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TRENDS IN MACHINE TRANSLATION AND THE FORCES THAT SHAPE THEM

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Abstract

Since AMTA-94, machine translation has embarked on an unparalleled surge of growth. As PCs and on-line access to networked computers have become universally available, the profile of the user has changed and many other new trends have emerged. By identifying the forces that shape these trends, we can plan better for the future. These forces are at once technological and human, and the human forces are political, economic, and social.

1 A New Wave

1.1 Overview

The dreams of yesteryear's MT visionaries are finally coming true. Since we met at AMTA-94 two years ago, machine translation has launched on an unparalleled surge of growth—truly a voyage into the future. We celebrate this impressive new trajectory in our theme, "Expanding MT Horizons." The last 24 months, and especially the last 12 months, have seen a historic shift in the way machine translation is being used and a phenomenal increase in the number of people who rely on it. We now have MT software that is viable, affordable, and runs on virtually any 1990s desktop. Today there are more than 500 vendors of MT software for the personal computer (PCMT) around the world, and among them they put out well over 1,000, possibly 2,000, products (more than 100 from or into Japanese alone, with Spanish in second place).[1,2] One of the vendors, Globalink, sells its extensive line of software in at least 6,000 stores in North America alone, and at present Europe is its fastest-growing market.

But more than anything else, what has unleashed the growth in usership is that we now have MT on-line, accessible through client-server arrangements such as NetClient offered by Logos and, on a much larger scale, through the Internet and commercial service providers. This is the phenomenon that is changing our whole way of thinking about machine translation. Together, these two developments—MT on-line and the superabundance of low-cost MT packages in shrink-wrapped boxes—are turning machine translation into an everyday commodity that is within the reach of virtually anyone with a late-model personal computer. Perhaps most important of all, we have graduated from the days when it was necessary for a system's caretakers to nurture it constantly in order for it to perform acceptably. MT now stands on its own, and, by and large, its users manage to fend for themselves.

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[1]Except for the references to Flanagan (*infra*), the data in this paper on current MT products and their use has been provided by L. Chris Miller and Edith Westfall, Multilingual Computing Solutions, Washington, D.C. Their database lists over 1,800 commercial MT products.

[2]These figures typically count the various language combinations offered by a single company as different products. The latest trend, however, is to offer several language pairs bundled on the same CD, and these are counted as one product.

While all these changes are taking place in MT use, other exciting trends are also reshaping the map of machine translation: the user profile has changed; new language pairs (and more challenging languages) are being tackled and added to inventories; the MT engine is now interfaceable with a variety of other products; speech translation is making steady progress; new tools are speeding up research and development; creative partnerships are being forged between and within the commercial and academic communities; systems of different philosophies are being married; and on many other fronts MT research is accelerating its ongoing march toward new horizons. It's safe to say that never in the history of our field has so much happened within such a short period.

1.2 The On-line Phenomenon

We have all been witnessing the explosive expansion of the Internet, especially the World Wide Web; the commercial on-line service providers; and now, the intranets. Not many of us, however, are aware of the extent to which machine translation is being swept along in this tide. Already on-line access is causing MT use to grow at an unprecedented rate. The numbers tell the story. As of September 1996, MT was being retrieved at some 30 on-line sites in cyberspace. Low-cost software, some of it sold on-line, gives access to MT to translate information on Websites. In another model for providing MT on-line, CompuServe offers three types of entirely automatic service to its members and crunches some 32 million words (128,000 pages) annually (Flanagan *infra*). Their first MT service was inaugurated on the MacCIM Support Forum two years ago. Six months later the experimental World Community Forum began machine-translating conversational messages between people around the world and today translates simultaneously into four languages for an enrolled membership of more than 75,000 users. Recently the company inaugurated a production service for the batch translation of documents. Both "raw" and postedited translations are provided, and each month the demand has increased. Mary Flanagan will be telling us about these experiences, as well as CompuServe's plans to offer MT for on-line chat and e-mail—the latter as a standard option for a potential market of more than 40 million messages a month.

