Chapter 19: Present developments and future prospects.

19. 1: The general scene in the 1980s.

When the Commission of the European Communities announced the installation of Systran in their translation service, it marked the end of MT's quiet period in the scientific and technical doldrums. MT emerged from 'academic' obscurity into public view, and further technological advances brought it on to the market place.

In the 1960s MT was primarily the concern of university linguists and computer engineers. Commercial interests were not absent, but they did not flourish. The dramatic miniaturisation and the increasing sophistication of computer equipment have changed the picture in the 1980s. Now MT is also the concern of translators and of those selling translation aids and systems. Academic interests remain, but are now not dominant.

In the 1970s MT activity was concentrated on two main areas. Firstly, progressive improvements were being made to systems of the 'direct translation' type; the most important being Systran. The second main area was the development of 'indirect' approaches, initially the interlingual systems at CETA and LRC and the ambitious Soviet 'meaning-text' model, and then the development of the advanced transfer approaches (TAUM, GETA, SUSY), which emerged as the most realistic and feasible foundation for MT systems of the 'second generation' (where the 'first generation' was considered to be the direct approach favoured in the previous decade). At the same time, the 1970s saw the beginning of semantics-based approaches, primarily associated with AI, and the development of commercial interactive systems.

In the 1980s these lines have continued to be investigated and developed. There is now a variety of MT systems which almost defies any neat classification. It is still often legitimate to apply the labels of the 1960s: practical vs. theoretical, empirical vs. perfectionist, direct vs. indirect, interlingual and transfer. But now there are new labels and new perspectives: interactive vs. fully automatic, 'try-anything' systems vs. 'restricted language' systems, mainframe systems vs. microcomputer or word-processor systems, AI-based systems vs. linguistics-oriented systems.

In overall MT design strategy it is clear that, while the transfer approach has now been adopted by most (linguistically) advanced systems, the 'direct' approach is still attractive as a well-tested strategy, and the interlingual approach continues to appeal to the idealists and 'perfectionists'. It may noted, however, that occasionally these familiar categories no longer seem completely appropriate: Systran has features of a 'transfer' approach in a basically 'direct' design; and the differences between the 'interlingual' and the 'transfer' approach have become blurred in Logos, Eurotra, and METAL, for example.

For large scale systems there is now a broad measure of agreement in basic design: the flexible transfer strategy of GETA and SUSY is to be found in its essentials in the Eurotra project and in the newer Kyoto project. There is now a sound foundation of well-tested linguistic and computational techniques of analysis, transfer and synthesis. The systems represent a continuation of the earlier 'indirect' systems (MIT, CETA, LRC, TAUM). At the same time, there are revivals of older approaches. There are again, for example, projects with 'empirical' approaches (the statistical and contextual models in the Soviet Union); and there are word-centred or lexicon-driven approaches (as in a number of AI systems).

In the past decade, however, the innovation with the most immediate impact has been the emergence of the interactive systems (ALPS, Weidner, etc.); as Vauquois (1976) forecast one of the most fruitful way forward in MT research has been the development of on-line interrogation and editing techniques; there are now a number of systems available, more will no doubt appear in the next few years, and nearly all systems at present under development, whether designed for mainframe of microcomputer, envisage some kind of interactive component.

Finally, there remain attractions in 'restricted language' systems. Most of the earlier systems were designed primarily for particular subject areas (chemistry, mathematics, etc.); the

most successful recent example has been METEO for meteorological reports. A variant is the restriction to language which computer programs can handle relatively easily (TITUS, Smart), or the pre-editing of text input.

All these various types of MT systems have each their own places and functions. The MT field is a mixture of practice and research. Practical operational systems apply well tested methods, both in large scale systems for mainframe computers (e.g. Systran and PAHO) and in smaller systems for microcomputers (e.g. Weidner and ALPS). Experimental systems test new ideas, such as AI methods, new parsers, logico-semantic representations. Some innovative approaches are to be found in the sophisticated and complex linguistics-oriented 'transfer' systems (GETA, Eurotra, Kyoto); others are to be found in the smaller scale AI-inspired knowledge-based systems (Yale, LUTE and ATLAS); and others in the new interlingual approaches (DLT, Rosetta). From these projects will no doubt emerge the techniques of future fully automatic systems.

It is evident that the earlier divisions between pragmatists (e.g. IBM, Georgetown) and perfectionists (e.g. MIT, Berkeley) remain to the present. Now the pragmatists are mainly the designers of interactive systems, and the perfectionists are among those who experiment with AI approaches.

