[from: *MT News International*, no. 22, July 1999, pp.5-6, 15]

From the archives…

Warren Weaver Memorandum, July 1949

In July of this year the MT community celebrates the 50th anniversary of one of its most significant milestones: the memorandum circulated by Warren Weaver, director of the Natural Sciences Division of the Rockefeller Foundation., to some 30 acquaintances on the possibility of using the recently invented digital computers to translate documents between one natural human language and another.

The Weaver memorandum is probably the single most influential publication in the early days of machine translation, since it formulated goals and methods before most people had any idea of what computers might be capable of, and since it was the direct stimulus for the beginnings of research first in the United States and then later, indirectly, throughout the world (Hutchins 1997).

Weaver had first mentioned the possibility of using the computer to translate in March 1947 in a letter to the cyberneticist Norbert Wiener and in a conversation with Andrew Booth, a British x-ray crystallographer, who was visiting various locations in the United States where computers were being built. In the following two years, he had been urged by his colleagues at the Rockefeller Foundation to elaborate on his ideas. The result was a memorandum, entitled simply “Translation,” which he wrote in July 1949 at Carlsbad, New Mexico (Weaver 1949).

In his position at the Rockefeller Foundation, Warren Weaver was responsible for instigating and approving grants for major projects in molecular engineering and genetics, in agriculture (particularly for developing new strains of wheat and rice in Central and South America and Southeast Asia), and in medical research. He was a mathematician and had a special interest in probability and statistics. During World War II, Weaver had been seconded from the Foundation to head the Applied Mathematics Panel at the U.S. Office of Scientific Research and Development, where he directed the work of several hundred mathematicians on operations research of all kinds. Because of this background, he was fully familiar with the development of electronic calculating machines and well aware of the successful application of mathematical and statistical techniques in the deciphering of enemy messages.

The impact of Weaver’s memorandum is attributable not only to his widely recognized expertise in mathematics and computing, but also, and perhaps even more, to the influence he enjoyed with major policy-makers in U.S. government agencies.

The memorandum began with a brief account of what had been done already to apply computers to the task of translation. Firstly, there had been some experiments with punched cards by Richard H. Richens and Andrew D. Booth in England, which had produced crude word-for-word translations of scientific abstracts (later published as Richens and Booth 1955). Secondly, there had been newspaper reports of a computer in Los Angeles which was intended to be used for simple experiments in translation. (Although Weaver does not say so, the computer was based at the Institute for Numerical Analysis at the University of California Los Angeles, a branch of the U.S. National Bureau of Standards, and the research was directed by Harry Huskey, who had previously worked on computers at Princeton University and the National Physical Laboratory in England.) These were, of course, just the beginnings, and Weaver was quick to point out the grave limitations of any simplistic word-for-word approach. His memorandum was designed to suggest more fruitful methods.

He put forward four proposals. The first was that the problem of multiple meanings might be tackled by the examination of immediate context:

> If one examines the words in a book, one at a time through an opaque mask with a hole in it one word wide, then it is obviously impossible to determine, one at a time, the meaning of words. " Fast" may mean "rapid"; or it may mean "motionless"; and there is no way of telling which.
>
> But, if one lengthens the slit in the opaque mask, until one can see not only the central word in question but also say N words on either side, then, if N is large enough one can unambiguously decide the meaning. . .

The problem was, of course, to determine how much context would be required, and Weaver expected this to vary from one subject to another. However, Weaver thought that "relatively few nouns, verbs and adjectives" were actually ambiguous, so that the problem was not large. How wrong he was!

His second proposal started from the assumption that there are logical elements in language. He drew attention to a theorem proved by McCulloch and Pitts (1943)—developed in fact in the context of research on the mathematical modeling of the neural structure of the human brain—that "a robot (or computer) constructed with regenerative loops of a certain formal character is capable of deducing any legitimate conclusion from a finite set of premises." The mathematical possibility of computing logical proofs suggested to Weaver that "insofar as written language is an expression of logical character," the problem of translation is formally solvable. (A further influence in this regard may also have been Rudolf Carnap's *Logical Syntax of Language* (1937), but Weaver does not refer to it, so this must remain speculation.)

The third proposal concerned the possible applicability of cryptographic methods. Weaver had been impressed at the success of cryptography based on, as he put it, "frequencies of letters, letter combinations, intervals between letters and letter combinations, letter patterns, etc. *which are to some significant degree independent of the language used.*" (Weaver's own underlining.) He illustrated with a wartime experience of deciphering a Turkish text. It had been given to a mathematician who, without knowing what the original language was, had succeeded in "recreating" the Turkish source text.