You may be tempted to dismiss these on-line aficionados as curiosity-seekers. How do we know that the MT product is actually being used? While with software purchased off the shelf there is no direct way of measuring the use that it gets, on-line usage can be documented automatically. For example, the records for CompuServe's batch translation service show that there is a large percentage of repeat users. Certainly they would not come back if they weren't reasonably satisfied. Flanagan's statistics (*infra*) reveal that about 85% of the requests are for *raw* (unpostedited) MT—a much larger percentage than she had anticipated. What cannot be determined is whether the translations are being used for gisting purposes only or being postedited for further use. In either case, the MT output is performing a service that is sufficiently useful that the consumer is willing to pay for it. In the World Community, although there is no direct evidence of the extent to which the machine translations are being relied on, at least one fact can be reported: the forum's sysop is inundated with complaints on the rare occasions when the MT system goes down. On the other hand, there have been only a very few criticisms of translation quality. On the contrary, the users are cooperative and understanding, and they frequently offer specific suggestions for improving the system's dictionaries.

This intensity of usage surpasses the wildest dreams of the most ardent optimists in the early days of MT. Moreover, subsequent experience with hard realities had led us to lower our expectations considerably. So it was with great skepticism in 1992 that I read the suggestion, in a draft article by Ken Church and Ed Hovy (later published as Church and Hovy 1993), that MT ("*crummy"* MT, no less!) would be useful for translating on-line messages. I was *certain* that electronic messages were too slangy, unstructured, and fraught with spelling and grammatical errors to ever be effectively translated by machine. Users would be

dismayed by the results, I thought, and with little positive reinforcement they would quickly abandon the translation option. I saw the writing on the wall: MT would once again lose credibility and be widely rejected, just as it was thirty years ago after publication of the ALPAC report (ALPAC 1966).

How wrong I was! I had failed to foresee the emerging currents that were to change the picture so dramatically in these few short years: the universalization of the personal computer, the widespread availability of affordable MT software, the geometric expansion of the Internet and commercial on-line services, the growing need for instant communication across language barriers, the forgiveness of a willing public, and finally, improvements in the quality of the MT product itself. This latest leap in MT history reflects the quickening pace of computer technology in general. Church and Hovy were among the few who even dared to think about the possibility of using MT for electronic messaging, and I doubt that even they foresaw the magnitude of this potential market—or the ready acceptance that "crummy" MT would encounter.

1.3 The New User Profile

We have seen some new trends in how MT is being offered to the public; now let's look at the perspective of the user and the end consumer.

Dissemination vs. assimilation. As we have heard so often, there are users who produce translation for dissemination, and there are those who simply assimilate the gist. Dissemination is for a wide readership. It requires that the MT output be postedited, usually by a professional translator but sometimes also by others with knowledge of the source and target languages—for example, an editor, a technical expert on the subject, or even a novice specially trained for the task. Assimilation, on the other hand, is typically for a readership of one or at most a very few persons, who will read and digest the content but not put the text itself to further use. These two categories differ in many ways, starting with the basic function and characteristics of the process.

The first use of MT, back in the 1960s, was as an "information-only" or "gisting" tool for individual technical experts B i.e., for assimilation. In this role it was very useful (Henisz-Dostert 1979)—and continues to be so (Bostad 1987 and p.c.). Part of the problem with the 1966 ALPAC study was that it applied mixed criteria and did not accurately or fully assess the value of MT as merely an information tool.

By the late 1970s circumstances had changed sufficiently to turn MT into a tool for dissemination—i.e., for the preparation of final postedited texts. This became the mode of the majority of MT users for the next 15 years (Vasconcellos 1993a). But now the pendulum is swinging back again to the information-only user. The fact that complaints flood in when MT is not available on CompuServe's World Community Forum tells us that MT is playing a new role. And in this role its use is poised to grow by orders of magnitude as soon as it is available to handle on-line chat and e-mail.

Participation of professional translators. Until recently a number of leaders of the translation profession in the United States were vocal in their opposition to machine translation. For example, while some members of the American Translators Association were open to learning about MT and experimenting with it, most of them either lurked on the sidelines or took an active stance against MT. In other countries, however—Canada and England, for example—it seems that more of the translators have been open-minded about MT.

Since the late 1970s, a few professional translators have worked as MT posteditors at such places as Wright-

Patterson Air Force Base, Environment Canada, the Pan American Health Organization, the European Commission, Xerox Corporation, and several translation agencies—for example, Antler and LexiTech, to mention some well-known case histories. It is also true that some of the corporate MT operations have employed posteditors with no experience in translation.

