress of Science and the useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.").

30 *See* Adam Mossoff, *Rethinking the Development of Patents: An Intellectual History, 1550-1800*, 52 HASTINGS L.J. 1255, 1315 (2001).

31 *See* Act of April 10, 1790, ch. 10, § 2, 1 Stat. 109 (1790).

32 *See* Graham v. John Deere Co., 383 U.S. 1, 7 (1966) (noting Thomas Jefferson was the

rewarding any inventor of a new and useful invention with a limited monopoly over his or her invention as a means of ensuring efficient investment in and disclosure of this invention. Jefferson, himself an inventor, reasoned that some form of external protection was required to encourage the individual to share his or her idea for the benefit of society.[33] Despite his proclaimed aversion to any form of monopoly, Jefferson supported the grant of limited monopoly rights to provide this protection.[34]

The Patent Act of 1793 turned the patent system from an examination system, in which patent applications were screened to test for certain basic criteria, into a registration system, with no formal screening of applications prior to grant shifting responsibility for patents from the government to the courts and increasing the uncertainty associated with the quality and validity of the patents granted.[35] This led to a proliferation of poor quality and often invalid patents that were difficult to administer and burdensome for innovators and invention users, leading Congress to restore the examination based system in the revised Patent Act of 1836.[36]

The basic structure of the current Patent Act, adopted in 1952 and contained in Title 35 of the United States Code (the "Patent Act") maintains much of the structure and definitions from the revised patent acts of 1793 and 1836, and the patent concepts introduced by Jefferson have endured in the face of significant scientific advances and technology shifts.[37] It is ironic that the laws that sit at the forefront of technological change and innovation have themselves changed so little, and it is interesting to consider whether the same framework will continue to endure as discovery takes an increasingly intangible, automated form.

B. Who is the "inventor"?

Public beliefs about the justness and importance of rewarding human effort and stimulating the spark of human creativity embodied in invention have fuelled popular and political support for the Patent System. In the words of Abraham Lincoln, and echoed by courts in subsequent years, "[t]he Patent System added the fuel of interest to the fire of genius."[38] Although the explicit motivating principle of the American patent system is utilitarian, based on the

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author of the 1793 Patent Act) (citations omitted).

[33] *See* Letter from Thomas Jefferson to Isaac McPherson (Aug. 13, 1813) *at* http://press-pubs.uchicago.edu/founders/documents/a1_8_8s12.html. ("Considering the exclusive right to invention as given not of natural right, but for the benefit of society, I know well the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not.").

[34] *See id.*

[35] *See* Act of Feb. 21, 1793, ch. 11, § 3, 1 Stat. 318 (1793).

[36] *See* Act of July 4, 1836, ch. 357, § 6, 5 Stat. 117 (1836).

[37] *See* Act of July 19, 1952, ch. 950, § 1, 66 Stat. 792 (1952).

[38] Abraham Lincoln, Leture on Discoveries and Inventions (Feb. 11, 1859) in ABRAHAM LINCOLN: SPEECHES AND WRITINGS 1859-1865 11 (Don E. Fehrenbacher ed., 1989).

English model, the American patent system has also been strongly influenced by a belief in individual incentives and reward for performance, reflecting an adherence to the Lockean notion that an individual deserves to reap the rewards of his or her labor.[39] The traditional concept of "inventor" cannot easily accommodate the substitution of computers for human inventors.

While the Patent System does not explicitly require a particular threshold of human control and input into the invention process, the patent laws are framed in terms of human creation.[40] The notion of a human inventor is embedded in the patent application process, and patent legislation and the Patent Act are replete with references to human actions and entitlements.[41] Section 101 of the Patent Act focuses on "whoever" shall invent[42], and Section 102 prohibits patenting of subject matter that the person "did not himself invent."[43] The patent application process requires an oath or declaration from the inventor[44] and computers do not have standing to file an application or to initiate an infringement claim.[45]

Despite the fact that R&D is increasingly driven by corporations and the percentage of patents filed by individuals continues to fall, individual inventors are still named as the owners (and assignees) of the inventions. Although the concept of "inventor" has been stretched over time to accommodate universities, government laboratories and private companies (e.g., I.B.M., Bell Labs and Sandia National Labs) as key players in the invention process, and public media continues to promote organizations in terms of the individual personalities of their star players. Stretching the concept of inventor to include thinking machines may prove more difficult. Moreover, notions of scarcity and uniqueness of inventive talent will dissipate as computers make the process of invention cheaper and more readily available to people without special skills.

Although a demonstration of intentionality and purposeful action are not required as part of the patent application process, the substitution of brute force machine testing for human intuition also challenges the traditional understanding of "inventor." The concept of an inventor does not fit neatly into scenarios in which the invention emerges from random interactions between existing computer programs, repeated computer simulations using all

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[39] *See* Mossoff, *supra* note 30, at 1274, 1311.

[40] *See* Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980) (reaffirming that the Patent Act covers "anything under the sun made by man.")

[41] *See, e.g.*, 35 U.S.C. § 102 (2000) (stating that "[a] *person* shall be entitled to a patent unless.") (emphasis added); *Id.* § 115 (stating that inventors are required to take an oath as part of the application process).

[42] *See id.* § 101.

[43] *See id.* § 102(f). "A person shall be entitled to a patent unless - - he did not himself invent the subject matter sought to be patented . . ." *Id.*

[44] *See id.* § 115.

[45] *See id.* § 118 (requiring special action on the part of the Patent Office and is clearly not intended as a gateway for machine generated patents).

possible scenarios, or other forms of data mining, perhaps with little or no direction or forethought on the part of the human operator. Where the process of invention is not purposeful or directed, and there is no real human oversight or control over the process, and there may be no real "inventor" to lay claim to the patentable result.

Furthermore, the identification of the "real" inventor may be problematic if an invention process consists of multiple tasks that can be performed by the same or by different machines, particularly where the machines themselves may be amalgams of technology and databases provided by different sources. Distributed computing, in which multiple computers participate in the invention process by sharing tasks and information almost continuously, and by building on each others' results, will create difficulties in identifying a unique inventor. Where computers have drawn on databases composed of prior discoveries, the ability to limit the number of potential claimants to the resulting invention (itself a product of these databases of prior discoveries) becomes even more of a challenge. This difficulty in tracing an invention to the "inventor" has interesting implications in light of Section 102(f) of the Patent Act, which states that a patent will not be awarded if the inventor listed on the patent application is not the true inventor of the invention.[46]

As the role of the machine in the invention process expands, and machines are able to develop results unexpected by their human operators, questions will arise not only as to whether the human operator is indeed the inventor but also as to what credit should be given to the machine participants. There is currently no legal requirement to identify machine participants, regardless of the materiality of the role played by these machines, and there is also no clear framework for identifying ownership of the results generated by these smart machines, particularly where multiple machines and databases are used in the process of discovery. Employers and consultants utilizing thinking machines as part of their inventive activities may need to give some thought to new forms of protecting ownership and control over the resulting intellectual property. To take a futuristic view, it may one day become necessary to obtain an assignment of invention rights from computer agents, and in the meantime, due diligence over what computer resources are being used, how, and who owns, controls, and has access to the results is warranted.

C. What is the "invention"?

Patent law practitioners will face similar difficulties in applying the traditional concept of "invention" to the new paradigm. Thinking machines solve problems by transforming concrete situations into a sequence of machine solvable programs. In the present state of the art the human operator is responsible for configuring the structure of the problem to be tested and for identifying a method of evaluating the results generated by the thinking machines in repeated testing. As the sophistication of thinking machines increases, through computer learning as well as enhanced computational

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[46] *See* 35 U.S.C. § 102(f) (2000).

capabilities, the human role will increasingly be limited to identifying basic problem structures and evaluation criteria for results, and thinking machines will dominate the rest of the invention process. Determining what part of these procedures is the "invention" and, in some cases, separating the "invention" (a patentable discovery) from the "inventor" (the process of discovery) may become harder as more steps are added, more participants are added, and transformations back and forth between real world applications and computer simulations become more frequent and intertwined.

Since the automated invention process may not be deterministic, the same testing procedures may yield different results on different trial runs, resulting in "classes" of solutions. This leaves open the question of determining whether the invention is the process of reaching the solution, the solution framework, the class of parameters that comprise the solution, or the particular physical manifestation of the solution in a concrete application. The extent to which a physical model of a computer simulated design is required in order for the discovery to cross the "invention" threshold will be of particular importance as design and testing become increasingly automated.

Where the results of computer processes exceed the scope of human imagination, the implications and scope of the discovery may not be immediately clear. Where there are multiple potential applications, many of which are as of yet undiscovered or untested, questions arise as to what the inventor can reasonably claim as being included in the scope of the invention and the degree to which something more than simulation of results is required. Where the inventor is itself a machine, and the "thought process" used by the machine takes a discrete, tangible form, the patentability of the "inventor" becomes an important issue. Patents have already been obtained for certain evolutionary software systems that reflect early stage attempts at the design of invention machines.

The possibility of automated invention processes that can expand beyond human direction and encompass diffuse machine participants and sources of information will challenge both the justifications for the patent system and the underlying conceptions of inventor and invention on which they rest, creating challenges for the Patent Act that are more fundamental than previous technological revolutions.