Weaver's ideas on cryptography were linked to *information theory*, which had recently been advanced by Claude Shannon. In fact, Weaver was writing a book about information theory with Shannon at the time (Shannon and Weaver 1949). The theory is concerned with the basic statistical properties of communication, including the effects of noise in telecommunication channels and of relative frequencies of signals. In particular, it embraced "the whole field of cryptography." (Shannon was himself the author of one of the most influential texts on cryptography, originally written in 1945 but not published until 1949 (Shannon 1949), and it is quite likely that Weaver had seen it before publication.) Weaver admitted that the validity of the cryptographic approach was difficult to assess, but he was obviously attracted:

> It is very tempting to say that a book written in Chinese is simply a book written in English which was coded into the "Chinese code." If we have useful methods for solving almost any cryptographic problem, may it not be that with proper interpretation we already have useful methods for translation?

As it happened, researchers in machine translation were to recognize very soon the fallacy of Weaver's argument. The mistake lay in a confusion between the activities of decipherment and translation, which arise whenever the same person does both, as indeed is often the case in cryptanalysis.

For his fourth proposal, Weaver became more utopian. It was based on the belief that, just as there may be logical features common to all languages, there may also be linguistic universals. Earlier in his memorandum he commented on a paper by a sinologist, Erwin Reifler, who had remarked that "the Chinese words for 'to shoot' and 'to dismiss' show a remarkable phonological and graphic agreement." Weaver's comment was: "This all seems very strange until one thinks of the two meanings of 'to fire' in English. Is this only happenstance? How widespread are such correlations?" Obviously, Weaver thought that such universals may be very common.

At the end of the memorandum, Weaver asserted his belief in the existence and applicability of language universals with what is one of the best known metaphors in the literature of machine translation:

> 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. It is difficult to make the sound penetrate even the nearest towers, and communication proceeds very poorly indeed. 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.

He realized, of course, that this approach involved a "tremendous amount of work in the logical structures of languages before one would be ready for any mechanization." However, he believed that some steps towards it had been made, particularly in the proposed Basic English of Ogden and Richards, which was then at the height of its popularity (Ogden 1930).

Response to the memorandum was mixed. Some rejected the very idea of mechanizing the complexity of translation—in much the same terms as many professional translators reject machine translation today. Others, however, were less negative.

One of the first to pick up on Weaver's proposals was Erwin Reifler, the sinologist. Over the next few months, Reifler proposed possible uses for crude word-for-word "translations," introduced the notions of *pre-editing* and *post-editing*, and suggested the use of regularized languages (Reifler 1950).

Another was Abraham Kaplan at the Rand Corporation, who followed up Weaver's suggested statistical approach to resolving problems of multiple meaning (Kaplan 1950). In addition, at UCLA there were some early studies on possible methods of automating syntactic analysis (Oswald and Fletcher 1951).

In the long term, however, perhaps the most significant outcome of the Weaver memorandum was the decision in 1951 at the Massachusetts Institute of Technology to appoint the logician Yehoshua Bar-Hillel to a research position. Bar-Hillel wrote the first report on the state of the art (Bar-Hillel 1951) and convened the first conference on machine translation in June 1952.

References

Bar-Hillel, Y. (1951): ‘The present state of research on mechanical translation.’ *American Documentation* 2 (4), 229-237.

Carnap, R. (1937): *The logical syntax of language*. London: Kegan Paul. [Translation of: *Die logische Syntax der Sprache*, Vienna: Springer, 1934.]

Hutchins, J. (1997): ‘From first conception to first demonstration: the nascent years of machine translation, 1947-1954. A chronology.’ *Machine Translation* 12, 195-252.

Kaplan,. A. (1950): ‘An experimental study of ambiguity and context.’ Santa Monica: The RAND Corporation. Repr. in: *Mechanical Translation* 2 (2), 1955, 39-46.

McCulloch, W.S. and Pitts, W. (1943): ‘A logical calculus of the ideas immanent in nervous activity.’ *Bulletin of Mathematical Biophysics* 5, 115-133.

Ogden, C.K. (1930): *Basic English: a general introduction with rules and grammar.* London: Kegan Paul, Trench, Trubner.

Oswald, V.A. and Fletcher, S.L. (1951): ‘Proposals for the mechanical resolution of German syntax patterns.’ Modern Language Forum 36 (3/4), 1-24.

Reifler, E. (1950): ‘Studies in mechanical translation, no.1’ [Seattle: University of Washington.]

Richens, R.H. and Booth, A.D. (1955): ‘Some methods of mechanized translation.’ In: Locke, W.N. and Booth, A.D. (eds.) *Machine translation: fourteen essays* (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology), pp. 24-46.

Shannon, C. E. (1949): ‘Communication theory of secrecy systems.’ *Bell System Technical Journal* 28 (4), 656-715.

Shannon, C. E. and Weaver, W. (1949): *The mathematical theory of communication*. Urbana: University of Illinois Press.

Weaver, W. (1949): ‘Translation’. Repr. in: Locke, W.N. and Booth, A.D. (eds.) *Machine translation of languages: fourteen essays* (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology, 1955), pp. 15-23.