In the last two years we have seen an impressive upsurge of interest in MT on the part of professional translators. Many are asking for information on MT, and Flanagan reports (*infra*) that she receives a steady stream of résumés from translators seeking employment with CompuServe's Document Translation Services. As I suggested earlier, of the 85% raw MT provided by the CDTS, it is possible that some is being postedited by translators or others.

Corporate/institutional vs. individual user. Major changes in the user profile are also seen in the shift from corporate or institutional users to individuals. As long as MT programs ran on mainframes, minicomputers, or sophisticated workstations like the Sun, the high cost of hardware and software, not to mention overhead and support personnel, limited MT to the corporate or institutional setting. Even today, in fact, some MT vendors still believe that they should concentrate on the corporate user. This was the thinking that led the authors of the 1991 Ovum report (Engelien and McBryde 1991) to forecast that by the year 2000 some 400 MT units would be being sold annually in Europe and the United States, each at a price of about US$150,000. As it turned out, the phenomenal growth of the PC market over the next two years proved their numbers to be off by a factor of *250* in terms of units sold, and by a factor of as much as *2,500* in terms of the price (see 2.1 *infra* and Vasconcellos 1993a).

The corporate user calculates the costs involved and monitors productivity carefully—often with highly detailed statistics. The output is usually postedited because more often than not the MT system has been enlisted to support or produce a marketable product—otherwise, the high cost is difficult to justify; translating "raw" information has not proven to be commercially profitable and has therefore had to be subsidized by the public sector. Postediting is the most expensive of all the factors of production, and therefore the one that has been studied the most. In addition, months are usually spent on customizing the dictionaries in order to improve translation quality and thereby reduce the amount of postediting required. Corporate and institutional users also make an effort to demonstrate savings over alternative approaches, usually human translation. Case histories are studied to learn from the experiences of others.

The first commercial MT product to run on a microcomputer, or "PC" as we know it today, was MicroCAT, introduced by Weidner in 1983. While the software was still quite expensive, nevertheless it opened up MT to a whole new world of users. Now, of course, we have an infinite variety of off-the-shelf PC packages selling at bargain-basement prices—many of them for less than US$ 100 per unit. Since the hardware is usually already in place and the software is eminently affordable, there is no longer any great need to monitor costs or productivity. Also, many more types of applications are possible, attracting a much broader-based user population. For a number of applications, the user does not need much knowledge of the languages in question. In fact, MT is often used to determine whether or not a text is worth translating, or to scan a text for keywords in order to decide on its further disposition. The latter has been particularly successful in law offices. Whereas for the corporate user the translation of retrieved information has been expensive and difficult to justify, for the individual consumer MT is just another low-cost software package. There are many reports of PCMT meeting users' needs in both business and the home—the first case for repetitive business correspondence, documents, books, patents, technical manuals, software, etc.; in the latter, for personal letters, recipes, tourist travel, homework, and a much bigger "etc.," since the possibilities have been far from fully explored. And with MT on-line the possibilities are beyond imagination: technical

support, forum messages, chat, e-mail, material downloaded from databases—the sky's the limit.

Mass customization. The "in" concept these days is to offer mass-produced products that are at the same time customized or customizable to suit the needs of individual users—a trend that has been hastened by the lower cost of producing software on CDs. An example is Globalink's newest engine, Telegraph, which bundles a number of language pairs in one package and also plugs-and-plays with a variety of other products. As corporate MT evolved over the years, it became reasonably flexible and adaptable to users' needs. However, such tailoring was costly and often required frequent contact with the vendor. Now the products come with a much wider range of options; the dictionaries are more easily updated; topical glossaries are available for a large range of subject areas; some products, such as Globalink's Telegraph, allow the user to update linguistic rules; and, as we saw above, the translation engine can be plug-and-played with other software such as pre- and postprocessors, grammar and style checkers, translation memory, dictionaries and thesauri on CD-ROM, on-line databases, etc. The options now available allow for highly individualized customization.

1.4 Other Trends

At the beginning of this presentation I mentioned a number of trends in addition to the changes in MT availability/usage and the MT user profile. Although space does not allow them to be covered here in detail, it appears useful to classify them under two broad branches: user/usage and research/development.

Under user/usage, in addition to the major trends described earlier, there are many new source languages being developed as well, along with pressure—and capacity—to deal with the more challenging ones.

