A renewed international effort is gearing up to design computers and software that smash language barriers and create a borderless global marketplace.

ILLUSTRATION BY JOHN HERSEY

Talking to Strangers

A woman sits at a desk in Manhattan, talking to herself in French. The phrases she balances on each breath are musical to American ears. She has postcards of Montreal tacked up on the walls of her cubicle – pastel-painted houses in the snow – so as she sculpts the contours of each syllable, she can remind herself of the place where the sounds she's making are heard every day in the street. Her name is Guylaine Laperrière, and she came to New York City more than a decade ago to study musical theater. One day, a friend asked her if she wanted to make a little cash dubbing a French voice-over for a promotional short about insurance. She took the job, and was surprised how much she enjoyed bringing ideas from one language home into another.

"*Ceinture baudrier*," she repeats softly to herself. "*Ceinture diagonale*." *Ceinture baudrier . . . ceinture diagonale . . .*

Seat belt, seat belt.

Laperrière is one of more than 12,000 translators employed by Berlitz, the century-old advocate of language learning and the largest translating firm in the world. Today, Laperrière's task is editing a translation of the new Chrysler PT Cruiser owner's manual into Québécois dialect. With more than 50 manuals and related materials to port into 15 languages each year, DaimlerChrysler is Berlitz's biggest translation account.

As one might expect in an industry based on moving words around, the digital revolution brought changes to the office. About four years ago, Berlitz's translators had to start being as fussy about their SGML tags as about their circumflexes, umlauts, and accents graves. Soon Laperrière and her team will start using a translation-memory system called Trados. Trados looks for phrases that have already been translated in previous documents so Laperrière won't have to weigh *baudrier* against *diagonale* each time a new sedan drops out of the chute.

Even in an age when we take satellite telephony and international videoconferencing for granted, this is the way most documents on Earth are relayed from culture to culture: by professional translators like Laperrière, who work painstakingly by hand, bringing expertise and intuition to bear on a phrase by turning it over and over in their minds. That we still do things this way would be a surprise to anyone recalling an article that appeared in a British newspaper 50 years ago, trumpeting a breakthrough that should have wiped Berlitz off the map: an electronic device, invented at the University of London, which allowed students and secretaries to compose and translate texts into a dozen languages. "As fast as [a user] could type the words, say, in French," the *News Chronicle* reported breathlessly, "the equivalent in Hungarian or Russian would issue forth on the tape."

Six years later, a scientist at the University of Michigan who was also working on translation by computer – so-called machine translation, or MT – confidently assured the Associated Press that "within a generation, machine translation will be a fait accompli, as will machine reading." In his *Introduction to Machine Translation*, published in 1960, another researcher, Emile Delavenay, exulted that "the translation machine . . . is now on our doorstep. . . . Will the machine translate poetry? To this there is only one possible reply – why not?"

This indefatigable optimism shows up again in a *Business Week* item from 1998, predicting that by the end of last year, AT&T and the Advanced Telecommunications Research Institute in Japan expected to have a "prototype system" of telephones that would automatically translate calls from "spoken Japanese into English, and vice versa." And this past January, President Clinton's State of the Union message included a promise that "soon, researchers will bring us devices that can translate foreign

languages as fast as you can speak."

This dream of accurate, automatic, real-time translation by computers – a practical version of the Universal Translator from *Star Trek* – has been a consuming obsession for some of the brightest minds in computing, linguistics, and AI research for more than five decades. It has marshaled heroic R&D efforts on academic and commercial fronts from IBM to MIT, burning through billions of dollars in pursuit of what is either the supreme embodiment of a borderless global society or the ultimate vaporware.

And it's still largely a dream. Where are our translating phones? Why is Guylaine Laperrière still talking to herself about seat belts? Why does the future of MT never seem to arrive?

English as a Second Language

It looks like we may be needing that future ... about five minutes from now. Analysts project that sometime this year, a kid logging on for the first time somewhere in China, India, or Northern Europe will tip the Net's English-speaking majority into a minority. Of the five most frequently used domain name suffixes, the fourth and fifth – right behind .com, .net, and .org – are .jp (Japan) and .de (Germany). There are now more domain names registered outside the US than inside. By 2003, Forrester Research estimates, US users will account for only a third of the Net's population.

For a brief moment, it appeared that the Web was going to be the perfect high tech battering ram to cram Americanese down everybody's throats. The fact that the lexicon of MTV was the mother tongue of the first generation of webzines and chat rooms seemed to ensure the dominance of English as the global lingua franca well into the 21st century. Americans didn't need translation – at most, we needed a phrase book when we wanted to soak up local color in a country so backward they didn't speak *our* language. "The only thing I'd rather own than Windows," Sun's Scott McNealy declared to the Senate Judiciary Committee in 1998, "is English."

Now here comes everybody, and they're bringing their own dialects to the online potlatch. An Israeli startup called Slangsoft is using Java to create onscreen keyboards that accept input in 42 languages, including those with non-Roman alphabets, such as Chinese, Korean, Hindi, Hebrew, and Sanskrit. The latest versions of Netscape and Internet Explorer make it easier to compose Web pages with text running from right to left, which is good news if you're building sites in Hebrew or Arabic. The blueprint for a new Tower of Babel is being sketched out in HTML. The widespread adoption of Unicode – a standard for encoding text that assigns a unique number to each letter, punctuation mark, and technical character in the world's major languages – is sparking an explosion of multilingual software.

It feels awfully old economy, however, when email arrives from the Tokyo office as screenfuls of indecipherable symbols. It doesn't seem unreasonable to expect a Save as Spanish option when working in Word. The frictionless ease with which words sluice through our networks and applications teases us with the promise of a high tech cure for the virus that "confounded" (says the King James translation of the Bible) all the tongues of the Earth. As the trickle of incomprehensible texts swells into a flood, we're paddling into the deluge with a kind of faith that, in the near future, the Net will interpret linguistic differences as damage and route around them. Though we're not the first generation to imagine that an MT breakthrough is just around the corner, we *are* the first to lay the foundation for a global marketplace that will drain every translation resource we've got.

To find out how close we really are to installing a Universal Translator on our desktops, I visited researchers at Lernout & Hauspie, the biggest manufacturer of commercial translation software; at IBM, MT pioneers since the days of the Cold War; and at two leading academic greenhouses for MT development in the US, Carnegie Mellon University and New Mexico State University. I also spoke with linguists, cognitive psychologists, and poets – people who work under the hood of language, probing around in the engines of cognition.

To see a living embodiment of MT's evolution, visit the Babel Fish. Named for a creature in Douglas Adams' *The Hitchhiker's Guide to the Galaxy*, the software at *babelfish.altavista.com* is most netsurfers' first exposure to computer translation. While it may seem like the forerunner of a new species of Web sites, the Babel Fish is more like that coelacanth discovered in an Indonesian market in 1997: a prehistoric survivor, the descendant of a race of MT dinosaurs who once roamed the Earth, mighty with the ambitions of the first generation of AI theorists and computer linguists. The code that drives the Babel Fish was built by Systran, a company launched in 1968 by one of the researchers who participated in the first public demo of MT.

For a brief moment, it appeared that the Web was going to be the perfect high tech battering ram to cram Americanese down everybody's throats.

It has become de rigueur in articles about machine translation to quote some passage from, say, "Three Blind Mice" or *Hamlet* that's been mashed through several languages by the Babel Fish to demonstrate the inherent goofiness of MT. Or, as the Babel Fish itself tells us, in English phrases that have taken a single round-trip through Spanish and German:

It has from turned rigueur in articles over the automatic translation for estimating a certain job step e.g., "three hidden mice" or the village, *which were crushed with some languages by the fish by Babel, in order to show goofiness, which is appropriate from the TA. Or also, because the fish themselves of Babel say to us, on the cliches, the one individual Spanish round journey to have taken and that German.*

Even if bouncing idiom-laden text back and forth between languages to trigger compound errors is playing "dirty pond," as the Babel Fish would put it, a close reading of the garbled passage above uncovers a couple of neat things about the code. Though the software doesn't know its Shakespeare from a mouse-hole in the ground, it did notice that "say," in this context, should be glossed as "e.g." But what of that seemingly capricious change of "MT" to "TA"?

Traducción automática, señor.

A small thing – but enough to reveal the shadow of a human hand in the translation process. Most random two-letter combinations pass undigested through the Babel Fish's parsers. Somewhere along the line, a

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*Contributing editor Steve Silberman (*digaman@wired.com*) wrote about UK startup Autonomy in* Wired *8.02.*

programmer at Systran, the company that built the Babel Fish, decided that when someone typed "MT" they were probably referring to machine translation (or *traducción automática*), and therefore hard-coded that particular interpretation into the translation stream. The brain of the Babel Fish is a hybrid of human and artificial intelligence – a suitable icon for MT, which was born in a charged moment of speculation at the crossroads of life sciences and a new generation of thinking machines.