IV. CHALLENGES IN APPLYING LEGAL RULES

In order to obtain U.S. patent protection for an invention, a patent applicant must surmount a series of hurdles, or statutory tests, that are designed to screen for contributions that fall within accepted categories of subject matter, are novel, useful, and unlikely to be discovered without special effort and/or creativity.[47] When tests for patentability were first being developed by Jefferson and other early patent policy makers, the focus was on providing

[47] The Patent Act establishes a series of hurdles that an invention must surmount to be patentable, including utility (35 U.S.C § 101), patentable subject matter (35 U.S.C. §101), novelty (35 U.S.C. §102), and non-obviousness (35 U.S.C. §103).

property rights for physical embodiments of ideas with concrete and useful applications, primarily in manufacturing, and the statutory rules developed to fit the types of inventions that were characteristic of the times.[48] Technological breakthroughs have continued to raise issues for courts seeking to interpret and apply traditional statutory tests.

A. Patentable Subject Matter

Although Section 101 of the Patent Act has, at least in the abstract, been interpreted broadly to include "anything under the sun that is made by man,"[49] the Patent Act includes specific categories of patentable and excluded subject matter intended to reflect and support the constitutional objective of promoting the progress of science and generating "useful knowledge."[50] Unfortunately, while the constitutional objective is broad enough to accommodate technological change, the categories designed to implement this objective are more difficult to adapt to changing technology. The following discussion illustrates the difficulty of transitioning from a traditional model of invention to a new and as of yet poorly understood model of invention while continuing to rely on existing rules for assessing patentability.

A discovery must be useful to be patentable.[51] In its early rulings the Supreme Court emphasized that only patents which serve to advance the "useful Arts" by adding "to the sum of useful knowledge" may be granted.[52] Before receiving patent protection, an inventor was required to establish that his or her invention would confer a tangible (as opposed to abstract) and operable (rather than speculative) benefit to society.[53]

This requirement was interpreted by the Supreme Court as an inherent constitutional limitation on the discretion of Congress to grant monopolies, designed to ensure that the scope and grant of monopolies were targeted to the promotion of social benefit through innovation.[54]

As a practical matter, the requirement that an invention be "useful" has served an increasingly minimal role in determining patentability.[55] Courts have expanded the domain of patentable subject matter primarily by

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[48] *See* Diamond v. Chakrabarty, 447 U.S. 303, 308 (1980).

[49] *See Chakrabarty*, 447 U.S. at 309.

[50] *See* 35 U.S.C. § 101. "Whoever invents or discovers any new and useful *process, machine, manufacture, or composition of matter*, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title." *Id.* (emphasis added).

[51] *See* 35 U.S.C. § 101.

[52] *See* A. & P. Tea Co. v. Supermarket Corp., 340 U.S. 147, 152, 154 (1950).

[53] *See* Brenner v. Manson, 383 U.S. 519, 534-35 (1966) (affirming a Patent Office rejection of a patent application for a steroid where the inventor had not discovered any use for it, on the rationale that to be patentable, an invention should confer a "specific benefit … in currently available form.").

[54] *See id.* at 535-36.

[55] *See In re* Brana, 51 F.3d 1560, 1565-67 (Fed. Cir. 1995).

weakening rather than modernizing statutory tests such as the requirement of "usefulness."[56] The Federal Circuit now appears to require only the minimal showing that the invention is operable and provides a tangible benefit.[57] The current utility threshold is likely to be satisfied as long as an inventor provides a concrete application for his or her invention and this application does not involve implausible scientific principles or clearly unrealistic assumptions.[58] Rather than abandoning the test of "usefulness" altogether, it would be instructive to explore what "useful" contributions to knowledge might look like in the new paradigm, and the degree to which a modernized test of "usefulness" should continue to play a screening role.

The Patent Act adds additional structure to the definition of patentable subject matter by identifying five categories of patentable subject matter: processes, machines, manufactures, composition of matter, and new uses of any of the above.[59] These categories reflect the traditional focus of the Patent System on concrete, tangible, applied ideas, particularly new methods or instruments of production or new products. A discovery has historically been held to fit within one of the five classes provided that it takes the form of the embodiment of an idea in a tangible medium or as part of a tangible process used to accomplish a concrete and (at least minimally) useful objective.[60] As many discoveries have taken increasingly less tangible forms, courts have continued to retain and apply the same five categories, describing the new technologies in "patent language" designed to fit them within these categories instead of altering the categories to reflect changes in the subject matter of modern innovation. While this approach has the positive effect of allowing broader patent coverage for new technology, relying on an unchanging patent "language" to describe new technologies may lead to confusion about the real nature of the patented subject matter, as well as obscuring differences and similarities among the discoveries that are receiving protection. Courts have, for example, held that discoveries that involve software are patentable as "transformations" of a "general purpose machine" to a "single purpose machine" – a characterization that is not always conducive to accurate

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[56] *See id.*

[57] *See id. See also* John. R. Thomas, Collusion and Collective Action in the Patent System: A Proposal for Patent Bounties (2001) (unpublished manuscript, George Washington University) (on file with author).

[58] *See* AT&T Corp. v. Excel Communications Inc., 172 F.3d 1352, 1357 (Fed. Cir. 1999), *cert. denied*, 120 S. Ct. 368 (1999); Hughes Aircraft Co. v. United States, 148 F.3d 1384, 1385 (Fed. Cir. 1998) ("[P]atents are the backbone of much of the national economy, and, as this court has recently held, virtually anything is patentable . . .") (citing *State St. Bank & Trust Co. v. Signature Fin. Group, Inc.*, 149 F.3d 1368 (Fed. Cir. 1998) *cert. denied* 525 U.S. 1093 (1999)).

[59] *See* 35 U.S.C. § 101 (2000) (providing that "[w]hoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.")

[60] *See AT&T Corp.*, 172 F.3d at 1357.

categorization or description of the underlying discovery.[61] Computation is playing a growing role in multiple areas, and there are now defined fields of computational chemistry, computational neuroscience, computational genetics, computational immunology and computational molecular biology. Computational sociology, anthropology and archaeology are on the way.[62] Defining discoveries that may be based in part on new software but which add primarily to different fields of knowledge as "special purpose machines" will clearly fail to capture the real elements of discovery and may shift the focus of the patents and the patent examination away from the true sources of innovation.

Protecting the "tools" of invention for public use. Laws of nature, natural phenomena, and abstract ideas are explicitly declared unpatentable under the Patent Act.[63] In the past Courts have extended these categorical exclusions to include inventions that consisted solely of mathematical algorithms, software, or business methods, on the grounds that such subject matter is too much like a law of nature or abstract idea.[64] These exclusions have been grounded in concerns about protecting natural laws and phenomena and public domain knowledge (the basic tools of human discovery) from appropriation.[65] In the words of the Supreme Court, "The function of a patent is to add to the sum of useful knowledge. Patents cannot be sustained when, on the contrary, their effect is to subtract from former resources freely available to skilled artisans."[66] Each of these categorical exclusions has proven to be unsustainable in the face of new areas of discovery and corresponding demands for intellectual property protection, perhaps reflecting the fact that patents are social tools that are designed to respond to and promote society's perceived economic needs.[67] The reasoning applied by the courts both to expand and to limit protection to discoveries previously thought to fall within excluded categories highlights issues and policy concerns that will resurface in the face of an automated invention process and discoveries that take increasingly intangible forms.

The distinction between natural and created discoveries. Early Supreme Court cases held that discovery of the properties of natural phenomena, such as combinations of bacteria with beneficial properties as inoculants, did not rise

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[61] *See* Gottschak v. Benson, 409 U.S. 63, 67 (1972).

[62] *See* Johnson, *supra* note 2, at §4, p. 1.

[63] *See* Diamond v. Diehr, 450 U.S. 175, 185 (1981) (citations omitted).

[64] *See id*. at 185-87. Note that more recently the Court has allowed the patenting of mathematical algorithms, software and business methods. *See infra* notes 78-85 and accompanying text.

[65] *See id.* at 185.

[66] *See* A. & P. Tea Co. v. Supermarket Equipment Corp., 340 U.S. 147, 152 (1950).

[67] *See, e.g.*, John F. Delaney et al., *When Dot-Coms Grow Up, Then What?*, N.Y.L.J., March 27, 2000, at S5 (offering tips on handling intellectual property assets to dot.com start ups and explaining that business methods patents can sometimes be the life blood of Internet companies).

to the level of invention, even if such properties were hitherto unknown, because such discoveries were simply revelations about an existing body of natural law.[68] To be patentable, the discovery must come from "the application of the law of nature to a new and useful end," as distinguished from an end that would have been revealed through natural occurrences.[69] This line of reasoning, which was to repeat itself in the context of patenting of mathematical algorithms, was challenged in the late 1970s and early 1980s, when the Patent System was repeatedly challenged by advances in the rapidly evolving fields of molecular biology and genetic engineering. In 1980, the Supreme Court ruled that the fact that a discovery is alive is without legal significance, and held that a live, human-made micro-organism with properties that were different from those occurring in nature was patentable subject matter because the discovery was "not nature's handiwork, but his own."[70]

Although the sole fact that a discovery is alive is no longer a legal impediment to patentability, distinctions in the Patent System between natural and created substances remain.[71] Natural substances with potentially valuable commercial applications such as drugs are not eligible for the same level and type of patent protection as synthetic drugs, for example.[72] If a natural substance is isolated and discovered to have certain properties, then the discoverer is limited to a use patent covering the application of that substance to a particular use.[73] Whereas if a synthetic drug is discovered the drug itself can be patented.[74] This distinction exists regardless of the level of investment required to demonstrate the value and uses of the respective substances. Computers can synthesize many naturally occurring substances once the basic data about the natural substance becomes available. If synthetic copies of natural substances receive greater or more readily obtainable protection than the natural substances they simulate, pioneers who isolate and identify new natural substances may be placed at a disadvantage. More generally, distinctions between natural and artificial creations will be difficult to sustain in a world of automated design, simulation and development.

