IT-Driven Automation: The Next Wave

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There has been much discussion in the press about productivity improvements that grew at an annual rate of 3.55% from 2000 to 2003 [BW04]. One of the sources of this productivity growth is automation. We have all witnessed numerous ways in which companies have automated their business processes over the past decade. As a recent example, The Dallas Morning News reports in [Baj04] how Atmos Energy, the Dallas-based gas company, is automating its gas meter reading capabilities by using wireless technologies and thus reducing its staff by 225 employees over the next five years. In this article, we will examine current trends in the technology-driven automation and will argue that *we are still in the early stages of a new wave of automation that will profoundly affect the economy and will significantly contribute to the productivity growth over the next 10 – 15 years.*

Industrial automation is an old phenomenon that goes back to the Industrial Revolution when machines replaced physical labor on a massive scale. Automation profoundly affected manufacturing over the past 25 years when industrial robots replaced various manual jobs in different spheres of manufacturing, including automobiles, computers and telecommunication equipment. More recently, automation was primarily driven by IT. For example, toll booth collectors recently became victims of IT-based automation when some of them lost their jobs to EZ-Pass technologies. Similarly, 225 employees at Atmos Energy will lose their jobs within the next 5 years due to the advancements in wireless technologies [Baj04]. Also, many cashiers in department stores and supermarkets will soon lose their jobs because of the advancements of the RFID tag technologies.

Most of the jobs lost to automation have been *routine production* jobs, according to the job classification proposed by Robert Reich in [Rei91]. The main characteristics of these jobs are repetitiveness and structuredness since they have well defined procedural job descriptions. Examples of these jobs include assembly line workers, foremen, data processors, and toll collectors. The routine production jobs have been replaced by mechanical, electrical and IT-driven machines, including industrial robots and wireless communication devices.

In this article, we claim that the next waive of automation will affect not only routine production workers, but also what Reich calls *symbolic-analytic* workers [Rei91], such as engineers, office and knowledge workers, managers, educators, and other groups of "mind workers." Although few of these jobs will be eliminated completely, many of the more routine tasks in these jobs will be delegated to *"smart machines"* within the next 10 – 15 years, leading to major *restructuring* and *consolidation* of some of these jobs. This phenomenon is examined in the rest of this article.

Which Jobs Can be Automated

The author has recently taught a course on Advanced Technologies for Business Applications at the Stern School of Business at NYU, most of whom where part-time MBA students working in full-time jobs during the day. As a term project, the students were asked to describe what parts (if any) of their jobs or the jobs of their closest colleagues, could be automated within the next 10 – 15 years. All of the students were symbolic-analytic workers according to Reich's classification, some of them working in managerial positions. Based on about 30 student reports, a very interesting picture emerged about the types of jobs that can be automated and the extent and scope of this automation. This picture will be described in the rest of this section.

Characteristics of Jobs that Can be Automated. In general, jobs can be classified along the following dimensions:

- *Repetitiveness:* a job is repeated over time. For example, a salesperson repeatedly meets with the clients.
- *Stability:* a job does not change over time. For example, a salesperson meets with the same client, as opposed to meeting different clients.
- *Structuredness:* a job can be described with a clear procedure, perhaps even expressed as an algorithm. Based on Keen and Scott Morton's characterization [KSM78], jobs can be classified into structured, semi-structured and unstructured. For example a salesperson can have a structured interaction with the client asking several standard questions and making several standard offerings of products. Alternatively, the interaction can be unstructured and open-ended.

Also, many jobs consist of several *tasks*, each task characterized by the three dimensions of repetitiveness, stability and structurdness. Graphically, a job can be represented with a set of points in the three-dimensional space shown in Figure 1, where each point constitutes a particular task of the job.

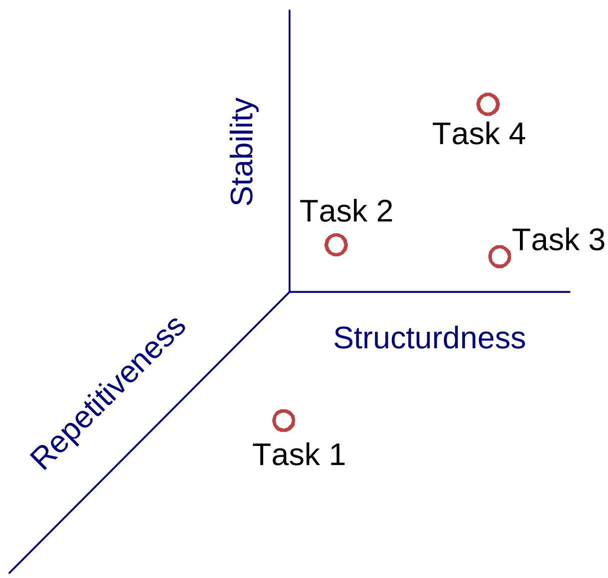

Figure 1: Job representation as set of tasks in 3D space (each dimension is measured in terms of High and Low, where High is at the *origin* and Low at the *end* of the axis)