What the Babel Fish and lessons from 50 years of MT research suggest is not only that we have to change our ideas about what an appropriate role for computers in the act of translation might be, but that we may have to reform our notions of progress.

What Warren Weaver Knew

One morning during World War II, an amateur cryptographer at Brown University told a friend that he'd come up with a scheme for cracking code. He invited his friend, who was a German mathematician, to give him an encrypted message to test the new method. Applying a numerical cipher to a text of about 100 words, the mathematician delivered a column of five-digit numbers to the cryptographer. The next day, the cryptographer told his friend that his new method had failed. He'd retrieved only meaningless strings of letters. When the mathematician saw the letters, however, he informed his colleague that he'd succeeded in slicing through the code after all. There was something about the original message he hadn't realized – the mathematician had written it in Turkish. The cryptographer couldn't recognize the letters as words because he didn't read Turkish.

One of the people who heard this story was Warren Weaver at the Rockefeller Foundation. The foundation, launched in 1913, was one of the major sources of funding for innovative science in the last century, bankrolling a wide range of projects, from the construction of Mount Palomar's Hale Telescope to the search for new contraceptives to the mapping of genes of blight-resistant strains of rice. Weaver, who coined the term "molecular biology" in the '30s, headed the foundation's programs in the natural sciences. He believed that the 20th century would be remembered as the century of biology and, during his tenure as the foundation's VP, allocated more than $90 million to cutting-edge research that wouldn't have had a prayer of finding funding anywhere else.

A brilliant conceptual mathematician who was also fascinated by the poetic intricacies of language, Weaver published books and articles on fluid dynamics, probability and the concept of Lady Luck, and whether or not a scientist could believe in God. With Claude Shannon, he coauthored one of the cornerstones of information age thought, *The Mathematical Theory of Communication*. When we use signal-to-noise metaphors to talk about writing, politics, or art, we are unknowingly footnoting Weaver's book.

John McKelvey, an agriculturist who was hired by Weaver in 1945, remembers him as a short, round-faced man with an "overpowering" intellect. When he visited Weaver in Connecticut, he watched him hike through the blackberry and raspberry bushes that grew on the land around his house, brambles catching in his skin and blood streaming down his legs. "Most people liked Warren," McKelvey recalls, "except for a few guys who had lost arguments to him."

Along with the visionary code breaker Alan Turing, Weaver was one of the first people to realize that the newborn generation of Big Iron – hulking machines with names like ENIAC, Edsac, and Colossus – might grow up to be more than dumb but very fast calculators. In 1947, Weaver wrote a letter to Norbert Wiener at MIT, a kindred off-trail roamer who was applying the study of feedback and other mechanical processes to living systems – what we now call cybernetics. With the anecdote about the Turkish cipher in mind, Weaver proposed that translation could be considered a cryptographic problem: "When I look at an article in Russian, I say, 'This is really written in English, but it has been coded in some strange symbols. I will now proceed to decode.'"

Wiener took two months to respond, and his reply was discouraging. "I frankly am afraid the boundaries of words in different languages are too vague," he wrote, "and the emotional and international connotations are too extensive to make any quasi-mechanical translation scheme very hopeful."

But Weaver wouldn't let go. He believed that the barriers to understanding between cultures could be worn down with the aid of MT – a concern that must have seemed especially relevant in the lengthening shadow of the A-bomb. On July 15, 1949, Weaver typed up a 12-page memo and sent it to 200 of the brightest minds of his generation, prefacing it with a note that is still charming in its earnestness and modesty. "I have worried a good deal about the probable naïveté of the ideas here presented," he wrote, "but the subject seems to me so important that I am willing to expose my ignorance, hoping that it will be slightly shielded by my intentions."

The memo began with the story of the Turkish cipher, which suggested to Weaver that computers – like the cryptographer – might be able to translate language purely mathematically, without being programmed to "understand" the meanings of the words. Other sections of the memo accurately predicted many of the perplexities that would bedevil MT for the next half-century, from word ambiguity, irregular syntax, and multiple meanings to the larger problem of providing a computer that had very limited memory with context for a phrase under consideration. "If one examines the words in a book, one at a time as through an opaque mask with a hole in it one word wide," he wrote, "then it is obviously impossible to determine, one at a time, the meaning ... 'Fast' may mean 'rapid'; or it may mean 'motionless'; and there is no way of telling which." In the mind, the fabric of context extends into a vast loom of associations and memories with no visible horizon – where does the context of a word end?

Weaver suggested that the language of scientific docu-

Machine Translation's Past and Future

1629
René Descartes proposes a universal language, with equivalent ideas in different tongues sharing one symbol.

1933
Russian Petr Smirnov-Troyanskii patents a device for transforming word-root sequences into their other-language equivalents.

1939
Bell Labs demonstrates the first electronic speech-synthesizing device at the New York World's Fair.

1949
Warren Weaver, director of the Rockefeller Foundation's natural sciences division, drafts a memorandum for peer review outlining the prospects of machine translation (MT).

1952
Yehoshua Bar-Hillel, MIT's first full-time MT researcher, organizes the maiden MT conference.

1954
First public demo of computer translation at Georgetown University: 49 Russian sentences are translated into English using a 250-word vocabulary and 6 grammar rules.

1960
Bar-Hillel publishes his report arguing that fully automatic and accurate translation systems are, in principle, impossible.

1964
The National Academy of Sciences creates the Automatic Language Processing Advisory Committee (Alpac) to study MT's feasibility. ►

1966
Alpac publishes a report on MT concluding that years of research haven't produced useful results. The outcome is a halt in federal funding for machine translation R&D.

1967
L. E. Baum and colleagues at the Institute for Defense Analyses (IDA) in Princeton, New Jersey, develop hidden Markov models, the mathematical backbone of continuous-speech recognition.

1968
Peter Toma, a former Georgetown University linguist, starts one of the first MT companies, Language Automated Translation System and Electronic Communications (Latsec).

1969
In Middletown, New York, Charles Byrne and Bernard Scott found Logos to develop MT systems.

1978
Arpa's Network Speech Compression (NSC) project transmits the first spoken words over the Internet.

1982
Janet and Jim Baker found Newton, Massachusetts-based Dragon Systems.

1983
The Automated Language Processing System (ALPS) is the first MT software for a microcomputer.

1985
Darpa launches its speech recognition program.

1986
Japan launches the ATR Interpreting Telecommunication Research Laboratories (ATR-ITL) to study multilingual speech translation.

1987
In Belgium, Jo Lernout and Pol Hauspie found Lernout & Hauspie.

ments, with their strictly defined terms, might be well suited for translation by machines. He was right: The most reliable MT applications have relied on "pre-editing," or restricting the language of the source text to predefined terms and limited domains of discourse. The classic example of MT that works is the Météo system, developed in Montreal, which has been translating Canada's weather bulletins between English and French on a daily basis since 1977. In the world of Météo discourse, "front" always means a weather system. The translation of forecasts was so boring that before Météo took over, the Canadian government had a hard time keeping translators on the job for more than a couple of months.

One of the most resonant passages of Weaver's memo is a section musing over the possibility that a system of prelinguistic symbols underlies all human languages, like a shared source code of thought. If such a system could be discovered, or created, Weaver speculated, it could be used as a medium for converting ideas from one language into another. By translating the words in an original text into this code, and then translating back into the desired language, the code could be used as a universal interface between languages.

It is an idea older than the computer itself. In 1629, René Descartes suggested inventing a cipher that would assign the same number to equivalent concepts in different languages. This, he hoped, would make possible the construction of a universal dictionary. John Wilkins, the first secretary of the Royal Society of London, proposed a new "philosophical language" that divided every conceivable thing in the universe into 40 categories, each of which would be given a logically derived name. All elements would have names beginning with *de*. Fire would be *deb*; a particular flame would be *deba*. His notion was to create a global second language that was "legible by any Nation."

Such a universal interface came to be known as an interlingua. Weaver wrote:

Think, by analogy, of individuals living in a series of tall closed towers, all erected over a common foundation. When they try to communicate with one another they shout back and forth, each from his own closed tower. . . . But when an individual goes down his tower, he finds himself in a great open basement, common to all the towers. Here he establishes easy and useful communication with the persons who have also descended from their towers. Thus it may be true that the way to translate from Chinese to Arabic, or from Russian to Portuguese, is not to attempt the direct route, shouting from tower to tower. Perhaps the way is to descend, from each language, down to the common base of human communication – the real but as yet undiscovered universal language – and then re-emerge by whatever particular route is convenient.

Weaver wrote the memo at one of those rare and felicitous moments when tectonic shifts in the zeitgeist and a man's personal passions converge on the same spot, offering him a point of leverage in history; later in his life, he would consider it to be one of the two or three most significant accomplishments of his career.