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[68] *See* Funk Brothers Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 132 (1948).

[69] *See id.* at 130 (distinguishing between the discovery of features of natural phenomena and the discovery of a non-naturally occurring manufacture or composition of matter.); *See also* Hartranft v. Wiegmann, 121 U.S. 609, 615 (1887) (holding that for purposes of the tariff laws simply cleaning and polishing sea shells in order to sell them as ornaments does not transform them into manufactured articles "having a distinctive name character or use from that of a shell").

[70] *See* Diamond v. Chakrabarty, 447 U.S. 303, 310 (1980).

[71] *See id.* at 313.

[72] *See* DONALD S. CHISUM, CHISUM ON PATENTS, at § 1:02[7][a] (2001) ("any significant alteration of the product from its natural state would seem to make the product a "manufacture" and remove the product-of-nature problem.").

[73] See Michael E. Horwin, Comment: "War on Cancer": Why Does the FDA Deny Access to Alternative Cancer Treatments?, 38 CAL. W. L. REV. 189, 221 (2001).

[74] *See id.*

Protection of practical applications but not abstract ideas. Discoveries consisting solely of software, business methods, or mathematical algorithms were traditionally regarded by the courts and the Patent Office as unpatentable abstract ideas.[75] These exclusions were tempered by rulings providing for patenting of mathematical algorithms and software where incorporated into a known tangible process designed to accomplish a concrete end.[76] In *Diamond v. Diehr*, for example, the Supreme Court reasoned that "it is now common place that an application of a law of nature or mathematical formula to a known structure or process [in this case a process for curing rubber] may well be deserving of patent protection."[77]

In the recent decision of *State Street Bank and Trust Co. v. Signature Financial Group*, the Federal Circuit extended legal protection to business methods embedded in software.[78] The Court concluded that the question of statutory subject matter "should not focus on which of the four categories of subject matter a claim is directed to – process, machine, manufacture, or composition of matter", but rather on the essential characteristic of the subject matter, in particular, its practical utility" which is further defined as producing "useful, concrete and tangible results".[79] The court specified that these results could be measured in numerical terms such "as price, profit, percentage, cost or loss." In this decision, the Federal Circuit took the important position that machines that are "a practical application of an abstract idea" which produce "a useful, concrete and tangible result" are patentable under 35 U.S.C. §101, and that this general analysis should be applied to any type of claim.[80] In *AT&T v. Excel Communications, Inc*., the Federal Circuit took the *State Stree*t position one step further.[81] The Court held that "methods" employing mathematical

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[75] *See* Gottschalk v. Benson, 409 U.S. 63, 72 (1972) (holding a computer program unpatentable subject matter) ("Phenomena of nature, though just discovered, mental processes, and abstract intellectual concepts are not patentable, as they are the basic tools of scientific and technological work.") ROBERT P. MERGES ET AL., INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGY AGE 1007 (2d ed. 2000) (stating that during the 1950's and early 1960's the Patent Office's uniform response to applications for software patents was that they were not patentable subject matter).

[76] *See* Diamond v. Diehr, 450 U.S. 175, 192-93 (1981).

[77] *See id.* at 187.

[78] *See* State Street Bank and Trust Co. v. Signature Financial Group, Inc., 149 F.3d 1368, 1370 (Fed. Cir. 1998) (reviewing the Signature Financial Group patent obtained for a computerized system that allows multiple mutual funds (spokes) to pool their investment funds into one investment portfolio (a hub) organized as a partnership).

[79] *Id.* at 1375.

[80] *Id.* at 1374-75.

[81] *See* AT&T Corp. v. Excel Communications Inc., 172 F.3d 1352, 1353-55 (Fed. Cir. 1999) (involving patent claims for a "method" or process embodied in an algorithm for billing inter-exchange telephone calls where one of the primary claims in dispute involved no specific physical structure or transformations, apart from a relation of the structure to the general system environment, and the only real result in this method was the insertion of a special data value into a data field) (holding that recitation of a physical structure or

algorithms are patentable subject matter so long as they are "practical applications" that produce " a useful, concrete and tangible result" and the patent claims do not pre-empt use of the general principles of the algorithm and "other applications" of those principles.[82]

To date, courts have been able to accommodate new subject matter, including software, business methods and mathematical algorithms, even if not embodied in software, without introducing new statutory tests for patentability. The *AT&T* decision leaves open important questions, however, about how "applied" results from the implementation of an abstract idea must be in order to be patentable and the extent to which actual physical construction and demonstration of the invention needs to be completed prior to patentability.

B. Novelty

In order to be patentable, an invention must be "new," in the sense that it has not been claimed by somebody else, has not been used more than one year before filing a patent application, and the inventor must have invented the subject matter.[83] Inventions are compared against the pool of existing knowledge – or at least that part of existing knowledge captured and identified as "prior art" – to determine whether the invention is sufficiently new and different from available discoveries and know-how.[84] The new paradigm of invention is likely to increase the challenges involved in identifying the relevant body of prior art, understanding it, updating it, searching it, and using it to isolate new contributions.

Technical Understanding Required. Patent examiners will be unable to determine the novelty of new discoveries effectively in the absence of a working familiarity with technical and often complex subject matter. Where claims include new elements that are intermingled with already invented subject matter, narrowing down the claims to encompass only new elements may be almost impossible without technical training. The new paradigm will require both familiarity with computers, where discovery takes an automated form and inventions are described in technical software terms, and with the particular field in which the discovery applies.

When is the Invention New? Whether an invention is considered to be novel also depends on how the invention is defined and on how prior inventions have been defined. In the world of machine inventions, similar decision making techniques may produce a range of different applications that may appear closely related or unconnected depending upon how broadly the first

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physical transformation was not required and that this was a "useful" result for purposes of patentability).

[82] *Id.* at 1357 (citation omitted).

[83] *See* 35 U.S.C. § 102(a)-(b) (2000).

[84] *See id.* (stating that prior art includes all patents and printed publications available anywhere in the world, as well as inventions know or on sale within the United States, available more than one year before the inventor filed an application at the Patent Office or prior to the time of the invention).

applications are described. Technically, each result of a computer experiment could be considered a "novel" contribution where there is randomness in the process. On the other hand, machine generated inventions often rely on similar or identical algorithms and data sets, and there may be a significant degree of overlap between the computer generated processes or results, if compared in the abstract.

Disclosure by Inventor. The ultimate responsibility to identify prior art is left to the patent examiner, and later to the courts if there is an action challenging patent validity. In new areas of invention, where information flows have not been fully established, methods of categorizing existing knowledge have not matured, and the parameters of what is appropriately considered prior art have not been examined or fully understood, courts and patent examiners will have difficulties in assessing novelty, and will rely more heavily on inventor disclosures of prior art. The inventor is only obligated to disclose prior art of which the inventor is aware,[85] and as computers substitute for trained and experienced practitioners, the knowledge required by and thus disclosed by the inventors will decline, potentially decreasing the chances that prior art will be identified.

C. Non-Obviousness

The test of "nonobviousness" is typically one of the most difficult hurdles for the inventor since the standard is largely subjective and the assessment is being made, in the first instance, by patent officials who do not necessarily have expertise in the specific field of invention. To be patentable, the differences between the subject matter of the invention and the prior art must be such that the subject matter as a whole "would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains."[86] In applying the test of non-obviousness, surrounding factual circumstances are taken into account, including the scope and content of the prior art, the level of ordinary skill in the field of the invention, the differences between the claimed invention and the prior art, and any objective evidence of non-obviousness such as long identified but unsatisfied need and commercial success.[87] Applying this test in the face of automated invention introduces new questions about appropriate inferences to draw from existing knowledge and the appropriate starting point and comparison group "skilled in the art" for evaluating the contribution.

As sciences and computer science blend in the discovery process and the same solution is increasingly adapted to very different areas, it will become harder to define the appropriate comparison group of people "skilled in the art." With a fragmented invention process, different parts of the discovery

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85 *See* 37 C.F.R § 1.56 (2002) (discussing the duty to disclose to the Patent Office "all information known to that individual to be material to patentability").

86 35 U.S.C. § 103 (specifying also that "[p]atentability shall not be negatived by the manner in which the invention was made").