In terms of research/development, the most notable trends are the formation of creative partnerships between and within the commercial and academic communities; the harnessing of different types of systems to work in tandem; and significant progress in specific areas of MT research.

2 The Forces of Progress

As I thought about these new developments, I noticed that there were identifiable forces which have shaped the progress of machine translation since day 1. Even if we accept that MT is complex and multifaceted and that its nature changes with each application, there are generalizations that seem to hold true. It occurred to me that an understanding of these forces might contribute to a more rational and effective approach to MT development and use.

For half a century progress in MT has always been fueled by a tandem combination of technological and human forces—the former setting the stage for the latter. Unlike most inventions, where the human need is the initial impetus, it has often happened that new developments in computer technology have prompted new things to happen in MT as well. And as the pace of technology has quickened, so have developments in machine translation. Once the technological advances have inspired MT development, then the actual direction of progress has been shaped by social needs and prevailing economic and political conditions.

2.1 The Technological Forces

MT owes its existence and current usage largely to a series of technological milestones: first, the invention itself of a fully electronic computer; second, miniaturization; third, word-processing; fourth, computerized publishing; fifth, the affordable personal computer; and sixth, client-server technology, leading ultimately to on-line access to the giant worldwide networks of on-line service providers and the Internet.

The electronic computer. Next year will mark the 50th anniversary of MT. The initiative of Warren Weaver is believed to have dated from 1947 (Hutchins 1986, p. 21). What is interesting is that Weaver was inspired by the need to find applications to justify the further development of computers modeled after the ENIAC (Electronic Numerical Integrator and Calculator), which had made its debut only a year before. Ideas about how to make use of this exciting breakthrough were in short supply. *Weaver saw natural language translation as an application that could expand the usefulness of the new technology*. We know, of course, that Weaver's initiative was followed by a period of 15 years during which MT R&D projects mushroomed.

Miniaturization => word-processing. Miniaturization brought compact storage and speedy access to the data sets that MT requires (dictionaries, rule bases, etc.), making R&D faster, easier, and more efficient. Even more to the point, it brought with it *word-processing*. Up until the late 1960s, progress in MT was hampered by the fact that texts input to the computer had to first be laboriously keypunched onto cards representing no more than 80 characters each (Vasconcellos 1993b). This period coincided with the low point in MT history following the ALPAC report. It was not until word-processing became widely available that MT got the boost it needed. For the first time machine translation could realistically be used in a production setting. Texts could be input easily, either by hand or from floppy disks. Just as important as ease of input, at the output end it was now possible to postedit directly on-screen. No longer was it necessary to have the posteditor's handwritten corrections entered by a specially trained keypunch operator. As word-processing caught hold in offices everywhere, the most tedious steps in the MT process—input and postediting—suddenly became easy and cost-effective. It's safe to say that without word-processing MT would never have gotten off the ground, and, conversely, had word-processing for the masses existed 10 years earlier, MT would have avoided its ALPAC Waterloo and had a much healthier history.[3]

Computer publishing. The next development to affect MT history was the shift in the early 1970s from linotype to computer printing. Soon commercial companies with extensive documentation turned to publishing in-house. As markets expanded overseas, it became necessary to translate user and technical support manuals into other languages—i. e., to "localize." MT was embedded in the publishing chain. The first company to take this step was Xerox Corporation. Even more impressive were the savings to be made by attaching filters at each end of the MT system to ensure that all the typesetting codes and graphics were transferred automatically into the output text. So great were the savings that quality standards for the raw product could be relaxed somewhat as long as the text could be fixed up. MT was welcomed because it kept terminology consistent and eliminated the need to re-create format codes and graphics in target-language documents. Let's make no mistake: the emergence of this ideal niche for machine translation has been a major factor in keeping the industry afloat from the late 1970s up to the present. In a survey of MT users undertaken three years ago (Vasconcellos 1993a) I found that 17 out of 30 respondents (57%) were using MT to translate technical documentation and other localization materials, and the combined production of

[3] Around this same time developments in optical character recognition (OCR) provided automatic assistance for the capture of texts that were not already on disk or tape, but in fact progress in this area has had only a marginal influence on MT history.

such users—97.7 million words—accounted for 55.5% of the total volume reported in the study. These users found that MT was saving them money (whereas most of the other users were providing a subsidized public service).