Weaver's memo acted like a seed crystal dropped into a solution supersaturated with nascent ideas about computing, communication theory, and linguistics.

Within two years, MT programs had been launched at MIT, UCLA, the National Bureau of Standards, the University of Washington, and the Rand Corporation. MIT hired Yehoshua Bar-Hillel, the first academic researcher to work full time in the field. In the summer of 1952, Bar-Hillel organized the inaugural MT conference. It was a heady success, spinning off studies of "automatic dictionaries," "micro-glossaries," "universal grammar," and the search for an interlingua.

Not everyone was ready for the idea of digital machines crunching on anything but digits. Professional linguists claimed that Weaver's ideas were naive. An enthusiastic science librarian at Unesco wrote in a plaintive note to Weaver that he wished he'd had a copy of the memo in his pocket when he'd "introduced the mechanical translation idea"

Weaver's memo acted like a seed crystal dropped into a solution supersaturated with nascent ideas about computing, communication theory, and linguistics.

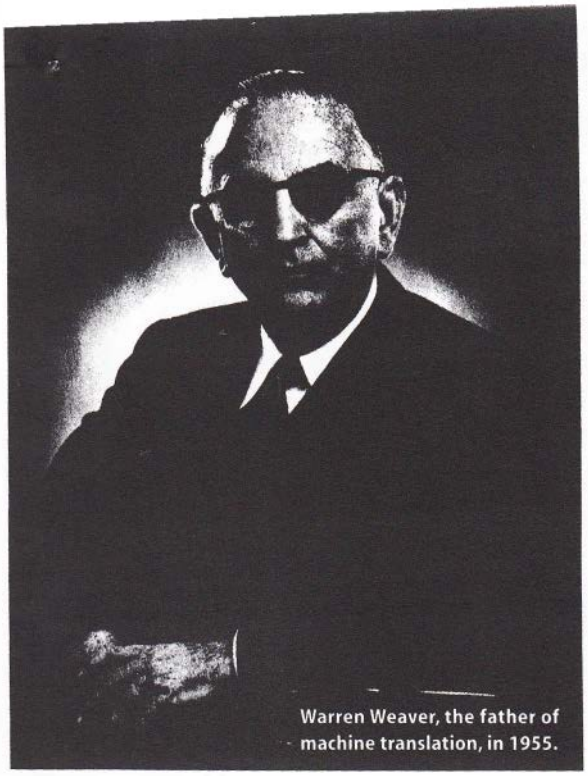
during a dull moment in a meeting. "Most people thought that I was joking and the interpreters seemed to be supremely unconcerned at this potential threat to their jobs. Not having your knowledge of the subject, I . . . allowed the matter to pass off as a comic interlude."

But the meme proliferated, and the memo got picked up by *Scientific American*. One correspondent offered that "it was indeed fascinating to picture a machine that can reproduce the relatively low order of mental processes that occur in, say, a student translating his daily passage of Caesar."

References to MT started appearing in textbooks and academic journals. On January 7, 1954, a Georgetown University team hosted the first public demonstration of MT at IBM's Technical Computing Bureau in New York. Inevitably, the featured performance was a translation from Russian into English. True, the IBM 701 could handle a vocabulary of only 250 words, 6 grammar rules, and 49 handpicked sentences – but English came out the other end. The demo's success was widely reported in the press.

By 1956, MT research had caught fire all over the world, with teams working in Cambridge, Milan, Tokyo, Kyoto, Moscow, and Leningrad. A year later, the Soviets blasted a 184-pound advertisement for Russian-to-English MT into orbit. *Sputnik* was perceived as a drubbing not only of Ameri-

PHOTOGRAPH: COURTESY LERNOUT & HAUSPIE



Warren Weaver, the father of machine translation, in 1955.

can rocket science, but of American intelligence gathering, hampered by a lack of rapid means of translation. (Months before the liftoff, a Soviet hobbyist magazine alerted ham-radio enthusiasts to the imminent launch of an experimental satellite, even providing a shortwave frequency for tracking it. The US Navy, however, never saw a translation of the article. After the launch, it scrambled for days to reconfigure its "radio fence" to intercept *Sputnik*'s transmissions and figure out what it was doing.) Edward Teller, the father of the hydrogen bomb, declared shortly after the launch that the US had lost "a battle more important and greater than Pearl Harbor."

By the end of 1962, China, Mexico, Belgium, Yugoslavia, Hungary, East Germany, and France had also jumped into the MT race. Just as the rise of technology stocks and the ecommerce boom have made the impact of the Internet visible even to those who previously ignored it, so MT was a tangible pursuit that seemed to legitimize a whole range of academic and scientific interests, from AI to the statistical mapping of grammar and lexicons to blue-sky research in data indexing and retrieval. The Department of Defense, the Air Force, the National Science Foundation, and the CIA showered the contents of their coffers onto the heads of researchers who showed interest in MT – many of whom had been toiling away on arcane projects as chronically undersubsidized academics. When Georgetown University declined to award big bucks to its own faculty members for producing the 1954 MT demo at IBM, the CIA stepped in with more than $1 million. The NSF handed Harvard another million, and MIT and UC Berkeley took home nearly as much. Even IBM was on Santa's list, with the Air Force signing off on a $1.7 million grant to fund its development of a faster hard drive for MT.

As with the space race, many of the best things to come out of the MT race had little do with achieving the ultimate goal. It sparked an explosion of interest in formal linguistics, just as Noam Chomsky was publishing his revolutionary theories that certain fundamental structures of language were inborn, like a verbal OS that babies come with out of the box. Much of the early important work in artificial intelligence and optical character recognition was done to address problems in MT. Comit, one of the first high-level programming languages, was cooked up at MIT so linguists wouldn't have to haul in the geeks to bang together routines in assembler language every time they needed to tweak their parsers. Even the heated arguments about linguistics theory – "brute-force" versus "perfectionist" approaches to MT – opened up new channels of international dialogue that seemed like a taste of a future free of language barriers.

So what was the ultimate goal? Some researchers claimed that their aim was (with a '50s mania for abstruse acronyms) FAHQT – fully automatic, high-quality translation. The text-to-text version of the Universal Translator on *Star Trek*, more or less. A translating telephone would be FAHQT indeed, but hardly anyone swept up in the original excitement about MT was working on speech-to-speech translation, which must tackle the additional irregularities of conversational speech and has the added requirements of accurate voice recognition and voice synthesis at both ends. Good text-to-text translation was hard enough to pull off. Speech-to-speech MT was beyond going to the Moon – it was Mars. A program that didn't play dirty pond with three hidden mice on an individual Spanish round journey was FAHQT enough to aim for.

But under all that good buzz – the headline-grabbing conferences, the claims that "translating machines will soon take their place beside gramophone records," the six-figure votes of confidence from Uncle Sam – there was a little secret about MT: Most of the programs, when they worked at all, weren't very good at producing comprehensible translations. At best, MT output read like the following, rendered from Chinese into English by IBM's million-dollar photoscopic drive:

Modern guided missile already possible carry with war head of hydrogen bomb and atomic bomb. Therefore it is one kind weapon with very big power of destruction.

A lot of MT read more like this, produced at the University of Washington:

Infection/corruption (by/with/as) nodular (by/with/as) bacteria comes/advances/treads especially/peculiarly (it)(is) light/easy(ly) at/by/with/from (of) plants....

Translators hired to do "postediting" – smoothing out translated texts – complained that MT scrambled the meanings of the original texts more thoroughly than even the most bumbling human translator would. A human reader might get words or phrases wrong, but they usually can

1988
Researchers at IBM's Thomas J. Watson Research Center revive statistical MT methods that equate parallel texts, then calculate the probabilities that words in one version will correspond to words in another.

1990
Dragon Systems releases its 30,000-word-strong DragonDictate, the first retailed speech-to-text system for general-purpose dictation on PCs.

Darpa launches its Spoken Language Systems (SLS) program to develop apps for voice-activated human-machine interaction.