The tasks that are closer to the origin in Figure 1, i.e. those that are high on repetitiveness, stability and structurdness, constitute the primary candidates for automation. For example, the task of a salesperson meeting with the same client over and over again and interacting with the client in a structured manner asking the same set of questions and offering a simple array of services based on the answers is a good candidate for automation by an intelligent software agent. Moreover, most of the routine production jobs that have been lost to automation, rate highly on all of the three dimensions and therefore are located very close to the origin. In contrast, the tasks that are away from the origins on all the three dimensions are the hardest to automate. For example, the task of a salesperson meeting with different and ever-changing clientele and having unstructured open-ended discussions with them is very hard to automate.

If all the tasks of a given job can be automated, then the entire job can be *eliminated.* However, this situation is unlikely to occur for most of the symbolic-analytic jobs since most of them have some tasks that are ranked high along at least one dimension in Figure 1. Therefore, most of the symbolic-analytic jobs can be automated only *partially* within the next 10 – 15 years.

Extent and Scope of Automation. One of the surprising outcomes of the student term projects is the *extent and scope* of possible automations that the students identified in their papers. In particular, they described numerous interesting ideas and found many creative opportunities for various tasks in their jobs that could possibly be automated or at least performed much more efficiently using advanced Information Technologies. The scope of these ideas was highly diverse, spanning various industries and different types of jobs, including accounting, marketing, sales, finance, human resources, IT, and healthcare.

For example, one type of a job that has already been automated is that of the Client Accountant. This job is responsible for ensuring that all the client's transactions settle properly, all the funds are transferred and all the account balances are reconciled with various parties involved in the transaction. It is a very routine and "paper intensive" job that rates very highly on all the three dimensions in Figure 1 (the point is close to the origin). In the past, there were many client accountants due to very high volumes of transactions in many applications. This job has been automated over the past few years in the financial services and other industries, and the Client Accountant positions have been reduced drastically. According to a student report, a single client accountant can now monitor transaction activities of ten times more accounts than was feasible in the past.

Another example of a job that is currently being partially automated in some companies is that of a Marketing Associate who participates in creating company's responses to various Requests for Proposals (RFPs) and Requests for Information (RFIs). One of the tasks for which Marketing Associates are responsible is the collection, reviewing and compiling the account-related information (such as performance figures, market values, etc.) into a presentable format. It is a laborious and manual process involving running various reports, cutting and pasting information from Excel and Word documents and eventually building a PowerPoint presentation. In many applications this process is structured, straightforward, and does not require much creativity. Therefore, as with the Client Accounting job, it rates highly on all the three dimensions in Figure 1. Thus, this task is a good candidate for automation, and some companies are currently trying to automate it. However, it does not mean that the job of Marketing Associate will be eliminated, as was the case with many Client Accountant jobs, since it involves other tasks that are less routine and structured. This means that the Marketing Associate jobs will be *consolidated* and *restructured* by automating the tasks of responding to RFPs and RFIs and letting marketing associates focus on more human-oriented parts of their jobs.

These two examples constitute the simplest types of symbolic-analytic service jobs that are close to the origin in Figure 1 and that currently are the primary targets of automation. The students also provided numerous examples of more advanced automation tasks. For example, a whole category of automation tasks aims at "taking the human out of the loop." Currently, many business processes have been already *partially* automated by delegating some parts of the business process to machines and other parts to humans. Examples of such human-centered tasks include moving information from one system to another, converting information from one format to another, or checking the results returned from one part of the business process before initiating another part. These human activities are often required because various systems may not "talk" to each other or may return questionable results that need to be inspected before the business process can continue. These activities usually constitute the "leftovers" from previous automation projects and comprise the hardest parts of these projects that were left un-automated for the reasons mentioned above. Naturally, they are primary candidates for new automation attempts using more recently developed information technologies, such as Web services [Cla02], that are particularly well-suited for taking the humans "out of the loop" in business processes.

Another category of tasks that can be automated are *support* tasks. For example, one student described various sales support technologies, including CRM-based Sales Force Automation software, wireless communications, PDAs and Web Services that can partially automate different sales functions.[1]

The students also explored various other jobs that are significantly harder to automate, such as new product development, systems analysis and project management, that require significant advances in technologies before "smart machines" can perform these jobs. Although they claimed that such unstructured, non-repetitive and evolving jobs are impossible to eliminate, the students identified various *tasks within these jobs* that could be automated within the next 10 – 15 years. As one student put it,

> "I would be able to use the power and intelligence of machines to do the tasks that add little to my knowledge or skills. At the same time, I will be able to spend time doing things that I now relegate to the back burner because the routine tasks take up so much time. … Since I will be more efficient at the jobs that I am doing and the drudge work will be done by machines that will have near-zero error rates, I will spend less time debugging code and rechecking new systems to make sure there are no errors."