87 *See* Graham v. John Deere Co., 383 U.S. 1, 17-18 (1966).

process may utilize tools from very different areas of expertise and the combination may not fall within any well-defined domain of skilled individuals. In this case, questions arise as to what "control group" to rely on for the theoretical determination of "obviousness", and how diverse the skills of the "control group" should be. Patent examiners will need to carefully consider the appropriate beginning parameters of knowledge and data processing and testing capabilities to adopt when applying the test of "obviousness" in the new paradigm of invention. If the ingenuity of the inventor becomes increasingly limited to the selection and definition of the problem, the test of "obviousness" may either have to be adapted to give the novelty question more weight or altered to reflect the level of computation required to achieve the result.

Applying the test of "non-obviousness" to machine inventions raises questions about whether and how the obviousness standard should be adjusted to accommodate the "augmented" invention capabilities provided by computers. The new standard may require one to determine what a person, equipped with a supercomputer, skilled in the art, would have discovered. A standard that contains forseeability as one of its elements may need to incorporate the greater ability to calculate and predict that computers offer. It will not be appropriate to judge the invention according to what a "person skilled in the art" could have predicted if machines are heavily relied upon to generate results that lie beyond human imagination.

If discovery becomes simply the end result of data mining, and no special skill is involved in either defining the question or computing the answer, questions arise as to whether the result should be considered "obvious" and therefore unpatentable. Massive computational ability raises the question of whether obviousness will ultimately become a function of the level of computational capacity needed to reach the answer. If an invention is the result of brute force trial-and-error testing, the result could be construed as obvious, because of the inevitability of discovery, or as not obvious, because the result was not "foreseen." On the other hand, where elements of randomness are built into the experimental process through evolutionary software techniques there are some senses in which the results are never obvious.

V. LOGISTICAL CHALLENGES

The new paradigm poses a number of practical problems for participants in the Patent System. The Patent Office must develop strategies for coping with large volumes of patent applications, changing technologies, and a complex, growing body of prior art. Practitioners must determine how to draft and file increasingly complex patent claims and how to advise clients on appropriate patent filing and enforcement and licensing strategies. Inventors must struggle with difficulties in detecting and avoiding infringement. Additionally, the courts must assume a greater role in assessing patent validity and face greater difficulties in making determinations of and assessing damage from infringement.

A. *Volume of Patent Applications*

The Patent Office is already struggling to keep up with an increasing volume of patent applications, particularly in new areas of technology. The Patent Office received 315,015 patent application submissions in 2000, 295,926 of them utility patents (excluding reissued patents), as compared to 288,811 patent applications, 270,187 of them utility patent applications, submitted in 1999 and 176,264 patent applications, 164,558 of them utility applications, submitted in 1990.[88] Over the span of ten years, the number of patent applications has increased by approximately 79% and the number of utility applications has increased by approximately 80%. Overall, the patent application filing rate has increased by at least 8% a year since the mid-1990s and the rate continues to increase.[89] This increase in volume of patent applications has already had a noticeable impact on the speed of patent prosecution, the quality of application screening and evaluation of appropriate breadth and scope, and the ability of the Patent Office to maintain and search prior art databases effectively. The increase has been facilitated by the expansion of patentable subject matter (most notably software and business method patents) and has been concentrated in the areas of telecommunications, information processing and biotechnology (all fields in which automated discovery has made early inroads).[90] Applications for mechanical discovery have declined.[91] Lower cost of invention, increased computational capabilities and scale economic in inventing are likely to increase the number of patent applications even further.

B. *Quality of Patent Grants and Patent Office Resources*

Quantity of Patent Grants. The Patent Office issued 176,087 patents, including 157,497 utility patents, in calendar year 2000, making a total of 2,364,879 patents as of the end of the calendar year. Annual grants for all patents increased by 4.1 % in 2000 over 1999, with a 2.6% increase in the number of utility patents granted over the 1999 total.[92] The number of patents granted in 2000 increased by 8% over the number of patents granted in 1991. According to Patent Office statistics, approximately 60 to 65 percent of patent applications have resulted in issued patents and this trend appears to be

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[88] *See* U.S. Patent Statistics Calendar Years 1963-2000 *available at* http://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm.

[89] *See* Bruce Kisliuk & Jesse Marshall, *Business is Booming: Managing growth—while improving quality—is high priority for PTO*, 1 PTO TODAY 1 17, 19 (Jan. 2000) *available at* http://www.uspto.gov/web/offices/ac/ahrpa/opa/ptotoday/monthlist.htm.

[90] *See* Thomas, *supra* note 57.

[91] *See* U.S. Patent and Trademark Office, *Technology Assessment and Forecast Report: Mechanical Classes 1977 – December 2000*, *available at* ftp://ftp.uspto.gov/pub/taf/stmech.pdf (indicating a steady increase in the number of mechanical patents granted since 1991).

[92] U.S Patent and Trademark Office, Patenting Trends Calendar Year 2000 *available at* http://www.uspto.gov/go/taf/pat_tr00.htm.

continuing.[93] Questions have been raised as to whether the increase in patent grants are reflective of increases in technology that is deserving of patent protection, or instead are attributable to a decline in quality control and a rule of thumb approach to patent examination procedures and grants.[94]

Uncertainty about patent quality and about the value of patents as vehicles for providing market returns on the use of valuable new technologies is likely to increase in response to the increased volume of applications and increased complexity of claims likely to result from the new paradigm.

Patent Office Resources. The Patent Office is self-financing, and the application and maintenance fees paid by patent and trademark applicants and owners finance all operating costs. Although the Patent Office's workload has increased by more than 60% since 1996, the federal government has not allowed spending to keep pace and has siphoned funds from the Patent Office for use on other federal programs.[95] While the Patent Office is projected to earn $1.346 billion in revenue this year, for example, President Bush's budget mandated a spending cap of only $1.139 billion for 2002.[96] The lack of funding relative to demand has lead to a decline in the resources available to evaluate each patent application. Currently the average period of time between filing for a patent and the issuance of the patent is 30 months,[97] and patent examiners devote an average of 18 hours to the evaluation of each patent application over this prosecution period.[98]

The current high volume, low processing time and "customer" focus of the patent application screening process threatens to turn the Patent System into a de facto "registration" system by placing the burden on the courts to determine the validity of a patent. Given the small number of lawsuits involving patents, relative to the number of patents, this is a worrying trend. Lemley estimates that only about 2 percent of all patents are ever litigated and that less than two tenths of a percent of all issued patents actually go to court - not a surprising fact given that the median cost per side of patent litigation rises to over $1,500,000 through trial and appeal.[99] Issued patents are held invalid in between 30 and 50 percent of cases that reach a determination of validity.[100]

C. Prior Art

The difficulties inherent in determining what is prior art in the face of new categories of patentable subject matter and new areas of innovation have been

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[93] *See* Mark Lemley, *Rational Ignorance in the Patent Office*, 95 NW. U.L. REV 1495, 1498 (2001) (discussing PTO patent application data).

[94] *See id.* at 1495.

[95] *Id.* at 1498.

[96] *See* Kent Hoover, *Patent Backlog Grows*, MEMPHIS BUS. J. (June 29, 2001), *available at* 112001 WL 10459054.

[97] *See* Lemley, *supra* note 93, at 1498 n.12.

[98] *See id.* at 1500.

[99] *Id.* at 1502.

[100] *See id.* at 1502.

illustrated by recent struggles with patent applications for business methods, and the new paradigm of invention is likely to continue to increase the challenges inherent in this critical part of the patent examination process.[101] One of the big difficulties in screening inventions in new areas is the lack of a well-defined database for examining prior art. The huge volume of patent applications and patents, combined with the rapid pace of technological change and the related difficulty in cataloguing new types of discoveries, has made it difficult for the Patent Office to keep complete and well organized databases of prior art. Questions arise as to what types of subject matter may be considered to constitute prior art and where (and in what form and medium) such prior art is to be located. Examiners will also need search techniques capable of handling voluminous databases of prior art. Where there are no established databases or existing inventories of patents covering similar subject matter, techniques for gathering and searching different forms and areas of research and knowledge must be developed and improved upon. New forms of recording and sharing information have increased the complexity of maintaining comprehensive databases of existing knowledge, turning the search for sources of prior art into a moving target.

Searching existing inventions and identifying commonalities between new and existing discoveries is difficult without a good, or at the very least consistent, system of categorizing and describing inventions. The Patent Office is still struggling with a system of organizing software patents using a language that programmers will be able to understand and locate, for example - at the moment many software patents don't even have the words "computer," "software," "program" or "algorithm" in their abstracts.[102] Moreover, there is no easy way to categorize the patentable inventions that are included within a computer program.[103] Where inventions are presented in computational form, but relate to non-software applications, effective systems of cross-classification are required.

Where existing technology is not systematically incorporated into the types of databases used to determine prior art, tests of novelty will tend to be ineffective. The same problems of categorization and search that create difficulties for the Patent Office create difficulties for inventors and businesses

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[101] *See* Patent, Trademark and Copyright BNA Newsletter, Vol. 5, No. 1468, at 710 (discussing the responses of Patent and Trademark Commissioner, T. Dickinson , to concerns about the quantity and quality of business method patent applications being granted with a business methods patent initiative that includes measures to expand prior art searchers, increase quality control, and increase technical training for examiners); *see also* Jenna Greene, *Patent Office at Center Stage: As the Value of IP Soars, Patents and Trademarks Pour In,* 23 NAT'L L.J. 21 B8 (Jan. 12, 2001) (discussing the responses of Patent and Trademark Commissioner, T. Dickinson , to concerns about the quantity and quality of business method patent applications being granted with a business methods patent initiative that includes measures to expand prior art searchers, increase quality control, and increase technical training for examiners).