This opposition of practicality and idealism is a sign of health. MT is not just a special sort of data processing, just another application of computers. This lesson was learnt in the early days of MT when computer engineers found that translation was rather more than manipulating a dictionary. Nor is MT just another branch of linguistics, of computational linguistics, or of artificial intelligence. It is not an 'academic' quest for theories of language or for models of human intellectual behaviour. The primary stimulus for MT research has been the urgent needs of scientists, engineers, technologists, economists, administrators, etc. to cope with an ever increasing volume of materials in foreign languages. In the 1950s and 1960s most demand was for access to scientific literature (in the United States, mainly from Russian); now the demand is for technical, legal, commercial and administrative translations prompted by the 'linguistic equality' of the European Communities and the biculturalism of Canada, by the needs of multinational companies and the exigencies of global telecommunications.[1]

MT is a marriage of practical needs and theoretical idealism. Wilks referred to MT as a 'testbed' for AI theories. MT has been and continues to be a test for linguistic theories, although linguists have been reluctant to acknowledge the fact. MT provides a touchstone for the realism of theory; small scale models applied to carefully selected or specially composed texts are no proof, large scale application to actual texts outside the laboratory are the real test. As yet, the more sophisticated approaches (of GETA, Eurotra, and AI systems) have not demonstrated their capabilities; only the earlier cruder 'direct' systems and the interactive systems have shown their practicality.

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[1] Developments in MT research and usage since the book was written in 1984/85 are recorded in: W.J.Hutchins, 'Recent developments in machine translation: a review of the last five years', *New directions in machine translation: international conference, Budapest 18-19 August 1988*, ed. D.Maxwell, K.Schubert, T.Witkam (Dordrecht: Foris, 1988), pp. 7-63; J.Hutchins, 'Latest developments in machine translation technology: beginning a new era in MT research', *The Fourth Machine Translation Summit: MT Summit IV*. Proceedings: International Cooperation for Global Communication, July 20-22, 1993, Kobe, Japan. [Tokyo: AAMT, 1993], pp.11-34; J.Hutchins, 'Research methods and system designs in machine translation: a ten-year review, 1984-1994', *Machine Translation: Ten Years On*, 12-14 November 1994. [Proceedings of conference at] Cranfield University ... [London: British Computer Society, 1994]; J.Hutchins, 'A new era in machine translation', *Aslib Proceedings* 47(1), 1995, pp. 211-219; J.Hutchins, 'The state of machine translation in Europe', *Expanding MT horizons*: proceedings of the Second Conference of the Association for Machine Translation in the Americas, 2-5 October 1996, Montreal, Quebec, Canada. [AMTA, 1996], pp. 198-205; and J. Hutchins, 'The development and use of machine translation systems and computer-based translation tools', *International Conference on Machine Translation & Computer Language Information Processing*, 26-28 June 1999, Beijing, China, ed. Chen Zhaoxiong [Beijing: Research Center of Computer & Language Engineering, Chinese Academy of Sciences, 1999], pp.1-16. All available at: http://ourworld.compuserve.com/homepages/WJHutchins.

19. 2: Linguistic problems and methods

MT research is a mixture of solid achievement and speculative experiment. There are now few problems with morphological analysis and with dictionary searching routines. There is broad agreement among MT researchers on general strategies for these processes, and the same techniques are found repeatedly in one system after another. This has been true since the mid-1960s and it is surprising, therefore, that there seem still to be no standard programming 'packages' available (Damerau 1976).

Syntactic analysis techniques are likewise well tested and relatively efficient. There is now a wide variety of computational techniques and aids to choose from (cf. King 1983): context free parsers, ATN parsers, tree transducers, charts, etc. There are, of course, still disagreements about the relative merits of different parsing strategies: bottom-up vs. top-down, etc. (Ch.3). A more recent issue is the question of production systems vs. procedural systems (Rosner 1983, Johnson 1983): production systems are sets of unordered generalised rewrite rules, which may be applied as appropriate to input strings or trees (as in Q-systems and charts, cf. Ch. 9.14-15 above); procedural systems by contrast specify sequences of rewriting rules (e.g. ATN parsers), they represent a deterministic approach to parsing. As yet, choice of syntactic analysis strategies would seem to be largely a matter of individual preferences (Johnson 1983)

Two recent developments in formal linguistics may well influence future developments in parsing, since both deny the need for transformational rules. One is the theory of 'lexical-functional grammar' (e.g. Bresnan 1982), in which relationships between semantically related surface structures are handled by lexical rules. Thus, whereas in the standard transformational approach (Chomsky 1965) active and passive forms are derived from the same underlying 'deep' phrase structure, in lexical-functional theory the equation is expressed through correlations of functional structures assigned to the active and passive verb forms, i.e. that the object of the active form of a verb has the same thematic function as the subject of the verb's passive form. In this way language-specific features are removed from the syntactic (transformational) component into the lexicon. As a parser the model supports a lexicon-driven approach.