Personal computer. The mass availability of PCs has finally created economies of scale for MT. The rush to reach the popular market was led by MicroTac's Language Assistant series, now owned by Globalink, which has a retail price of US$ 59 and sells on the street for even less. It would seem that when the cost is that low, large numbers of people are willing to try MT. For example, all-time total sales for the Language Assistant line, not including upgrades or returns, amounted to 400,000 units at the end of 1994 when MicroTac and Globalink merged, and that figure has long since passed the half-million mark. As I pointed out earlier, there are now more than 500 commercial vendors of packages around the world, and there appears to be a robust market for their products. As MT becomes more fully customizable and adaptable to a multitude of plug-and-play options, this, too, should result in a major expansion of the market.

On-line access to networks. While PCs have brought about the biggest revolution yet in the history of machine translation, on-line MT is ready to take off on a trajectory that will far surpass anything we have seen to date. We should bear in mind that the numbers from CompuServe that I quoted at the beginning of this paper are from only three very limited experiments, one of them launched only a few months ago. It is reasonable to assume that on-line MT will be expanding our horizons beyond anything ever dreamed of by even the most visionary and optimistic of our pioneers.

2.2 The Human Forces

While technological development has had a tremendous influence on progress in MT, it is important to also take a look at the human forces—political, economic, and social—and the role they have played in the MT story.

1950-1965: Political forces predominate. In the beginning, machine translation was largely an intellectual event. Research was aimed at showing that it could work; once it did, then the next step would be to go out and find places where it could be used. World War II had ended, but the Cold War was at its peak. Even though the U.S. Government had not identified an urgent need for translation,[4] most of the support for MT research was coming from the intelligence community and defense-related agencies. The bulk of the work was therefore focused on Russian as the source language (some projects looked into German), and the target language, of course, was English.[5] MT was being envisioned (possibly more by its developers than by the government) as a tool for scientific and military eavesdropping—in other words, for gisting purposes (assimilation) from "foreign" languages into English. This era was to end with the ALPAC report (1966), which coincided with the winding down of the Cold War. Economic forces had not yet come into play to any great extent. As for social forces, some translators were vocal in their opposition to machine translation. They lobbied for a congressional hearing on the subject, which was held in 1960, and they were most surely

[4]Although it was estimated in a 1960 hearing before the U.S. Congress that the volume of Russian technical literature available to be monitored amounted to 780 million words, witnesses for CIA testified that their annual translation output of 23 million words was sufficient to meet the Agency's need.

[5]While some counterpart R&D was being undertaken from Russian to English in the Soviet Union, it was hampered by a shortage of computers and it can safely be said that from 1945 to 1965 the lion's share of R&D was based in the Western Hemisphere. In fact, when SYSTRAN demonstrated English-Russian MT for the Apollo-Soyuz mission in 1975, it was said that the Russians were "still sharpening their pencils."

participants in the process that led to the ALPAC study. Meanwhile, MT research was being hampered by difficult communication with programmers, who could virtually write their own ticket because there were few of them and they were highly sought after.

1966-1975: Transition from political to economic forces. Although machine translation got a bad name from the ALPAC report and public support for R&D slackened off after that, some MT systems continued to be used and enhanced B namely Georgetown University's Russian-English system at Oak Ridge National Laboratory (1964–1987?) and IBM's Russian-English Mark I and Mark II at Wright-Patterson Air Force Base (1964–1969), replaced in 1969 by SYSTRAN, the first product of the first commercial machine translation company. Also in 1969 another politically motivated MT initiative got under way: a second commercial MT company, Logos Corporation, was formed and began to develop MT for the translation of aircraft training modules from English into Vietnamese.

Still motivated by politics but in a more peace-making mode, the first renewal of U.S. Government support for MT, and the first request from English into another language, came from NASA, which funded a project in 1974–1975 for SYSTRAN to machine-translate documentation for the Apollo-Soyuz space mission in both language directions, Russian-English and English-Russian. This was also the first use of MT for dissemination, and the standard applied to quality would be higher than for the Russian-English information tool developed by Georgetown University and already being used at Wright-Patterson Air Force Base.

Economic factors were beginning to pressure MT developers to go commercial, while at the same time markets for U.S. products abroad were expanding and creating the need for a new type of machine translation.