[102] *See* Lemley, *supra* note 93, at 1495.

[103] *Id.; see also* Simson L. Garfinkel, *Patently Absurd,* WIRED, July 1994.

seeking to avoid infringement and determine the novelty of their own inventions. Without standardized methods for describing inventions and guidelines on appropriate search procedures, both inventors and patent examiners are left to their own devices, with inadequate incentives to properly explore the landscape of existing knowledge.

D. Determining Patent Scope

In the face of new forms of human intervention in, and discovery of, properties of living creatures, patent professionals were called upon to determine how broad patents for discovered living phenomena should be. Questions included, in particular, the appropriateness of awarding patent protection for general processes or results inferred from specific demonstrated examples. For example, in 1988, the Patent Office granted a patent for a procedure to engineer transgenic non-human mammals to the inventors of a transgenic mouse.[104] The grant was based on the acceptance of the inventor's argument that the procedure could be used to engineer higher order animals.[105] Thus, the grant allowed the patent claim to extend to cover any "non-human mammal" made with their procedure, regardless of how much additional work and innovation might be required to generalize the specific result (a transgenic mouse) to other animals.[106] Such breadth could significantly dampen future research and innovations in this area.[107] Similar concerns have arisen over stem cell patents that now threaten to restrict a variety of different forms of stem cell research.[108]

Courts have required a certain level of human intervention as one way of limiting the scope of patent.[109] It is not sufficient for an inventor to isolate a property of a natural substance, the inventor must also demonstrate how to apply this property to achieve a specified result. The Federal Circuit has increasingly sought to limit patent scope to what inventors have actually done and disclosed, leaving outside of the scope of protection conceptual speculations about what could be produced.[110]

To the extent that measures of human intervention continue to play a role in patentability and patent scope, such measures will need to be adapted to an invention paradigm in which machines replace human ingenuity for much of

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[104] *See* Roger P. Merges & Richard R. Nelson, *On the Computer Economics of Patent Scope*, 90 COLUM. L. REV. 839, 841 (1990).

[105] *See id.*

[106] *See id.*

[107] *See* F. Scott Kieff, Property Rights and Property Rules for Commercializing Inventions (unpublished manuscript, Northwestern University) (on file with author) (analyzing how property rights may serve as tools for facilitating commercialization of innovations).

[108] *Id.*

[109] *See* Diamond v. Chakrabarty, 447 U.S. 303, 310 (1980).

[110] *See* AT&T Corp. v. Excel Communications, Inc., 172 F.3d 1352, 1357 (Fed. Cir. 1999).

the discovery process.[111] The determination of the appropriate patent scope may need to include consideration of the degree of search and computation time required to reach the discovery, and the amount of additional time and search required to demonstrate various applications of such discovery. Similarly, where concrete demonstrations of concepts are required, the Patent Office will need to consider what such demonstrations would look like when dealing with intangible assets or applied ideas not reduced to physical form.

Determining the appropriate scope of patent protection for an invention may become harder as inventions take increasingly intangible forms and the boundaries between abstract and applied ideas become more fluid. Innovation that relies on computer generated discoveries will create special challenges for a Patent System that is already struggling to maintain a balance between rewarding the inventor of a new idea and incentivizing the development and use of this idea to spur further innovation. Evolutionary computer technologies are characterized by a pattern of sequential innovation in which previous programs and techniques are often merged into and incorporated with new programs and techniques. Where evolutionary technologies are used, multiple generations of programs interact with each other according to somewhat random evolutionary operations. This limits control over the direction of the invention process and leaves room for different results to emerge from similar starting points and similar directions.

One of the key trade-offs in determining how to patent the results of thinking machines is likely to be the selection between patenting of product (the concrete applications developed by thinking machines) and patenting of process (the patenting of the decision making techniques, or the thinking machine software itself, used to generate the result). While policy makers will want to encourage advances in thinking machines by providing incentives to develop new techniques, allowing monopoly control over broad areas of problem solving may have a dampening effect on future innovation in this area and will restrict the future use and development of key tools in innovation. Patenting the "product" may result in too little protection, while patenting the "process" is likely to yield too much protection.[112]

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[111] *See, e.g., Chakrabarty* 447 U.S. at 313 (dwelling on the distinction between products of nature, whether living or not, and human-made inventions. The Court suggests that "respondent's micro-organism is the result of human ingenuity and research," rather than a simple product of nature).

[112] *See* Hugo A. Hopenhayn & Matthew F. Mitchell, *Innovation Fertility and Patent Design*, NBER Working Paper 7070, National Bureau of Economic Research, 2-4 (1999) *available at* http://www.nber.org/papers/w7070. The authors argue that innovations that benefit society largely through their role as building blocks in future innovations ("fertile inventions") require a greater scope of patent protection. *See id.* They investigate situations in which lost profits may be decreasing the usefulness of an invention to future innovators, for a given level of patent protection, due to the erosion of monopoly profits from improvements not captured by the existing patent rights. *See id.* The thinking machines paradigm of invention can be characterized as one ranking high in "innovation fertility." *See id.*

E. Specification and Requirement of Best Mode

One of the primary purposes of the Patent System is to provide incentives for full disclosure of inventions so that others can understand and build on the inventions. Section 112 of the Patent Act serves this purpose by requiring patent applications to include a specification (or description) of the invention that provides a characterization of the "best mode" of solving the problem contemplated by the inventor.[113] Guidelines for what constitutes an adequate disclosure of the invention will need to accommodate new forms and processes of invention. The nature of the required disclosure will depend upon the intended audience and the skills such audience is presumed to have. Sufficient disclosure could be judged based on the ability of a particular computer to produce the results, on the ability of a computer performing the specified operations to produce the result, or, at one further stage of removal, in a way that admits of replication by an individual. A demand for a written description of an automated inventory process could be construed as a requirement to produce the machine code or source code used to generate the solution, or as provision of guidelines that would enable someone to use their own computer to replicate the results. Where the computer is used to substitute for particular areas of expertise, there is also a question as to how to interpret "any person skilled in the art" – does this mean skilled in the particular application of the computer, or more generally in the use of computers for these purposes.

F. Identifying, Evaluating and Avoiding Infringement

Evolutionary computing involves the evolution of programs through multiple generations, with considerable overlap and combination along the way. The process by which the resulting optimal program is derived may well involve the splicing, combining and deleting of various parts of a family of programs. Moreover, one of the most significant sources of growth in invention is the unfettered access to information offered by the World Wide Web. Determining how to assign property rights to products that are unidentifiable amalgams of information and ideas drawn from the World Wide Web poses a significant challenge.[114] There may be no effective way to identify the various components that have been included in the invention process, or to locate where these components came from. Concerns about unintentional infringement could dampen the use of evolutionary computing.

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[113] *See* 35 U.S.C. § 112 (2000).

[114] *See* Anandashankar Mazumdar, *Trends in IP Rights on Internet Disturbing Traditional Balance with Individual Freedoms*, 5 ELECTRONIC COMMERCE & LAW BNA REPORT 366, 366 (2000). During a conference on Computers, Freedom and Privacy held on April 6, 2000, panellists expressed concern at the problems caused by the meeting of intellectual property law and modern technology. *Id.* The panellists expressed particular concern about the trend towards allowing legal rights in pure information, such as the content of databases, and the apparent willingness to grant patent protection to subject matter that was previously regarded as unpatentable. *Id.*

While avoiding patent infringement may become more difficult, so too will enforcing patent boundaries. Ease of reverse engineering, coupled with the ability to reach a single outcome through multiple paths, will facilitate inventors to invent around existing patents and will make detection of infringement difficult. The doctrine of equivalents, developed to limit the ability of potential infringers to invent around patents, relies upon the application of legal tests that provide murky guidelines, [115] particularly in new areas of technology. The new paradigm will require a rethinking of the doctrine of equivalents that takes into account the machine power that can be used to replicate the same basic innovations through different steps.

One of the distinctive characteristics of evolutionary computing is the ability to move beyond human-designed "top down" systems. Research is extending beyond the imitation of human qualities to empower machines to solve tasks that, at some point, may extend beyond human control and understanding. The increasing autonomy of sophisticated machines will challenge existing rules for determining the responsibility for actions, particularly in areas such as patent invention and infringement.[116] Interesting questions arise as to whether the discovery paths taken by evolutionary technologies will be subject to examination for patent infringement. Since the process will be largely self-executing, control over the sequence of steps taken to arrive at a patentable solution will be limited. Patent policy will need to address the merits of awarding patent rights to, or asserting patent infringement claims against, human operators where the inventions are produced through processes that are beyond human understanding or control.[117]

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[115] The doctrine of equivalents allows a patent holder to sue for infringement in cases where the allegedly infringing invention is not exactly the same as the patent holder's but "it performs substantially the same function in substantially the same way to obtain the same result." Graver Tank & Mfg. Co. v. Linde Air Products Co., 339 U.S. 605, 608 (1950) (*citing* Sanitary Refrigerator Co. v. Winters, 280 U.S. 30, 42 (1929)). The issue left open in *Graver Tank* was whether the doctrine of equivalents' triple identity test required a comparison of the two patents in question on the whole or on an element by element basis. This issue was decided in favor of an element by element analysis. *See* Pennwalt Corp. v. Durand-Wayland, Inc., 833 F. 2d 931, 934-35 (Fed. Cir. 1987). However, some later cases appear to reject the element-by-element approach. *See, e.g.,* Hughes Aircraft Co. v. U.S., 717 F. 2d 1351, 1364 (Fed. Cir. 1983) (implying the doctrine of equivalents should be applied to the invention as a whole).