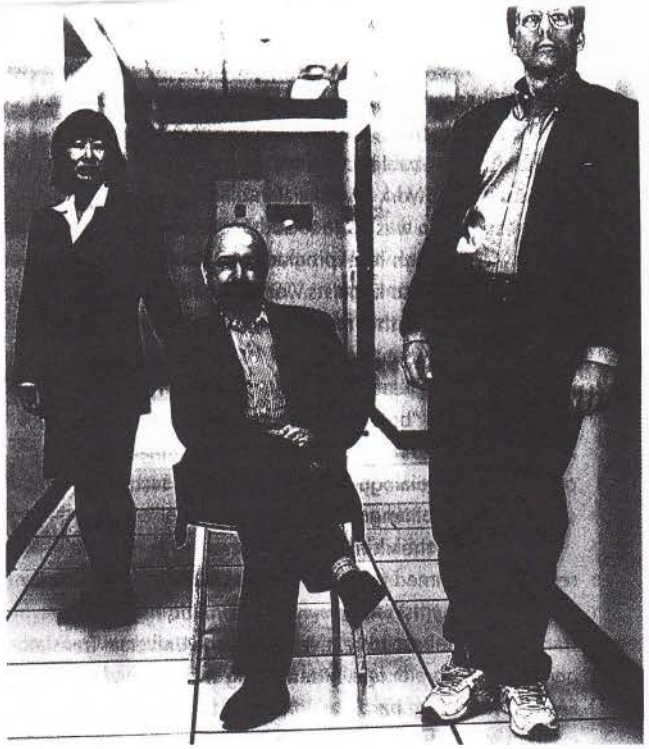
1991
The first translator-dedicated workstations appear, including STAR's Transit, IBM's TranslationManager, Canadian Translation Services' PTT, and Eurolang's Optimizer.

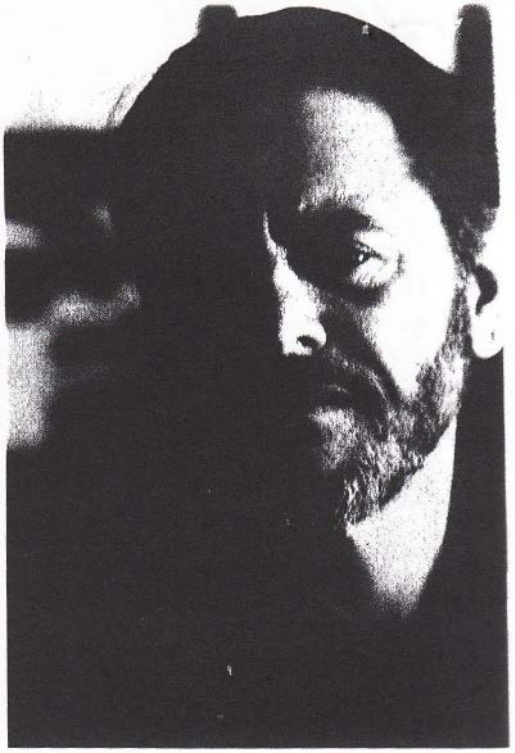
1992
ATR-ITL founds the Consortium for Speech Translation Advanced Research (C-STAR), which gives the first public demo of phone translation between English, German, and Japanese.

1993
The German-funded Verbmobil project gets under way. Researchers focus on portable systems for face-to-face English-language business negotiations in German and Japanese.

BBN Technologies demonstrates the first off-the-shelf MT workstation for real-time, large-vocabulary (20,000 words), speaker-independent, continuous-speech-recognition software.

1994
Free Systran machine translation is available in select CompuServe chat forums. ►





1997
AltaVista's Babel Fish offers real-time Systran translation on the Web.

Dragon Systems' Naturally-Speaking and IBM's ViaVoice are the first large-vocabulary continuous-speech-recognition products for PCs.

Parlance Corporation, a BBN Technologies spin-off, releases Name Connector, the first large-vocabulary internal switchboard that routes phone calls by hearing a spoken name.

1999
A televised newscast is automatically transcribed with 85 percent accuracy.

Logos releases e.Sense Enterprise Translation, the first Web-enabled multiple translator operating from a single server.

IBM releases ViaVoice for the Macintosh, the first continuous-speech-recognition Mac software.

Kevin Knight, of the University of Southern California's Information Sciences Institute (ISI), leads a multi-university team that develops Egypt, a software toolkit for building statistical MT systems. Egypt examines bilingual texts for statistical relationships, analyzes those patterns, and applies what it has "learned" to its translation functions.

2000
At MIT's Lincoln Laboratory, Young-Suk Lee and Clifford Weinstein demonstrate an advanced Korean-English speech-to-speech translation-system prototype.

USC's ISI performs backward machine-transliterations of proper nouns, which are replaced with phonetic approximations. *Southern California* translates to "Janoub Kalyfornya" in Arabic.

figure out the gist of a paragraph by comprehending the sum of its references. No such process of understanding through context took place in a computer at this stage of MT development, and a couple of crucial errors could throw whole drafts out of whack.

One author compares MT output to a jar of 100 freshly baked chocolate-chip cookies in which 95 of them weren't poisoned. "Such a cookie jar," he writes, "could be worse than useless; it could be tempting and therefore actively dangerous."

An Excess of Translation

As the checks from Washington kept rolling in, some of the original supporters of MT started distancing themselves, most notably Bar-Hillel himself. In February 1959, he published his devastating "Report on the state of machine translation in the United States and Great Britain." FAHQT was an unreachable goal, he said, "not only in the near future but altogether." As proof, Bar-Hillel cited a single sentence, "The box was in the pen," in the context of a short paragraph: "Little John was looking for his toy box. Finally, he found it. The box was in the pen. John was very happy." He charged that "no existing or imaginable program will enable an electronic computer to determine [the meaning of] the word pen in the given sentence within the given context." (It was perhaps unfortunate that "the box was in the pen" read like an implausibly contrived sentence.)

Bar-Hillel argued that a computer would never be able to figure out the difference between one kind of pen and another because it has no sense of how either kind of "pen" functions in relation to the rest of the world. To program a computer with a sufficient amount of knowledge to tell th difference between a writing instrument and a playpen, he wrote, "a translation machine should not only be supplied with a dictionary but also with a universal encyclopedia." The issue of context was not incidental – nor was it solvable with a few tweaks to the code. Though Bar-Hillel was prescient in calling for a realignment of focus away from FAHQT and toward development of automated aids for human translators, such an attack from one of the pioneers in the field was seen by many as a challenge to the notion that MT was worth doing at all.

Bar-Hillel did acknowledge that there were MT research projects under way that didn't have FAHQT as their primary goal. Even low-quality gist translations could be useful for extracting meaning from mountains of documents. No one at the CIA needed to feel secure that their English version of *Izvestia* preserved the nuances in each reporter's voice. The tide of public opinion, however, was turning against MT, which had produced so many "breakthroughs" and so few visible results.

In 1961, Mortimer Taube – whose innovations in the unsexy field of library indexing made him one of the first information-age millionaires – published his book *Computers and Common Sense*. He charged that "twelve years after the Warren Weaver memorandum, no practical, usable MT computer program exists." He declared that computers would never be able to translate properly because translation is an intuitive process, and "machines are not capable of intuition."

In the press, MT went from the Next Big Thing to the butt of popular jokes. The most infamous MT pratfall, cited to this day in many articles on the subject, involves a computer that supposedly translated the sentence "The spirit is willing, but

From left, opposite page: Teruko Mitamura, Alex Waibel, and Eric Nyberg, researchers at Carnegie Mellon's Language Technology Institute; IBM's Net maven, John Patrick; MT pioneer Martin Kay at Xerox PARC; Eric Silberstein, founder of Idiom, a human-driven translation service for Web sites.

PHOTOGRAPHS CLOCKWISE FROM LEFT: DEANNA [illegible]TH; JOHNATHAN WORTH; ©GREG GIRARD/CONTACT PRESS/PICTUREQUEST

the flesh is weak" into Russian as "The vodka is good, but the steak is lousy." W. John Hutchins, whose book *Machine Translation: Past, Present, Future* is the MT bible, traces the quip to a 1962 *Harper's* story. Even by the time the jibe ran in *Harper's*, he says, it was a familiar put-down not just of MT, but of *all* translation, including human translation.

The cataclysmic blow came in 1966. To evaluate MT's progress for the federal agencies scribbling the big checks, in 1964 the National Academy of Sciences convened the Automatic Language Processing Advisory Committee (Alpac), which consisted of a psychologist, two linguists, an AI theorist, a satellite-communications specialist, and two MT researchers. When the committee issued its report two years later, it was scathing.

"There is no immediate or predictable prospect of useful machine translation," it declared. The report blasted the Georgetown project for requiring human postediting, even though most human translation is given a second pass by another translator (as Laperrière was doing at Berlitz). The report claimed that the US government already had a huge surplus of underpaid translators, fulminated about a potential "excess of translation," and fretted that wholesale extraction of Soviet science journals might subject readers to "many uninspired reports that the US scientist could have been mercifully spared." The committee recommended that all funding for MT be cut immediately.

The fallout from the report triggered what those who work in the field today call the "MT winter." In 1963, 10 research groups were thriving in the US. Two years after the report was published, the three teams left standing were scrambling for funds. (One of the few other groups to soldier on was the Mormons, who believed that MT would help them spread the word of God.) The cold front blew overseas too, freezing up research in the UK, Japan, and even the Soviet Union. Academics now made tracks as quickly as they'd jumped aboard the MT gravy train. The Association for Machine Translation and Computational Linguistics had MACHINE TRANSLATION scraped off its doors and letterhead. Even Chomsky himself – who wrote his groundbreaking *Syntactic Structures* at MIT while working under Bar-Hillel's successor – got on the dis tip, calling MT pointless and futile.