As for social factors, translators and other opponents of MT had won a decisive victory with the ALPAC report and were resting on their laurels rather than continuing to build their case against MT. Research, while largely without funding, was nevertheless benefiting from the fact that higher-order programming languages enabled linguists to work directly on their systems and take programmers out of the loop. They were creating the new profession of computational linguistics.

1976-1992: Economic forces in the U.S. and Japan; political forces in Canada and Europe. The installation of SYSTRAN at Wright-Patterson marked the beginning of viable commercial MT. By that time the end of the Cold War had opened the way for economic forces to exert their influence. North American manufacturers were eager to expand their markets by selling their products overseas. Thus the private sector took over support for MT development and filled the void that had been left by the government. Machine translation was enlisted to disseminate technical manuals and other supporting documentation through machine translation *from* English *into* other languages ("one-to-many"). Companies would hold a competitive advantage if they could reach multiple markets simultaneously.

By this time heavy trade between Japan and the West had generated a translation market from Japanese into English and vice versa without parallel in history for a single language pair. A number of Japan's major electronic hardware manufacturers began developing their own MT systems, and the public sector was also investing in MT research (JTEC 1992).

Thus it was largely economic interest, in the form of market expansion in "foreign" countries, that established MT as a viable translation option. The free market succeeded in proving what in 1966 the American public sector had thought was impossible: that MT really works.

It was also at this time that yet another political factor, nationalism, asserted through the recognition of official languages in Canada and Europe, was coming into play. In Canada, the implementation of bilingualism had been creating pressure to enlist MT to deal with large quantities of translation. METEO, Canada's venerable MT weather translator, was a product of this trend. In Europe, the need to translate the 42 (later 72) combinations of the European Commission's official languages gave rise first to a heavy investment in the development of SYSTRAN and later to EUROTRA, the Commission's own mammoth project, which left a legacy of computational linguistic activity throughout Europe. During EUROTRA's heyday, SYSTRAN kept a low profile and remained in place at the Commission as a some-time aid to translators, and the Commission continued to invest in developing a large number of new SYSTRAN "cross" pairs.

Throughout this period the predominant direction was English into other languages and vice versa, with some development being done on German and Japanese as source languages. To a much lesser degree other "cross" pairs began to be developed, and this trend has recently been on the increase (JTEC 1992, ch. 3).

In terms of social forces, more translators were giving MT a try, while in the research area programmers were now out of the picture and researchers were turning into a strong new breed—computational linguists.

1993-1996: Social forces predominate. Our most recent period in MT history, described in the first part of this paper, reflects a new trend in which social forces have come to the fore. The nature of MT is being shaped not so much by national political or economic forces as by the vast population in aggregate sitting at computer screens and acting in the role of direct users. Suffice it to say that in 1992, after years of languishing as an aid for professional translators, SYSTRAN was made available to the entire secretariat at the European Commission, and within that same year use of the system increased many times over.

It is clear that machine translation has become very popular as an information-only tool. While the number of postediting professional translators is growing rapidly, at the same time it is meeting the needs and whims of the impressive ranks of direct users—most of them seeking MT for gisting purposes only. Here is where the mass customization concept is leading to major growth. It is not uncommon to find niche-market systems for specific purposes and specific language pairs. It is the mass of individual and specialized users that is actually driving the future of machine translation.

3 What Next?

Analyzing the trends in MT enables us to prepare for the future. We learn that we must first look at the technological development that's waiting in the wings.

A good example of technological progress that should be spawning more MT development is parallel processing. Like the ENIAC, this is an available technology in search of applications, and machine translation should be at the head of the queue. The functional and connectionist approaches in linguistics will undoubtedly offer rich fodder for parallel processing. It is incumbent on linguists, especially computational linguists, to explore the nature of language more deeply, and with fresh eyes, so that advantage can be taken of this exciting new avenue.

Similarly, the progress we have all seen in speech recognition and synthesis, coupled with the mass marketing of multimedia computers, is generating a demand for speech translation. Once sound is added to routine on-line communication, the pressure will be greater. As this pressure mounts, vendors will be

virtually forced to offer, as a first step, low-cost small-vocabulary speaker-independent systems that translate discreet speech. However, much research will still be needed before it is possible to handle continuous speech and large vocabularies. Parallel processing will no doubt prove to be very useful.

As other technological advances come to light, and as new pressures, possibly more social than economic, are felt, news paths will open for machine translation.

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