[116] *See* Paula Parisi, *The Intelligence Behind Al*, WIRED, Jan. 1997, at 132. Stanley Kubrick, director of 2001: A Space Odyssey, has focused on this very question. *See id.* As early as 1971, Kubrick was raising the issue of "at what point machine intelligence deserves the same consideration as biological intelligence . . . . Once a computer learns by experience as well as by its original programming, and once it has access to much more information than any number of human geniuses might possess, the first thing that happens is that you don't really understand it anymore, and you don't know what it's doing or thinking about." *Id.*

[117] *See* Roderick Simpson, *The Brain Builder*, WIRED, Dec. 1997, at 234. "The greatest strength of evolutionary engineering is the ability to develop systems whose complexity levels are beyond human understanding . . . . Evolutionary engineering will play an

G. Impact of New Paradigm on Competition

Patents are increasingly concentrated in the hands of large U.S. and multi-national corporations.[118] Awards of patents are also geographically concentrated in major business centers.[119] These trends may be explained in part by economies of scale in the invention process and the costs involved in obtaining a patent and enforcing patent rights. The new paradigm promises an increase in benefits largely due to the scale economies available in automated discovery and the low costs involved in enforcing patent rights.

In the current market environment there is often a divergence between the usefulness of an invention, in terms of the ability of the invention to provide new and useful products or stimulate the development of other products, and the value of a patent, which depends in part on the ability of the patent holder to stop other people from producing products and services which infringe on the patent. Recent research indicates that a majority of patents are never litigated or licensed.[120] Empirical research indicates that out of approximately two million patents currently in force, only a tiny number are litigated.[121] Recent evidence suggests that only two percent of all patents are ever litigated, and because a majority of those settle only two-tenths of one percent ever go to court.[122] Empirical information on uses of patents outside of litigation is lacking, but studies suggest that the number of patents that are licensed for royalties is not large, and that much of the perceived value from patents lies in defensive patenting.[123] Large companies have included defensive patenting as

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increasingly important role and eventually dominate traditional programming, as artificial brains get smart enough to write their own programs." *Id.*

[118] *See* Patenting Trends Calendar Year 2000, USPTO, *available at* http://www.uspto./gov. Fewer than 20,352 patents were granted to U.S. independent inventors (i.e. unassigned or assigned to an individual at the time of grant) in 2000, representing 21.0 % of the patents issued to U.S. residents, down from 20,540 (21.8%) in 1999. *Id.*

[119] *See id.* In 2000, 55.1 % of patents were issued to U.S. residents, as compared to 55.6% in 1999. Of the U.S. share in 2000, 20.5% were issued to California residents, 7.3% to New York residents, 7.0% to Texas residents, 4.7% to Illinois residents and 4.5% to New Jersey residents.

[120] *See* Lemley, *supra* note 93, at 1497-1501.

[121] *See id.* at 1501 (summarizing results of various empirical studies on patent litigation and licensing; about 1,600 patent lawsuits are filed each year, involving at most 2,000 patents, and only about 100 cases (and 125 patents) make it to trial).

[122] *See id.*

[123] *See id.* at 1503-06 (exploring results of studies on reasons for patenting and uses of patents). *See also* Bronwyn Hall & Rose Marie Ham, *The Patent Paradox Revisited: Determinants of Patenting in the U.S. Semiconductor Industry*, NBER Working Paper 7062, National Bureau of Economic Research, 3-5 (1999) *available at* http://www.nber.org/papers/w7062 (discussing the strategic use of patents); Ann Barton, *Separating Marketing Innovation from Actual Innovation: A Proposal for a New, Improved, Lighter and Better Tasking Form of Patent Protection*, 4 J. Small and Emerging Bus. L. 1 (2000) (describing uses of patents for UC financing and marketing purposes).

part of their market strategies. The motivation being to construct walls around new product areas, allowing these companies to act as gatekeepers of the product area. Market responses to uncertainties in the patent process for new technologies have included reliance on cross-licensing and joint venture relationships, a rise in industry consortia characterized by patent pooling, covenants not to sue as methods for sharing technology and avoiding threats of infringement.[124] These arrangements tend to benefit large market leaders at the expense of small technology rich companies.

VI. RESPONSES, RECOMMENDATIONS, AND FOOD FOR THOUGHT

"The essential feature that is new about the "New Economy" is its increased dependence on products and services that are the embodiment of ideas. A major challenge of the next decade is to identify the policies that will allow a market economy to thrive in the context of this intellectual property revolution."

- R. Pitofsky, Chairman of the Federal Trade Commission**.**[125]

Thinking machine technologies pose challenges to the invention process that are likely to be more pervasive and significant than previous technological changes because this new technology operates directly to transform the invention process. Both the invention process and the results of invention will be increasingly automated, with implications for cost, volume, types of inventions and the significance of human intervention.

A. Responses to Recent Patenting Trends and Challenges

American Inventors Protection Act. The American Inventors Protection Act ("AIPA"), enacted into law in November 1999, was the result of four years of debate among policymakers and various lobby groups about how to modernize patent law to meet 21st century challenges while protecting the interests of independent inventors and small businesses.[126] The AIPA is regarded by the Patent Office as one of the most significant modern day changes to the Patent System. One important effect of the legislation is a shift in the strategic focus of the Patent Office towards business goals and "customer service" for patent applicants. The AIPA introduces new incentive structures for Patent Office employees (many of them heavily weighted towards number rather than quality of disposition), changes in the guidelines for processing applications (particularly for business method applications), and changes in the re-

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[124] *See* Lemley, *supra* note 93, at 1503-06.

[125] *See* Chairman Robert Pitofsky, Federal Trade Commission, Remarks at the Antitrust, Technology and Intellectual Property Conference**,** Berkeley Center for Law and Technology 1 (Mar. 2, 2001) (transcript available at http://www.ftc.gov/speeches/pitofsky/ipf301.htm).

[126] *See Berkeley Technology Law Journal Annual Review of Law and Technology: Additional Developments*, 15 BERKELEY TECH. L.J. 505, 509 (2000) (noting the proposals initial intent was an overhaul of patent law but the result was six major changes) [hereinafter *Berkeley Technology Law Journal*].

examination procedure.[127] While the focus on improved efficiency is an important step in addressing increases in volume and concerns about the length of the application process for technologies that may very well have short commercial life cycles, the "customer" focus is unlikely to mitigate concerns about patent quality and creates potential conflicts with the social mandate of the Patent Office. The emphasis on meeting timelines for responding to office actions and disposing of patent applications quickly (keeping in mind the fact that it is easier and quicker to award a patent than to reject an application), along with cuts in staff and increases in workloads, are likely to resolve the quality of patent grants and patent validity.

The AIPA attempts to mitigate concerns about the failure to identify prior art in the area of business patents by providing a first-to-invent defense in patent infringement litigation to an accused infringer that was already using a patented business method more than one year before the patent owner filed his application for a patent.[128] The defense is limited in scope and subject matter, and does not appear to address similar concerns for other types of patents.[129] The Patent Office also has plans to increase the level of expertise of its patent examiners through training and hiring (although again the focus has been primarily on adding examiners with expertise in business rather than the cutting edge technologies of the Thinking Machine paradigm). It also plans to add a second layer of review for applications seeking patent protection in Class 705 (which includes electronic commerce-based business methods) in an effort to ensure compliance with search requirements, review reasons for acceptance, and review the scope of the claims that have been allowed. These are desirable changes, but need to be expanded to include areas outside of business methods.

Electronic Application Process. The Patent Office is seeking to automate the patent application process and has invested in technologies designed to automate search technologies for prior art and allow for electronic filing.[130] Patent applicants can now submit their applications on-line, and have electronic access to the Patent Office's existing database of patents.[131] At some point it may be possible for a computer automated inventory process to extend to include filing of a patent application for the results of the process. This electronic system may streamline the submission process, but may not be particularly helpful in improving the evaluation process. Moreover, just as building a new road may lead to more drivers, building a quicker and easier application procedure may lead to more new applications, increasing the burden on the Patent Office.

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[127] *See Berkeley Technology Law Journal*, *supra* note 126, at 509-10.

[128] *See* Robert C. Haldiman, Intellectual Property: Policy Considerations form a Practitioner's Perspective: Prior User Rights for Business Method Patents, 20 ST. LOUIS U. PUB. L. REV. 245, 248-50 (2001) (discussing the prior user right).