The first worldwide effort to open a global conversation using computers was over.

Life in the Interlingua

A billboard at the Pittsburgh airport informs travelers that they have landed in the Home of the World's Favorite Ketchup. That level of braggadocio feels about right. The former Iron City fell on hard times during the construction slump in the '80s and is casting about for a new raison d'être. Its hills, Victorian architecture, and encircling water could make Bay Area expats feel right at home ... someday. The notion occurs to my cab driver as we cruise in from the airport. "We gotta get some of those computer people in here," he tells me. "Some of them make $80,000 a year."

For now, most people come to Pittsburgh for one of two reasons: to have surgery or go to school. I'm here to visit Carnegie Mellon University, where researchers have spent more than a decade doing some of the most promising – and practical – work getting MT ready for a networked world.

Alex Waibel, associate director of the Language Technologies Institute at Carnegie Mellon, is one of the durable dreamers who began his academic career in the dead of MT

2001
Carnegie Mellon University's Language Technologies Institute (LTI), led by Jaime Carbonell, constructs speech-to-speech translation for "small" languages like Croatian or Mapudungun, spoken by Mapuches in Chile.

USC biomedical engineers Theodore Berger and Jim-Shih Liaw create a new Berger-Liaw Neural Network Speech Recognition System (SRS) that understands spoken languages better than humans do. Ford says the technology will be incorporated into its cars to facilitate communication at fast-food drive-thrus.

2002
NowHear offers an agent-based newsreader device that translates articles from thousands of publications worldwide, delivering them as MP3 audio files.

2003
Text of Joyce's *Ulysses* is run through Cliff's Notemaker, a new omnidirectional literary interpreter and summarizer. Program: "Your professor didn't read it either. Don't worry about what your essay says, just include the words *Dublin*, *pub*, and *fuck*."

2004
Dragon Systems' Naturally Cursing software is added to wristwatches to ease communication at multi lingual construction sites.

2005
Employee at Allstate Insurance files suit against the company, citing emotional distress from the collective chatter of coworkers using speech recognition input devices.

GeoCities pulls down 350,000 homepages for failing to use *GeoCities Controlled English*, a 1,000-word edictionary designed to interface with its language translation software. ►

2006
"It's that .001 percent part that got us," moans NASA director Rafu Sanjali, after the fourth disastrous attempt to land a robot-controlled vehicle on Mars was foiled by the use of "99.999 percent accurate" MT technology.

2007
Microsoft pulls its "What do you want to think today?" campaign after reviewers unanimously trounce the company's much-anticipated Thought Recognition Interface (TRI).

2008
L&H's Travel Sunglasses offer real-time translation of road signs, marquees, and menus into a wearer's native language.

2009
CorconText introduces FinalCopy, a Japanese-to-English documentation translation program that uses AI-based semantic networks to reduce the need for human editing of output.

2012
Saruzuno embeds its Lexical Disambiguation System (LDS) into smartcards equipped with membrane microphones so travelers can converse with store clerks in dozens of languages.

2017
The Russian-made Durok II language tutor is used to train customs-and-immigrations bots (DNA-based servant-devices) employed at US points of entry.

2020
"Teaching a child reading and writing is a waste of time," declares Yeo Kiah Wei, Singapore's minister of education, who cancels the subjects in schools. "Children needn't be burdened with such an onerous task as deciphering tiny markings on a page or screen. Leave it to the machines."

winter. He hands me two business cards – one from Carnegie Mellon, another from the University of Karlsruhe, Germany. A bearded, pixilated 43-year-old with a German accent, Waibel is an embodiment of human translation: born in one culture, living in another, married to a woman from a third (Japan). He was instrumental in the 1991 formation of C-STAR, an international consortium of businesses and institutions tackling speech-to-speech MT.

While a student at MIT in the '70s, he went to one of his professors and told him that he wanted to develop a speech-to-speech translator. "He gave me a look that said, 'Yes. Now go back to your office and do your work.'" Waibel had to wait until 1987, when he went to work for the Advanced Telecommunications Research Institute in Osaka, before he finally felt the anti-MT chill lift. The local economy was booming, and as a trade-hungry chain of islands with a language that seems to have evolved independently from every other on Earth, Japan was eager to investigate even unlikely remedies for its linguistic isolation. "It was time to blast off," Waibel recalls.

From Japan, he went to Germany to help launch Verbmobil, a massive, ongoing speech-to-speech MT effort focused on tightly restricted domains of discourse – setting up appointment dates or making travel arrangements, for example. At Carnegie Mellon, Waibel has his hands in projects ranging from the development of MT glasses that display subtitled speech for tourists to the "translation" of lip movements using photo-realistic avatars.

Waibel takes me down to his lab to demonstrate Janus, a speech-to-speech system that translates from English or German into English, German, and Japanese. I'm seated in front of a whiteboard-sized touchscreen and microphone, and invited to make arrangements with a "German travel agent" – a student sitting across the room. As I speak in English, Janus' voice recognition software transcribes what I'm saying onscreen. I can actually see the computer work out what it's hearing me say. There's something thrilling about watching the phonemes and syntactic particles get mashed around until a sentence precipitates out of the chaos, like observing an EEG of someone who is desperately trying to understand you.

Janus employs the interlingua approach to MT, similar to Weaver's scenario of descending to the great, open space at the base of all the Towers of Babel. My sentences are first analyzed and boiled down to representations of their literal meanings in the interlingua code. From there, they're generated into appropriate sentences in the target language – in this case, German. Because you wouldn't want to transmit Babel Fish-isms about hidden mice to a travel agent along with your credit card number, Janus lets you correct its interpretations of utterances by generating an English sentence from the interlingua before sending it along.

I observe that the displayed sentences are usually gratifyingly close to the gist of my meaning, even though the word choices are often quite different. In the interlingua, sentences turn into formulas. For example, "I want to book an inexpensive hotel room" is represented in the code as "c:request-action+reservation+price+room (who=i, room-type=room, price=cheap)." Translated back into English, this comes through as "I would like to make a reservation for a room that is cheap." My question, "How do I get from Frankfurt to Heidelberg?" becomes "What about transportation from Frankfurt to Heidelberg?"

Because everything I say is boiled down to its essence, my "ah's" and "um's" – those little musical glitches that speech researchers call disfluencies – don't derail Janus. But while most of the translations are accurate sketches of my intent, they're deaf to tone and nuance.

When I approve the sentence – or modify it with my own corrections – the statements are translated and sent to the "agent's" computer, where they are spoken aloud in German by a synthesized voice. His answers, likewise transcribed, corrected, and translated, emerge in English. It's like a video-conferencing version of Expedia, with a live travel agent who sends me streaming videos of the places I want to visit.

Janus is wildly unliteral once, when I ignore Waibel's advice that the system can translate much of what might be said during a conversation about travel arrangements, but not, say, about astrophysics or 17th-century French literature. "What happens when I start talking about astrophysics or 17th-century French literature?" I ask Janus. *French literature* makes a round-trip in and out of the interlingua in decent shape, but *astrophysics* comes out as "Mastercard."

MT systems are known by the types of mistakes they make, and the Mastercard slip is an interesting one. Janus is a knowledge-based MT system: It uses AI techniques to give the computer a rudimentary understanding of the meanings of the words it's translating. The first generation of MT researchers, who had access to only very limited memory capacity and sluggish processing power, didn't have any practical way of incorporating what AI theorists call "world knowledge" into the translation process. In very broad terms, the computer is given a set of descriptions of basic relationships among the concepts it might come across in a dialogue – a scalable form of Bar-Hillel's universal encyclopedia – so it can draw reasonable assumptions about words' meanings without having everything spelled out for it.

For instance, the computer might be provided with a world model that tells it the sky is generally found "above" everything else, or that if someone is "going" to Paris, they aren't there yet. When encountering Bar-Hillel's "the box is in the pen," a knowledge-based system ideally would calculate that if the "John" in the paragraph is a child, the "pen" is most probably a playpen rather than a fountain pen or a pigpen. This is a brutal oversimplification, but one way to get a handle on it is to consider the dilemma raised by the authors of a 1992 textbook on MT: "Should we represent *The Three Stooges* as one concept or a set of three?"