The other development is the theory of 'generalized phrase structure grammar' by Gazdar and others (1985). Chomsky claimed to have proved that phrase structure grammars (and hence all context-free grammars) were mathematically inadequate for describing natural language sentence structures. Gazdar argues that Chomsky imposed unnecessary constraints on the formal properties of phrase structure grammars, in particular by excluding the use of complex symbols. Gazdar proposes formalisms which capture the generalisations and generative power of transformations without going outside the limitations of context-free grammar.

While syntax and parsing are thoroughly researched and well founded, the greatest problems remain, as they always have been, in the area of semantics. The use of semantic features for resolving certain types of syntactic ambiguity and the use of case frame analyses are now well established in very many systems of all kinds. The problems arise whenever information is required from outside the sentence being analysed. Pronominal reference is one area of difficulty; in practical systems a simple rule of taking the most recent noun phrase as the antecedent may work by and large, and corrections can be made during post-editing. Satisfactory treatment, however, clearly requires often 'real world' knowledge. Likewise, very many problems of lexical ambiguity and of TL lexical selection demand some 'understanding' of texts. Much can be achieved with restrictions of systems to particular sublanguages, but unfortunately few actual texts fall neatly into one particular subject field; most refer to other areas and disciplines.

There has been considerable activity in linguistics in all these areas. The work on sublanguages arose directly from problems of MT and related spheres of computational linguistics, e.g. Kittredge & Lehrberger (1982), both members at one time of the TAUM group, and Sager (1981) of the Pennsylvania group. There has been a growing substantial interest by linguists in

recent years in discourse analysis and text structures (e.g. Halliday & Hasan 1976, van Dijk 1977, 1980, de Beaugrande & Dressler 1981). Petr Sgall of the Prague group has made particular study of topic-comment structures and presupposition, both traditional specialities of Czech linguists (Ch.13.5 above). Although this linguistics research has aroused considerable interest there is little evidence yet of its direct effects on MT research.

It is an embarrassing fact for those who believe there can only be better quality MT with more linguistically sophisticated systems that the most successful operational MT systems so far (based essentially on the 'direct translation' approach) owe almost nothing to linguistic theory, or rather to be precise, to syntactic theory. What is the reason for this apparent 'failure' of syntactic theory to provide or suggest models appropriate to MT? One may be the distinction between 'competence' and 'performance'. Linguistic theory (largely inspired by Chomsky's theoretical position) has concentrated on the formal definition of language systems and has generally neglected the investigation of language behaviour in social contexts; it has pursued the goal of 'scientific' rigour, idealisation and abstraction without checking its hypotheses and theoretical models against empirical observations of actual linguistic usage. It is paradoxical that the primary impetus for the formalisation of grammars which made the automation of linguistic processes appear feasible should have itself encouraged the dissociation of theory and practical reality which has led to be adoption of unrealisable models.

The influence of linguistic theory in the past is to be seen in the strict separation of stages of analysis (morphological, syntactic, semantic), the adoption of the 'filtering' approach. This rigidity was found to be a major cause of the failures of the 'interlingual' systems (Ch.10). It was also a mistake, as Ljudskanov (1968) pointed out, to assume that translation processes necessarily took place at the 'deepest' levels of analysis; surface information was often sufficient, and was usually needed in any case. As we have seen, the newer linguistics-oriented systems have abandoned filtering, retain surface information and mix semantic, syntactic and lexical information in representations and procedures (GETA, Eurotra, METAL). These systems are no longer implementations of any particular linguistic theories; they are independent MT models, albeit founded on linguistics approaches. As such, they are still essentially developments of syntax-based MT strategies, and have problems whenever analysis has to go beyond sentence boundaries and whenever disambiguation needs to take account of 'real world' knowledge. Nevertheless, these systems have such a high degree of flexibility that there is no reason to doubt their capacity to incorporate new methods of analysis, including AI methods, without detrimental effects on existing successful procedures.

19. 3: Artificial intelligence and MT

For AI researchers, the difficulties and past 'failures' of linguistics oriented MT point to the need for AI semantics-based approaches: semantic parsers, preference semantics, knowledge databases, inference routines, expert systems, and the rest of the AI techniques.

There is no denying the basic AI argument that at some stage translation involves the 'understanding' of a SL text in order to convey its 'meaning' in a TL text. For AI researchers this means that texts must be given semantic or 'conceptual' representations (independent of particular languages), that parsing must be based on semantic criteria, that 'knowledge' of the world must be called upon to interpret relationships and resolve ambiguities, etc. The result is an impressive battery of AI techniques, some of which have been already described (Ch 15 above).

The concept of knowledge databases as sources of information necessary for disambiguation and inference mechanisms has considerable attractions. Many of the newer MT projects intend to incorporate such data in their systems. However, there have been no estimations of the size or complexity required for the knowledge base of a MT system. Therefore, despite assurances from AI researchers, there are many MT researchers who doubt the capacity of such approaches in large scale systems.