[129] *See id.* at 250-51.

[130] *See* U.S. Patent and Trademark Office, *at* http://www.uspto.gov/ebc/efs/index.html (last visited May 28, 2002).

[131] *See id.*

Support for Individual and Small Business Inventors. Debate over the AIPA included a number of concerns about the ability of independent inventors and small innovating businesses to thrive in an environment characterized by increasingly costly and complicated systems for protecting innovation. Independent inventors have made up a decreasing percentage of patent applicants and holders, while the concentration of patents in large corporations has increased.[132] The Patent Office established the Office of Independent Inventor Programs in 1999 to provide independent inventors and entrepreneurs with special assistance and guidance in the patent application process.[133] The assistance takes the form primarily of information and outreach activities designed to increase the transparency of the patent process. The high cost of enforcing patents, along with the other trends discussed earlier, suggest that these measures will be inadequate for entrepreneurs and small or medium sized businesses.

B. Guidelines and Training Materials for Patents in New Areas of Technology.

In recognition of the special challenges of automated invention, the Patent Office has created examination guidelines, training materials, and training programs for its examiners and for practitioners that are intended to clarify how to apply existing statutory tests of patentability to new forms of subject matter.[134] Recent training materials on the application of 35 U.S.C. 101 established that "useful, concrete and tangible is the current test for satisfying the practical application test of Section 101 with respect to computer-implemented inventions" and provided guidance on how to determine whether the results of a computer-implemented invention are "useful", "concrete," and "tangible."[135] The Patent Office also issued additional training materials for computer-related inventions to "address how to apply the Patent Office [Examination] Guidelines in the areas of business, artificial intelligence and mathematical processing applications" due to the high growth rate and increased examining complexity in these areas.[136] These guidelines and materials begin to grapple with the challenges of applying existing statutory

[132] *See* U.S Patent and Trademark Office, Patenting Trends Calendar Year 2000 *available at* http://www.uspto.gov/go/taf/pat_tr00.htm.

[133] The principal mission of the Patent Office is "to ensure USPTO-based support and encouragement of independent inventors and small business concerns through focused, innovative activities and projects." U.S. Patent and Trademark Office, *at* http://www.uspto.gov/web/offices/com/iip/abt.htm (last visited May 28, 2002).

[134] *See* U.S. Patent and Trademark Office, Patent Guidance Tools & Manuals, *available at* http://www.uspto.gov/web/patents/guides.htm.

[135] *See* Examination Guidelines for Computer – Related Inventions, 61 Fed. Reg. 7478, at § 4 (Feb. 28, 1996), *available at* http://www.uspto.gov/web/offices/pac/compexam/examcomp.htm.

[136] *See* U.S. Patent and Trademark Office, *at* http://www.uspto.gov/web/offices/pac/compexam/comguide.htm.

tests and concepts to new forms of invention. New antitrust guidelines have also been introduced by the Federal Trade Commission to guide businesses seeking to exploit their intellectual property or to exploit the intellectual property of their competitors.[137]

C. Recommendations

Deploy Technology to Improve Prior Art Analysis. One way of responding to the challenges that the thinking machines new paradigm of invention poses for the Patent System is to incorporate smart technologies into the patent examination process. If inventions are created in part or whole by computers, then patent examiners should be armed with the same computer capabilities when evaluating the resulting discoveries.

The massive search abilities of computers should be utilized by the Patent Office to perform their own prior art searches and to facilitate the categorization of new patents. Advances in pattern recognition will allow computers to search the Internet for similar ideas and developments, and can be used to provide various measures of relatedness between new and existing inventions. The volume of inventions and the volume of applicants may require computerized sorting and processing. The ability of computers to search databases and identify patterns may also be usefully employed to identify ways of enforcing patent laws and detecting anti-competitive patenting strategies.

Adjust Tests of Patentability to Accommodate Automated Inventors. Tests of usefulness, novelty and non-obviousness need to be adjusted to accommodate the changes in inventors and inventor processes caused by smart technologies. Computer equivalents need to be introduced for human constructs such as the level of human intervention in the discovery process. Standards of usefulness need to be tailored to inventions that take on an increasingly intangible form. Whether a discovery rises to the level of a patentable invention is determined in part by the existing state of knowledge (or at least that part of it captured by prior art databases) and what one skilled in the relevant art could readily infer from this knowledge.[138] Given the presence of computer agents in the invention process, the standard for comparison should be altered to include the capabilities and knowledge enabled by these agents.

New Role For "Useful" Requirement. Thinking machines are likely to increase the volume of inventions and the access of people with a broader range of skills and experience to the invention process. Computers can be used to generate results with little human direction or purposeful selection among experiments, increasing the likelihood of resulting inventions that have little or no practical value. Without a real utility test to screen for these types of

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[137] *See* U.S. DEPARTMENT OF JUSTICE & FEDERAL TRADE COMMISSION, ANTITRUST GUIDELINES FOR THE LICENSING OF INTELLECTUAL PROPERTY (Apr. 6, 1995), *available at* http://www.usdoj.gov/atr/public/guidelines/ipguide.htm.

[138] *See* 35 U.S.C. §§ 102, 103 (2000).

inventions, the Patent System could easily be cluttered with inventions that are useless and, in some cases, detrimental to future innovative activity. Where tests of novelty and non-obviousness serve as poor filters for selecting among machine generated outputs, limiting patent claims to concrete applications of inventions meant to solve discrete problems may increase the ability to identify prior art and will limit the scope of any potential overlap with existing knowledge.

Just as the challenge of the "information age" has been the ability to manage an overload of information the age of thinking machines may be characterized by a problem of too much invention, necessitating new ways of screening for valuable, "useful" contributions. A higher utility threshold could serve as a useful gate keeping role where generating "new" ideas is extremely easy and generating "useful" ideas is more challenging. This higher threshold will encourage internal screening of automated invention processes. Having a real utility standard will also be useful where strategic patenting, based on valuation of patents in terms of blocking power rather than productive power, is prevalent in the marketplace.[139]

Don't Patent the Inventor. Until the implications of this type of patenting have been sorted out, careful attention needs to be paid to the extent to which patent applications include basic evolutionary computing processes as part of the claimed result and the extent to which thinking machines are themselves included as patentable inventions. As these machines move closer to emulating human intelligence, the danger of patenting the "inventor" will continue to increase.

If Inventing Around Patents Becomes a Problem, Grant Shorter Broader Patents. Granting broader patents may provide one way of providing adequate patent protection for innovations if the ease of inventing around patents using data mining and other such technologies becomes a problem. Granting shorter patents will limit the dampening effect of intellectual property boundaries on future innovations and reduce the cost of over-broad patent grants.

Introduce Public Input. A greater level of public participation in the patent invention process may compensate for inadequate prior art databases and a lack of specialized technological expertise among examiners. Companies such as Bounty Quest have sprung up to provide a forum for public input into determinations of patent validity.[140] This input could be captured at earlier stages of the patent application process in a manner similar to the public opposition period for trademark applications.[141] Public input is particularly

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[139] *See* Lemley, *supra* note 93, at 1503-05.

[140] *See* http://www.bountyquest.com (last visited May 28, 2002) (offering prior art search services and encouraging web users to become prior art 'bounty hunters' and get paid rewards for locating prior art).

[141] *See* 15 U.S.C. § 1063 (2000) ("Any person who believes he would be damaged by the registration of a mark . . . including as a result of dilution . . . may . . . file an opposition in the Patent and Trademark Office, stating the grounds therefore, within thirty days after the publication.").

important for areas of rapidly changing technologies.

Take into Account New Market Options and Needs. New types of markets for inventions may emerge, providing new kinds of returns to innovators independently of rewards from patent protection. Consider, for example, a shift to a rental model in which one rents the "inventor" rather than licensing the invention. Individuals could reward the owner of the thinking machine by paying to gain access to the computer to solve their own problems. This would have the effect of reducing the net social benefits provided by patent protection. Policy makers need to critically examine the benefits that existing intellectual property rights are believed to confer and the alternatives available for achieving the same results. If patents have served as proxies for company valuations, for example, then new techniques for valuing intangible assets may be good substitutes for patents.

D. Food ("Chips") for Thought: Bridging the Divide of Machines and Creativity

In comparing machine and human inventive capabilities, the role of creativity and human ingenuity is often seen as a key distinguishing factor in promoting human invention. An interesting parallel can be drawn with the historical comparisons of American and Japanese inventive capabilities, where Japanese inventors were labeled as technicians rather than innovators and Americans were seen as having a comparative advantage in the area of creativity.[142] The comparison of American and Japanese inventive capabilities was later challenged in light of the superior Japanese progress in many areas of electronics and robotics design.[143] Interesting parallels can also be drawn between the techniques of invention now used by thinking machines and those used by famous inventors of the past. Thomas Edison, for example, one of the most prolific inventors and the father of electricity, has been described as an invention machine. His scientific method consisted primarily of repeated trial and error testing. Louis Pasteur made his famous discovery through the observation of the results of a random combination of elements, comparing the new observation with accumulated observations he had made in the past. It might ultimately prove to be the case that the sparkle of creativity is simply the occurrence of a random permutation coupled with the ability to notice the permutation and use it to improve on the status quo.