One of the major boons granted by accelerations in processing speed, breakthroughs in data storage, and refine-

PHOTOGRAPH: ©REUTERS NEWMEDIA INC./CORBIS

ments in AI over the last 30 years is the practical possibility of making world knowledge and more linguistic data available to the translation stream. Still, until we can build hard drives with the memory capacity of a human brain, knowledge-based systems like Janus work best in limited domains of discourse. If an MT system knows that a conversation is between a travel agent and a customer, a "card" is probably a credit card, not an ace of spades or a droll person. In the travel agent's universe, though a "Visa" could likely be one of at least two things, it's not unreasonable that the phonemes of *astrophysics* would end up being heard as "Mastercard."

Putting restrictions on the domain of discourse has proven to be one of the most successful strategies for designing highly accurate MT systems. MT is especially useful in translating technical documents, such as software documentation and equipment-maintenance manuals, which have predictable lexicons and simplified syntax – like Canada's daily weather reports. One of the things the Babel Fish does adequately is translate recipes, another form of restricted-domain language with stripped-down syntax.

French literature makes a round-trip in and out of the interlingua in decent shape, but _astrophysics_ comes out as "Mastercard."

Like Waibel and his wife, Carnegie Mellon's Teruko Mitamura and Eric Nyberg make an appealing poster couple for MT. Though they interrupt one another regularly (Mitamura in heavily accented English), they do so in the intricate dance of two strong-willed people who have combined forces to work in the same field. Since 1991, Mitamura and Nyberg have toiled away in the "CAT domain" – the universe of rivets, cylinders, pumps, and concrete – with Caterpillar, the makers of heavy construction machinery, to develop a knowledge-based text-to-text system called KANT.

KANT is the successful redirection of a misguided experiment Caterpillar undertook in the '70s to create Caterpillar Fundamental English, a special language for its manuals, which are translated into more than 20 languages. CFE's original purpose was to compel employees in other countries to learn just enough English (850 vocabulary terms plugged into bare-bones sentences) so the company wouldn't have to translate its manuals. Like most programs designed to make people learn something against their will, CFE failed miserably. A growth spurt of construction technologies threatened to bloat the skinny CFE lexicon with new terms. Many service technicians flatly refused to learn CFE. The company's technical authors eventually began writing in any damn flavor of English they pleased, stamped the new manuals "CFE compliant," and got on with their lives. Given a choice between buying bulldozers from a vendor whose manuals were printed in the local language and from one offering instructions in English for Dummies, it was adios Caterpillar.

By using unambiguous syntax (writing "when you start the engine," which has a clear subject, instead of "when starting the engine") and limiting the vocabulary to the CAT domain of 70,000 words and phrases, the amount of world knowledge and linguistic mapping that has to be incorporated into the KANT system is manageable. Ambiguities that can't be avoided are resolved by human editors assigning given meanings to words in particular sentences with SGML tags before handing them to the computer. The system, which runs on IBM Unix machines, is currently used for translating Caterpillar manuals into French, Spanish, and German, with Italian, Portuguese, and Russian on the horizon.

Nyberg recalls giving a presentation about knowledge-based MT to a group of visitors from Japan in 1991. After Nyberg was finished, the group leader politely said, "Oh, thank you very much," then turned to the group and said in Japanese, "This will never work." But Caterpillar now estimates that KANT allows the company's authors to work two to five times faster than without it.

It isn't FAHQT because it requires infusions of human intelligence at various stages. But it is MT for the real world. There's a joke among MT researchers that dates from the days when their approach to linguistics research was primarily theoretical: "Every time I fire a linguist, my MT gets better." Mitamura says that the emphasis on linguistics for MT at Carnegie Mellon is now firmly grounded in practical solutions.

"Here, linguists and computer scientists work together. It's highly interdisciplinary. We study formal linguistics, grammars, and lexicons so we can build more accurate systems. That's different from linguists worrying about which theory of linguistics is correct."

Back in the lab, Robert Frederking, Ralf Brown, and Christopher Hogan show me an MT system designed for use in environments where accuracy is a matter of life and death: Diplomat, a handheld system for translating directions through a minefield. Diplomat is rapid-deployment speech-to-speech MT for the front lines in a world of volatile hot zones. Running on a lightweight Pentium notebook, Diplomat was Carnegie Mellon's answer to a challenge from Darpa to develop MT systems for new language pairs that could be up and running in a couple of weeks, when there's not enough time for constructing an elaborate world model or coding in thousands of linguistic rules. There was a particular language pair at the top of Darpa's agenda: Croatian and English. The system had to translate in both directions. It had to have a memory footprint small enough to be wedged into a portable device. And the interface had to be comprehensible by someone who had never seen a computer – a Bosnian farmer, for instance.

Diplomat understands Hogan's questions well enough for a lab demo: His "How do we get to this minefield?" 288 ►

2021
PigLatin Furby reveals parents' plans for divorce. Dozens of toddlers are traumatized.

2043
Tower of Babel is completed in Iraq (formerly Babylonia) after a 4,000-year delay, thanks to NEC Technologies' Neutral Language.

2045
Telepathy system developed by Europeans. Users wear adhesive patches containing thought recognition and MT technology, plus a high-speed wireless transceiver.

2058
The Reformed Rifkin Institute (RRI) is awarded a patent for its invention of a symbio-parasite that feeds on the electrical impulses in the speech center of the human brain, then excretes a translated signal that can be understood by anyone who inserts the creature in their ear. The estate of Douglas Adams files suit, claiming prior art.

2108
Procter & Gamble researchers use their newly developed Distributed Tachyon Swarm System (DTSS) to learn that diphtheria bacteria band together as a hive mind capable of communication

2264
"Humans are dumber than bags of hair," declares Entity 296. "Only the most naive scientist would try to develop a technology to understand those smelly lumps of protoplasm," it states. "The noises they emit from the holes in their heads are ultimately less enlightening than cosmic static."

Compiled by Kristin Demos (kvdemos@yahoo.com) and Mark Frauenfelder (mark@well.com). 1629-2000: K. D.; 2001-2264: M. F.

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PHOTOGRAPH: ALFRED PASIEKA/SCIENCE PHOTO LIBRARY/PHOTO RESEARCHERS

Talking to Strangers

◄ 233 becomes "Had we get this minefield?" before he's offered a chance to correct it. I wouldn't trust my life to it yet. "Speech-to-speech translation is taking two hard problems that still haven't been completely solved – speech recognition and MT – and plugging them together," Frederking says.

Diplomat uses "multiengine MT," combining so-called example-based MT and a simple glossary of frequently used phrases. Example-based systems look for correspondences between words and phrases and parallel texts in the source and target languages ("bilingual corpora," in MT-speak) and generate statistical models of likely translations. Knowledge-based MT is a top-down approach, an effort to code enough rules and relationships into the process to account for most of the words and phrases that might come up in a passage of writing. Example-based MT is more a data-driven approach, allowing the computer to derive translation strategies from its observations in the wild – within the texts themselves. Once the various engines complete their translations of a phrase, Diplomat uses Bayesian statistical methods to select the one most likely to be accurate. (See "The Quest for Meaning," *Wired* 8.02, page 172.)

"Speech-to-speech translation is taking two hard problems in computing that still haven't been solved and plugging them together."

Translating between English and Croatian was an especially tough assignment because there aren't a lot of bilingual corpora lying around for statistical analysis – even on the Web. Recorded archives of Croatian speakers for programming the voice recognition modules are equally hard to come by. The researchers' indispensable ally turned out to be the Croatian population in Iron City. The team discovered that *Zajedničar*, the most popular Croatian newspaper in the US, is published in Pittsburgh. The paper's staff gave the university years of back issues to scan for their statistical models of the language. Ten Croatian locals came to work on the project; a faculty member's Bosnian wife furnished the phonemes for the voice synthesizer. After two months, they had a working prototype.

Then, says Frederking, the Army decided it "didn't want to field-test our device by trying to talk to guys with machine guns." But Diplomat will be given a second chance: Lockheed Martin has plans to demo the prototype of a new device it's building that incorporates the Diplomat code. One possible configuration is a wireless client thin enough to fit into the pockets of combat fatigues, that has most of its code on a server. The demo is being underwritten by a school for Army chaplains, which makes sense: The first soldiers sent in to talk with the locals – or even enemy POWs – are often clergymen.

In Search of Dick Tracy

The indecipherable command-line interface lives on in the decor of the IBM offices in Somers, New York. At each intersection in the stark white hallways, arrows direct the hapless visitor to destinations like "CDRF" and "DCBE." I'm here for a demo of IBM's Native Search, which went live on the company's alphaWorks site late last year.

Native Search lets Chinese speakers use search engines like Yahoo!, AltaVista, Google, and HotBot in their own languages. Queries typed in Chinese characters are converted to English and fed to the search engines; the resulting pages are translated back into Chinese, their formatting intact.