Although many findings in student reports were quite unusual, they should not be very surprising upon further reflection. For comparison, consider the chess program Deep Blue developed by IBM that defeated the world champion Gary Kasparov in the chess match in 1997. Also, consider various projects attempting to automate the art of painting, writing poetry and composing music described in the book by Ray Kurzweil "The Age of Spiritual Machine" [Kur99]. Although computerized painting, poetry and music composition technologies are still in their infancy, it is quite possible that significant progress can be achieved in these areas within the next 10 – 15 years, as happened in the world of computerized chess over the past 20 years.

If such highly creative, unstructured, non-repetitive and evolving tasks as playing chess, painting and composing music can be automated, then significant portions of the work currently performed by symbolic analytic workers can also be, as advocated by some of the students. It really becomes the question of not *if* but *when*, assuming that enough effort and resources are dedicated towards the development of appropriate technologies.

Moreover, the "low-hanging fruits" are being picked right now, as is evidenced from such activities as automation of the client accounting and marketing associate functions described above. As another example, [BW04] describes how Lehman Brothers Inc. is automating such grunt work as payroll and other administrative functions, while moving

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[1] However, the student also argued that the human interaction aspects of the salesperson's job are impossible to automate, unless human customers will be replaced with automated software agents one day.

software maintenance and testing jobs to India. The main question is how far along the three dimensions of Figure 1 the IT industry would be able to advance within the next 10 – 15 years.

The scope and extent of possible automation of symbolic-analytic jobs described in this section is possible only because of the developments of formidable technologies that can enable these automation processes. These technologies are described in the next section.

Technologies Supporting Automation

There are numerous technologies that can contribute to the automation of symbolic-analytic tasks within the next 10 – 15 years. Some of these technologies exist already, while others still need to be developed and perfected. We describe some of these technologies below.

1. *"Smart" Software.* There have been many "smart" devices and technologies developed over the past few years, including "smart" homes, refrigerators, laundry machines, cooking utensils, alarm clocks and tires. The existence of such devices is possible due to the "smart" software that monitors their behavior and drives and guides these devices. Some of this software uses various AI methods, including advanced heuristic searches in large search spaces deploying sophisticated evaluation functions (similarly to the methods deployed by IBM's Deep Blue chess program), advanced machine learning, knowledge representation and knowledge management methods. However, not all of the "smart" software relies on the AI techniques mentioned above, and some of it just uses standard computational methods.

2. *Business Process Automation Technologies.* Many efficiency improvements come from automation of business processes. There are numerous technologies that help "to remove the user from the loop" from various business processes and thus make these processes more automated. One class of such technologies is *Web services* [Cla02] that define several XML-based distributed communications protocols and help distributed computer systems interact among themselves and "understand" one another without any human intervention. These Web services technologies have become popular for implementing and automating some of the business processes. Another group of relevant technologies are the *workflow automation* technologies [CHR+97] that have been and will continue to be very useful for automating business processes. Finally, another important group constitutes *document analysis and processing technologies* that provide for the automated retrieval, analysis and processing of documents. Much human effort in the knowledge economy pertains to the processing of various multimedia documents containing text, images, video and audio information. This is achieved by parsing, analyzing and understanding these documents and recording the extracted knowledge in databases and knowledge bases. This labor-intensive activity is very difficult to automate because it involves natural language understanding and/or computer vision, which constitute two very hard areas of computer science. However significant progress has been made in both of these

areas over the past several years, and certain types of specialized textual documents and images can be analyzed by machines now. Also, more documents are generated in the XML format that is well-suited for the analysis by machines. All these automation technologies should reduce human involvement in processing various documents.

3. *Networking and Wireless Technologies.* Recent advancements in networking and wireless technologies enable the development of new automation methods and new ways to redesign business processes. For example, RFID tag technologies would provide for the elimination of the check-out lines in the department stores and elimination of many cashier jobs. The tags would also enable automation of the business processes in the supply chains resulting in numerous efficiency improvements. Also, EZ-Pass-like technologies are certainly not limited to the toll collection applications. The EZ-Pass *concept* (a person walking through a monitoring device that recognizes the provided service and automatically bills this person) will be significantly enhanced in the future and will find numerous applications in all spheres of business within the next several years. Finally, integration of wireless, location-based (e.g., Global Positioning Systems, GPS) and Web services technologies constitutes a powerful combination that would enable numerous automation applications within the next 10 – 15 years. As an example, there should be no need for the parking meter inspectors in the future. When a parking meter expires, and the car is still located in the parking spot, computer vision technologies can read the license plate of the car, and all the pertinent information for issuing a parking violation ticket can be wirelessly sent to the central office using Web services technologies. Thus, the parking meter violation and ticketing process can be completely automated.