In addition to mimicking the natural techniques of human evolution (e.g. through genetic algorithms) and human thinking (e.g. through neural networks), researchers have been increasingly successful at developing machines with human-like characteristics and sensory or emotional qualities.[144] Efforts are now being made to build robots with social skills and

[142] *See Study shows that number of U.S. patents issued to Japanese has grown over last decade*, BUSINESS AMERICA, Sept. 25, 1989, at 13.

[143] *See id.*

[144] *See* Adam Cohen, *The Machine Nurturer*, TIME, Dec. 4, 2000, at 108-110; Claudia Dreifus, *Do Androids Dream? M.I.T. Working On It*, N. Y. TIMES, Nov. 7, 2000, at F3.

humanlike experiences, based in part on notions that robots should be able to learn from experience and interact with their environment.[145] Members of MIT's Artificial Intelligence Lab have developed a robot named Cog based on analogies to a human infant and have sought to create a second robot with motivational drive.[146] Tiger Electronics has focused on developing toys that appear to show emotions and develop personalities, including, most recently, a robotic toy dog called I-Cybie that can perform life like motions and interact with its environment.[147]

As robots become able to mimic human emotions and engage in interactive behavior, questions will inevitably arise as to whether such machines should share in some of the legal rights and protections provided to their human counterparts. Questions have already arisen over the extent of ownership rights over these sophisticated entities as software engineers invest significant time in developing and interacting with robots that are funded by third parties.[148] While the ability to imitate human qualities is not seen as a final destination for artificial intelligence, this ability will probably play an important psychological role in human responses to machine intelligence. As machines start to "look" and "act" more like people, it will be more difficult to sustain the person/machine dichotomy that currently exists in the legal system.

Technology has been used as an equalizer of human physical abilities, including voice recognition for people who cannot write, computer generated voice translations for the hearing impaired, and automated limbs and internal valves.[149] A somewhat newer focus has been to use computers to augment human intelligence, skill, and training. MIT's Media Lab has used computers to act as information filters, problem solvers, and even "remembrance agents" (tracking files, e-mails, and other data for its user) for individuals.[150]

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[145] *See* Cohen, *supra* note 144, at 108-110.

[146] *See id.* The Artificial Intelligence Lab at M.I.T. has developed four different projects designed to build robots with social skills and humanlike experiences, including Cog, a robot built in an analogy to a human infant, and Kismet, a robot constructed with three motivational drives. *See id.*; Claudia Dreifus, *Do Androids Dream? M.I.T. Working On It*, N.Y. TIMES, Nov. 7, 2000, at F3. Another outgrowth of research on behaviour based computing is the development of interactive cartoon characters that can mimic human emotions. A company called Extempo Systems Inc., for example, uses software "agents" for Internet customer service. *See* John Markoff, *Web Site Offers Cartoons that Interact, With Feeling*, N.Y. TIMES, Sept. 12, 2000, at C6.

[147] *See* Julian E. Barnes, *Here, Boy. Come to the Toy Department Please!*, N.Y. TIMES, Feb. 4, 2001, Sec. 3, at 1.

[148] *See* Cohen, *supra* note 144, at 110. Although researcher Breazeal at M.I.T.'s Artificial Intelligence Lab created Kismet, it is technically M.I.T.'s property and, as Brezeal says, "[t]he legal system doesn't have parental rights for robots." *Id.*

[149] *See* Ray Kurzweil, *The Virtual Thomas Edison*, TIME, Dec. 4, 2000, at 112. "We are already placing today's generation of intelligent machines in our bodies and brains, particularly for those with disabilities (e.g. cochlear implants for the deaf) and diseases (e.g. neural implants for Parkinson's patients)." *Id.*

[150] *See* Patrick McGee, *In Search of Cyber Humanity*, WiredNews, *at*

Companies now offer software that allows users with little training to engage in sophisticated data mining and data comparisons.[151] This kind of "intelligence augmentation" allows the effects of automatization to creep up the skill chain, providing for the substitution of white collar jobs by machines and allowing people with less formal training and education to perform more sophisticated tasks.[152] In an interesting twist on concerns about the "digital divide," the same computer technology which some have seen as threatening to increase the gulf between the affluent and the not so affluent may in some ways equalize access to information, knowledge, and inventive capabilities.[153] People may increasingly be able to translate their questions into machine solvable tasks, reaching solutions without significant training or expertise.[154] It is questionable whether the current Patent System would be either efficient or sustainable in such an environment.

VII. CONCLUSION

"Law adapts by continuous increments and at a pace second only to geology in its stateliness. Technology advances in the lunging jerks, like the punctuation of biological evolution grotesquely accelerated."

- John Perry Barlow[155]

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http://www.wired.com/news/print/0,1294,38846,00.html (Oct. 28, 2000).

[151] For example, Celera advertises a "discovery system" combining their genomic and biomedical data with computational tools and super-computing power to provide a "bioinformatics infrastructure." *See* http://www.celera.com/genomics/commercial/home.cfm?ppage=cds&cpage=default (last visited May 28, 2002). Molecular Mining advertises software for data exploration, advanced inference and prediction of complex gene networks. *See* http://www.molecularmining.com/products.html (last visited May 28, 2002). Agilent Technologies advertises a LabChip Kit that facilitates analysis of biological samples. *See* http://www.chem.agilent.com/Scripts/Pcol.asp?1Page=50 (last visited May 28, 2002).

[152] *See* Chris Taylor, *Digital Divide, So Close and Yet so Far*, TIME, Dec. 4, 2000 at 120. "Degree-bearing graduates are eight times as likely to have a computer at home and 16 times as likely to access the Internet from home as those with lower levels of education, according to a recent Commerce Department study." *Id.*

[153] *See* Kurzweil, *supra* note 149, at 112. "The tasks that these machines perform required highly skilled engineers and technicians just a couple of decades ago…They represent the latest chapter in the story of automation, which started by amplifying the power of our muscles and in recent times has been amplifying the power of our minds." *Id.* The ability of increasingly young executives to permeate senior executive ranks may in part be a reflection of the use of technology to substitute for human variables such as experience and social networks. Taken to an extreme, technology might ultimately support a "commodification" of the invention process, in which new products would be developed by market professionals and consumers using intelligent Web-based tools rather than by research and development departments.

[154] *See* James Burke, *Inventors and Inventions*, TIME, Dec. 4, 2000 at 65-67.

[155] *See* Barlow, *supra* note 26.

We are currently at an interesting cross-roads in which the courts have accepted a vision of patentable subject matter that encompasses almost any type of human endeavor,[156] and technology has subsequently developed to encompass almost any type of human endeavor, leaving patent professionals struggling to keep up. Thinking machines have become an indispensable part of the invention process in a wide range of areas. Research on the frontiers of physics, chemistry and biology are becoming increasingly dependent on computation, resulting in a merging of science and computer science during the discovery process.[157] The expansion of computational capabilities and discovery of new applications presages even more pervasive and material changes to the invention process in the future as computer science becomes integrated into daily tools and activities and even household appliances are imbued with adaptive learning capabilities. Key features of the new "thinking machines" invention paradigm include low cost high speed computation; the substitution of brute force computation for human intuition; the automation of trial and error testing and experimentation; the sub-division of the invention process into discrete abstract tasks; and the blurring of boundaries between traditional concepts of invention, inventor and instruments of invention.

It is ironic that the legal profession, generally a cautious adopter of new technology, finds itself so often at the technological frontier, faced with the task of dictating rules that will guide the development of and control over new technology, long before experiencing the transformative impact of such technology on its own daily business practices. It is incumbent upon professionals involved in the patent process to develop the knowledge and implement the guidelines necessary to administer patents in the wake of technological innovations that are transforming the invention process. As the capabilities of thinking machines to solve higher level problems continue to progress, the necessity of human participation and direction of the invention process will decline. Human investment will be concentrated in early stages of the investment process, primarily in identifying and defining the problem to be solved, with computers left to structure the discovery process. In this "thinking machine" paradigm, the human operator is replaced by the computer as experimenter, and the Patent System is left to adjust to a world of decreasing cost, high volume, machine generated inventions.

The most immediate challenges for the Patent System will be to determine how to think about machine generated inventions and how to apply the existing tests for patentable subject matter, obviousness and equivalence to these inventions and to the thinking machines themselves. Guidelines for limiting

[156] *See* John R. Thomas, *The Patenting of Liberal Professions*, 40 B.C. L. REV. 1139, 1139 (1999).

[157] *See* Johnson, *supra* note 2, § 4 p. 1. "In fact, as research on so many fronts is becoming increasingly dependent on computation, all science, it seems, is becoming computer science….In the course of this augmentation of the scientific mind, the volume of data that needs to be analyzed has increased from a trickle to a torrent, with physicists and biologists making the heaviest demands." *Id.*

patent scope need to be developed based on a rebalancing of the changing incentives and costs of inventions. On a longer term basis, the framework for evaluating patents must be re-examined in light of the new paradigm to determine whether the rationale supporting the old framework supports the maintenance of this framework during the transformation of the invention process. Finally, serious thought should be given to the integration of new technology into the Patent System. Technological possibilities bring new meaning to the phrase "if you can't beat them, join them."