Using Native Search to scan through headlines on US news sites, I learn about *The Singers*, a TV show about New Jersey gangsters, and I'm tipped off that investors looking for "huge flotation" in the wake of the AOL-Time Warner merger are "yelling at wrong tree." Still, the translations are good enough for me to get the gist of the morning news and do some casual browsing.

"The object of this translation is not accuracy," IBM's Daniel Jue, my guide and translator, admits candidly. The lesson that MT researchers have taken from the first generation's rise and fall is truth in advertising: If anyone uses these products with *Star Trek* in mind, they're sunk. MT is like a 12-step program for software developers – one day at a time.

Curious about what Native Search users in China are trying to sniff out on the Net, I ask IBM for a list of popular queries. I'm told that "privacy and other considerations" prevent the company from giving me a list of actual search terms, but IBM says that top searches include "technical information and computer-related material, news organizations and sites, money-management sites, music, educational institutions in the West (especially in the US), and ecommerce, including items of apparel such as boots, jackets, shoes, and intimate apparel."

An employee who attended Native Search's Beijing launch remembers a slightly different set of search terms: porn, patches for Quake, MP3s, and articles about 蒙妮卡 萊溫思基 – Monica Lewinsky. He also tells me that at one of the demos on the mainland, a journalist tapped Native Search to navigate to the Web site of an auto-supply store in New Jersey and buy a part for his car. Welcome to the future.

Native Search and ViaVoice are just two pieces of a new way of computing that IBM is betting will be wireless, handheld, jacked into the Web – and driven by voice, not text. By using a language called VoiceXML (see "Capturing Eardrums," page 246) to migrate the front end of ecommerce from the PC to the phone in everyone's pocket, Big Blue is making the voice-Net connection the linchpin of an ambitious strategy to steal the future of the interface away from Microsoft. Late last year, IBM put its MT division under the leadership of Ozzie Osborne (no relation), formerly general manager of the company's Voice Systems products. Osborne will be in charge of pulling together voice recognition and synthesis, phone and handheld Net access, and machine translation.

Though IBM's Speech Browser is already up and running at a few Web sites (students at Western Connecticut State University can phone in and "voice-click" through payroll and financial-aid records stored on the school's intranet), Osborne admits that commercial voice-Net interfaces incorporating translation are probably still a few years away because of MT's stubborn accuracy problems.

"*Star Trek* was the line in the sand," he says. "What people really want is a Dick Tracy watch that will let them speak their natural languages with face-to-face translation. We're getting there. Voice recognition has never been better. Voice synthesis doesn't have to sound mechanized anymore. If we become an overnight success with speech translation, it will be because we've been working on it for 30 years. The Dick Tracy watch? Still three to five years out."

The grandfather of IBM's alphaWorks program is John Patrick, an intense, articulate Big Blue lifer who's installing an MP3 server in his house so he can pipe Mozart into every room. When I 290 ►

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◄ 288 walk into Patrick's office, his monitor greets me with a sketch for a "boom-box browser," a wireless device with flaring speakers. Patrick sees network-distributed MT as just one of many emerging technologies that will, as he puts it, encourage not ease of use, but ease of life.

"I'm not talking about call centers: 'Call us during our normal business hours' – that's gotta go. 'Listen carefully because our menu options have changed' – gotta go. When I can use my boom-box browser to take a course compatible with my schedule, in *my* language – that's the world I'm describing. The companies that win will have created this ease of life."

One bottom-up technology that has contributed to ease of life at IBM is the in-house buddy list, a form of Lotus instant messaging that was never formally launched within the company. Made available as a prototype, it quickly became indispensable, giving employees the sense of being continuously tapped into a commonwealth of expertise. There are 85,000 IBMers logged onto the system at any moment of the day, and the constant buzz of messaging has replaced playing phone tag with employees who are often on the road. Patrick gives me a little canned demonstration of adding voice recognition and MT to the buddy network – a preview of a multilingual conferencing system for bouncing ideas off of people in 30 countries.

My first glimpse of this type of global watercooler in action is at the Boston-area offices of Lernout & Hauspie, an leper, Belgium-based speech recognition firm making a name for itself by incorporating desktop MT software into its products and for its recently built Flanders Language Valley, an extensive research center shaped like a giant ear. Microsoft bought a $45 million stake in the company in 1997.

A demo manager for the company reads questions from a script into a microphone. He pauses a microsecond longer between each word than he normally would, speaking with the deliberate evenness of a patient son addressing an elderly relative: "What is the status of the Euro pricing for the European brochures?" (He enunciates the punctuation also, tying each question off with the crisp declaration, "question mark.") His words appear onscreen, typed out by Voice Xpress, a voice recognition product. Then more L&H software, Power Translator, goes to work to render the sentence into German. The translation appears on the other laptop. Finally, a voice synthesis program called RealSpeak pronounces the German aloud: "*Was ist der Status der Europreiskalkulation für die europäischen Broschüren?*" The voice sounds natural, even cordial, without the metallic edge that afflicted earlier voice simulation programs.

It's like Janus, but the conversation isn't restricted to a particular domain. I'm impatient to ditch the script and fire off questions myself, but like most voice recognition programs, Voice Xpress works best after a brief "enrollment" period to educate the software in the distinctive profile of a user's intonations. So I prompt the demo manager to ask questions about the weather, jazz, sex, beer – things people might rap about in a chat room in the real world. The news from virtual Munich at the far end of the room: "Here not for a week rained it."

Even if you translate every page on your ecommerce site *except* the form at the point of purchase, you're losing millions of potential customers.

It's just a little dog-and-pony show kluged together for Demo 99, but I feel a little frisson of seeing something for the first time that could become part of our everyday lives in a couple of years – garbled, half-nonsensical chitchat with people on the other side of the world who don't speak a word of English.

A funny moment at L&H reminds me of a Woody Allen bit in *Annie Hall*. He's whining to his analyst that he and Diane Keaton's character never make love anymore – or at most, three times a week. Meanwhile, across the split screen, Keaton's character is kvetching to *her* analyst that they have sex *constantly* – "I'd say three times a week." L&H chief executive officer Gaston Bastiaens crows over his products' "90 percent accuracy"; a few minutes later, Jeff Hopkins, the company's VP of technology, confesses his frustration that no matter how many thousands of linguistic rules they code into the software, "Talking with someone who got every tenth word you said wrong would make you pull your hair out."

This is the unavoidable paradox of MT. If you want to be able to translate any spontaneous utterance, you get Babel Fish babbling about hidden mice. If you want spot-on accuracy, you must tether the domain of discourse to a sphere narrow enough to confuse *astrophysics* and *Mastercard*. For accurate and graceful translations of anything but dull technical prose, human translators won't be beaten by computers anytime soon, but in the emerging networked world, it's precisely in the arenas of unscripted exchange – such as chat rooms and telephone conversations – where people will want MT most. And the Net can't wait for the paradoxes to be ironed out.

Ecommerce retailers are waking up to the fact that even if you translate every page on your site *except* the form at the point of purchase, you're losing millions of potential customers. Startups are rushing into the breach. Idiom, a new service launched by a group of Harvard undergrads, offers fast globalization of content – and not just translation, but culturally sensitive adaptations of a Web site's references, tone, and feel. (A button on a site for American buyers teases, "Want one?" while the same product for Japanese buyers is tagged with the more respectful "Click here for more information.")

Idiom uses only human translators, because 24-year-old founder Eric Silberstein subscribes to the poisoned-cookie-jar theory of MT – that machine translation, even with postediting by human translators, inevitably drags down accuracy. Idiom's focus is on creating new aids to human translation, such as software that tracks the time-stamped content on a Web site that needs to be translated immediately.

Some of the most innovative work in hybrid human-machine MT is being done under the guidance of Sergei Nirenburg, who left Carnegie Mellon in 1994 to lead a group of 70 researchers at New Mexico State University. Nirenburg and his team have constructed Web-based environments in which humans can aid the machines' learning in order to ramp up new languages for MT by answering questions like "Which letters are vowels? Do you use the inverted exclamation mark?"

"To really acquire knowledge of what a noun is, you need to do it the old-fashioned way – you have to sit down and acquire it," Nirenburg says. One way for a machine to do that is to bring "a very nontrivial human-knowledge acquisition tool" into the loop – that is, a human being.

Adding human intelligence to artificial intelligence is close to what MT pioneer Martin Kay – whose cousin was an interpreter at the 292 ►

◄ 290 Nuremberg trials – says he's been waiting 15 years for: applications of MT aimed at boosting the productivity of the human translator. By presenting documents that have been partially machine-translated to human translators with ambiguous phrases tagged with a set of options, MT could become a collaborative effort. "If we can get the idea of 'fully automated' machine translation out of our heads," he says, "systems designed to aid human translators could multiply their productivity by a remarkable factor."

The most promising future for the technology may reside in a window on the desktop of Guylaine Laperrière.