4. *Machine-to-Machine Interaction Technologies.* This class of technologies facilitates direct interactions between the machines (no humans "in the loop"). Currently, it incorporates distributed systems, networking, Web services, and workflow technologies. However, more complicated and "smarter" machine interactions will be possible in the future by integrating other types of technologies into the mix, including some of the AI-based technologies.

5. *Increases in Computational Power.* Some automation applications require formidable computing power. For example, some of the heuristic searches (similar to the ones used in computer chess) examine trillions of different alternatives. Also, monitoring numerous RFID tags will bring data processing, storage and networking requirements to the levels unthinkable today. These automation applications put pressure on the IT industry to develop increasingly more powerful computing technologies. So far, the IT industry met this challenge and continues to follow the Moore's Law, thus making computationally intensive automation solutions more feasible. It is important for some of the automation activities that this law would also hold in the future.

Consequences of Automation

The next wave of automation of symbolic-analytic jobs described in this article will have profound effects on the economy in both positive *and* negative terms. First of all, it will have significant effects on productivity in terms of improved efficiencies, increased production speeds, reduced costs, and job elimination and restructuring.

Second, these productivity improvements will have profound effects on the labor market, with many jobs and job categories being eliminated or significantly reduced, thus, affecting the symbolic-analytic workers. Also, job elimination and restructuring in some parts of the economy will result in job creations in other parts of the economy. For example, since automation would result in less work required to satisfy the basic needs of the population, people will devote more time and attention to higher levels in the Maslow hierarchy of needs [Mas70]. In particular, we can expect that the entertainment, arts, leisure/travel, and education industries will grow and attract more jobs in the future.

Third, we can expect higher levels of job satisfaction since automation is primarily targeted towards the elimination of routinized, repetitive and boring tasks and would allow workers to focus on more creative non-structured tasks requiring more thinking and ingenuity on the part of the workers. For example, as the quote from one of the students attests (see p. 5), automation should remove routine and drudgery tasks that add little to this person's knowledge or skills and would increase the job satisfaction levels.

Another consequence of automation pertains to political and social issues. Automation will result in increased efficiencies, which can generate higher profits for the companies. Should these extra profits stay within the company and be distributed *exclusively* among its stakeholders, or should the company pay extra "automation tax" to the society and thus contribute to various social programs? This issue of wealth distribution is a political and a social question and lies outside the scope of this paper.

Conclusions

There has been significant progress made over the last three decades in automating various activities throughout different parts of the economy. However, most of this automation involved routine "mechanical" activities and affected predominately the routine production workers. This article argued that the next wave of automation will involve "smart technologies," such as "smart" software, business process automation, machine-to-machine interaction, networking and wireless technologies, and will primarily affect the symbolic-analytic workers. Moreover, this article argued that this automation will be widespread in its scope and significant in its effects, and will affect large parts of the economy in major ways within the next 10 – 15 years.

Overall, this process will have positive effects on the economy, resulting in various productivity improvements and higher levels of job satisfaction. However, it will also lead to the restructuring of the labor market, which can cause significant pain if not managed properly. The key issue lies in developing policies for redistributing extra profits arising from the efficiencies generated by automation. However, the issue of who should benefit from the results of automation is a political and social question and lies outside of the scope of this article. Nevertheless, this issue should be raised and debated before the widespread effects of automation will affect us.

Bibliography

[Baj04] Bajaj, V. “Reprogrammed: Blazing productivity gains means some jobs no longer needed,” *The Dallas Morning News*, October 9, 2004.

[BW04] Cooper, J., “The Price of Efficiency,” Business Week, March 22, 2004.

[CHR+97] Cichocki, A., Helal, A., Rusinkiewicz, M. and Woelk, D. *Workflow and Process Automation: Concepts and Technology*, Kluwer International Series in Engineering and Computer Science, 432. December 1997.

[Cla02] Clabby, J. *Web Services Explained: Solutions and Applications for the Real World*, Prentice Hall, 2002.

[KSM78] Keen, Peter G. W. and M. S. Scott Morton. *Decision Support Systems: An Organizational Perspective*. Reading, MA: Addison-Wesley, Inc., 1978.

[Kur99] Kurzweil, R. The Age of Spiritual Machine: When Computers Exceed Human Intelligence. New York: Viking, 1999

[Mas70] Maslow, A. *Motivation and Personality*, 2nd ed., Harper & Row, 1970

[Rei91] Reich, R. *The Work of Nations: Preparing Ourselves for 21st Century Capitalism*, Alfred A. Knopf, 1991.