The Machine in the World

The lessons of MT's first 50 years aren't the kind we're used to hearing from our best and brightest machines: Make peace with stubborn limitations, cut the hype, think in the scale of decades of gradual evolution, forget about breakthroughs.

In our laptops, we already have memory capacity and processing speed that would have been barely imaginable in the age of the tube-driven mainframes, but MT historian John Hutchins believes that even "infinite computer power is not a solution." What is needed, he says, is deeper insight into the processes of language and cognition. "There is no such thing as 'perfect' translation," he adds. "There are only translations more or less suitable or successful for specific purposes and contexts."

Cognitive scientist Steven Pinker, author of *Words and Rules*, believes that with increased understanding of the structure of language to create more subtle linguistic maps, boosts in chip speed to accelerate the gathering of statistical data from texts, and refinements in the building of world models, MT will improve in small but significant increments in the next few years. "The better it works," Pinker says, "the less it will be called machine translation. It will just be called software."

One of MT's most eloquent critics is Douglas Hofstadter, who trains a high-resolution lens on both human and machine translation in his book *Le ton beau de Marot*. He considers the MT endeavor to be rooted in an essential misunderstanding of the ways language works. "There are a lot of specific examples of bad machine translation, but specific examples can't prove 294 ►

◄ 292 the point very well," he tells me. "Programmers will say, 'That's the kind of thing we can polish up very quickly.' Or people will say, 'That's because the programmers were bad.' But the most ordinary vanilla language contains a tremendous amount of subtle knowledge – what space is like to move around in, how people are, what people want. We know the structure of space because we've lived there." At the heart of communication, he believes, is the sharing of that subtle knowledge in mental imagery generated by cues of sound, sense, and association. By reducing words to tokens of their literal meaning, as in interlingua-based MT, much of that imagery – and the worth of the exchange – is lost.

It's clear that to do their job as translators, computers will have to rely on what is most human in us: the capacity to negotiate meaning. Even when hair-tearing levels of inaccuracy are introduced into chat room dialogue, Jennifer DeCamp, of Mitre Corporation, a federally funded IT think tank, points out that rapid back-and-forth exchanges can offer plenty of opportunities for what she calls "conversational repair."

I feel a little frisson of seeing something for the first time – garbled, half-nonsensical chitchat with people on the other side of the world.

Willingness to tolerate uncertainty and empathetic leaps of understanding are what keep conversations on course in any medium.

The question remains why language – the province and playground of any child – is so intractable, so resistant to being subjugated by greater and greater amounts of superhuman processing power, so elusive when we try to snare it in nets of rules and statistics. One answer is that Norbert Wiener was right when he told his friend Warren Weaver that "the emotional and international connotations of words are too extensive to make any quasi-mechanical translation scheme very hopeful."

Martin Kay, who has been teaching computers to translate since 1958, calls MT an "AI-complete problem." You have to solve *all* of the various difficulties of imbuing computers with the kind of knowledge that humans naturally harvest from experience before you can tackle the essential problem of MT. "When you want to hire a translator," Kay explains, "you ask, 'How good is your Chinese? How good is your French?' You don't ask, 'Have you been around much in the world?' The problem is, machines haven't. In order to understand a sentence, your knowledge of linguistics is a relatively minor matter. Your knowledge of the world is incredibly important."

One of the things that we've learned since Weaver's time – and partly because of MT-related research – is how much the basic structures shared by all languages appear to be part of our genetic inheritance. Babies babble at us in Castilian *s*'s, !Kung clicks, and gliding Cantonese tones, and gradually learn to filter out what they don't hear said back to them in the universal singsong that linguists call "motherese." Weaver's notion that a Russian document is an equivalent English document encrypted in the Russian code truly *was* naive – an understandable error to make in an age when a new generation of machines had demonstrated their worth as code breakers, but an error nonetheless. Rather than resembling a conceptual framework, a formal mathematics, or a complex cipher, language is more like a living system that flourishes inside us: an inner wilderness that our algorithms can't quite fence in.

Locking Eyebrows With Han Shan

In 1955, the young poet Gary Snyder took a job on a trail crew in the Sierra Nevada. For two months he repaired stone walls, cut out stumps, dynamited boulders, meditated at the top of 10,000-year-old cliffs, and read *Paradise Lost* by firelight. When he came back down to finish graduate school at UC Berkeley, Chen Shih-hsiang, his Asian studies professor, suggested that he try translating the poems of a hermit who scrawled his words on cave walls during the Tang dynasty. The poet's name – Han Shan, or "cold mountain" – was also the name of the place he lived.

The poems were written in the colloquial language of 7th-century China – far from Snyder's Oregonian English. Looking up the words in a dictionary didn't seem to help him to "lock eyebrows," as Zen students say, with the poems' author. Snyder suddenly realized that where he'd just spent two months – the High Sierra – wasn't so different from Han Shan's backyard. "I had a lot of mountain smells and temperatures very deeply in me," Snyder told me. "I hit on the discovery that I could imagine my way into the mind of the poet by putting myself into the prelinguistic world of the poem – the cold, clear stars glittering all night, the creek water so cold it made your teeth ache, the rich aroma of drying pine needles under your bedroll. If I could get to that place, I could write the poem in English."

The Cold Mountain trail goes on and on:
The long gorge choked with scree and boulders,
The wide creek, the mist-blurred grass.
The moss is slippery, though there's been no rain
The pine sings, but there's no wind.

It strikes me that Snyder's poem is nearly the *opposite* of a machine translation. Surely there's no word quite like *scree* – a word with the distinctive tang of Snyder's upbringing in the Pacific Northwest – in archaic colloquial Chinese. Snyder's version is more like a translation of cultures: a message transmitted from one mountain hermit in the 20th century to another in the 7th. The "mistakes" in his translation are mistakes that only a human would make.

Warren Weaver would have appreciated Snyder's attempt to "write" the poem in English. Beyond his work at the Rockefeller Foundation, his personal obsession was collecting foreign editions of *Alice's Adventures in Wonderland*, the first book he owned as a child. It was a hobby he pursued doggedly for more than 40 years until his death in 1978. The wit of *Alice*, ironically, thrives on the very things that wouldn't survive a round-trip through the interlingua: parodies of well-known songs, puns, mathematical wordplay.

One of Weaver's favorite incarnations of *Alice* was an extremely unliteral, playful translation into Russian by the young Vladimir Nabokov. Charlie Lovett, a Lewis Carroll scholar who has collected Weaver's papers on the subject, marvels that Weaver "could write you a letter that would convince you that you had to run down to the corner bookstore in the little town in southern Sweden where you were vacationing and look for a certain edition to send to him."

Weaver despaired, however, of ever being able to find copies of the first, fragile printings of the Chinese translation of *Alice*. He contacted Yuen Ren Chow, the translator, who advised him to take out classified ads in China. When Weaver told him he didn't speak Chinese and didn't know how to place ads in newspapers in China, Yuen 296 ►

◄ 294 offered to do it for him. A few months later, he wrote Weaver with the good news: "We cast a wide net and we have many fish."

In 1964, the same year the Alpac committee was convened, Weaver published a book called *Alice in Many Tongues*. In it, he compared 160 translations of the book in 42 languages. The task facing a translator of *Alice's Adventures in Wonderland*, as Weaver described it, lay somewhere between the two extremes of a poet trying to translate a haiku and a scientist programming a computer to convert an article on mathematics from Russian into English.

A half-century after Weaver launched an industry by wondering in a memo to 200 of his friends how a scientist might go about doing that, MT is still making people uneasy. When I spoke with Luisa Maffi, president of Terralingua, an organization that's sounding a global alarm about the extinction of indigenous languages, she expressed concern that MT could increase our laziness about learning other tongues. Encoded into every language are distinctive ways of adapting to experience. When we don't care enough to learn a language, or let a language die, she points out, we lose a set of cultural tools we may need in the uncertain future. A proliferation of MT, she added, might foster the illusion that getting scraps of literal meaning was the same as comprehending the culture of the person you're talking to.

What's amazing about language, however, is how potent a technology it is – how little needs to get through before we can spin worlds out of it. When we read Carroll's nonsense about how his slithy toves "did gyre and gimble in the wabe," we imagine we know just what he meant to tell us. Meaning isn't just something that sits inertly behind the words, like the source code of a Web page waiting to be revealed; it's a gift created in the act of exchange. If we build a place for our imperfect machines in that human loop, they'll help us relay our gifts as far as our networks can reach.

Perhaps we could come to see the rules, algorithms, and corpora of MT as a kind of motherese. Even as we teach our growing computers to translate "Jabberwocky" with the arrogant flair of a Nabokov, I have faith in words. An email message that begins its journey in Japanese and arrives at its destination in very strange English may turn out to be the first step on a trail that leads up Cold Mountain. ■ ■ ■