The degree of understanding required for translation is, in any case, still an open question. Does the translator of a biochemistry document need to be a biochemist? He must have some knowledge, it is true, but does he need to 'understand' as fully as the biochemist? It is surely evident that much translation can take place at a fairly superficial level (Slocum 1984a, Ljudskanov 1968). If this were not so, then 'word-for-word' translations would not convey any meaning at all. For practical MT purposes, it has yet to be shown that complete understanding in the AI sense is necessary. It is therefore not surprising that many MT projects still aim to translate at lexical and phrase structure levels (e.g. the Kyoto projects, Ch.18.7).

When considering the applicability of AI methods to MT, there need be no commitment to AI philosophy. That is to say, it does not matter whether we believe that AI programs map texts onto 'universal' conceptual representations or whether we take these 'representations' as just useful computer data structures and nothing more. What matters is whether the programs work, i.e. produce paraphrases, answer questions, translate. It may be dangerous, as Weizenbaum (1976) argues, to imagine that the machine really 'understands' and that it is simulating the way we as humans understand, since this has social and moral implications. But there is no need to see the computer as anything other than a symbol manipulator.

The most successful application of AI methods has been the development of expert systems, i.e. knowledge bases incorporating the 'lore' of experts in a particular field (e.g. medical diagnosis or geology) and an 'inference engine' to work out conclusions from data submitted by users. Most rules are conditional and probabilistic ('if X and Y are true then Z is likely with a probability of p'). An important feature is the ability of the computer to describe the steps leading to a conclusion or explain the logical reasoning being pursued, thus enabling the user to assess the validity of the output.

What could be the role of expert systems in MT? The most obvious one would be to assist in SL text disambiguation (as proposed for the GETA, SALAT, TRANSLATOR, DLT and LUTE systems). MT methods of semantic analysis have tended to apply 'selection restrictions' and measures of semantic compatibility (Ch.3.6). An expert-system approach would be less rigid, more probabilistic, more inferential - more, it would be hoped, like a human translator. The idea is certainly attractive, but the complexities of codifying the knowledge of an expert translator would appear to be particularly daunting.

Most AI systems have been experimental projects on highly restricted domains. The results in many cases seem promising, but there is no guarantee that if extended to larger scale system the methods would still work. AI researchers are confident: "Knowledge-based machine translation... has been implemented in a pilot system" which "established the technical feasibility of KBMT... Newer and more robust semantic-based parsing techniques and better natural language generators argue in favor of converting the KBMT approach from a laboratory exercise to production-quality translation systems in the very near future" (Carbonell & Tomita 1985). There were similar pronouncements by MT researchers in the 1950s. The history of MT has numerous examples of methods which promised much at first but proved disappointing failures.

Such exaggerations should not be allowed to disguise the real promise of AI techniques. There is no doubt that AI methods of semantic analysis will become standard components of MT systems in the future. But they will be components; AI approaches are in themselves not the whole solution. In the 1960s there was a tendency for a number of MT groups to concentrate on a single approach (particularly in syntax). The lesson of the 1970s was that integrated flexible approaches were needed. A number of AI researchers are recognising that efficient parsing cannot be exclusively semantics-based, and that some use of syntactic information must be made (Lytinen 1985). Similar conclusions were reached much earlier by the Grenoble and Saarbrücken groups, and flexibility of this nature has been built into the Eurotra system.

In this respect, it should be noted that a number of AI researchers have developed 'lexicon-driven' systems. A example is the 'word-expert' parser of Small (1983), where each word has

associated with it (in the lexicon) a set of predictions about preceding and succeeding lexical items and creates tentative 'concept structures' (or frames). Even word endings such as the plural *-s* invoke predictions. Although similar techniques have been applied in many AI experiments (e.g. the Yale group), this is the most extensive exploration. It may be noted in passing that both the word-expert approach of Small and the lexical-functional theory of Bresnan (above) are examples of the recent revival of 'lexis-oriented' grammars (which is also to be seen in the adoption by a number of MT systems of 'lexicon-driven' methods of analysis and synthesis, in general philosophy similar to some systems of the 1960s.)

There are now many MT groups already applying AI techniques; and many recent projects are to investigate the possibilities in greater depth. American researchers have been impressed by the achievements of AI techniques, and the same is true for many European MT researchers. A particular stimulus in Japan has been the launch of the 'Fifth Generation Computer Systems' project in October 1981 by the Japanese Ministry of International Trade and Industry. The project has political and social motives, to give Japan a leading, perhaps dominant, role in the future world economy. The Japanese see information technology as the key. "The goal is to develop computers for the 1990s and beyond – *intelligent* computers that will be able to converse with humans in natural language and understand speech and pictures... that can learn, associate, make inferences, make decisions..." (Feigenbaum & McCorduck 1984). MT has a central role in the project, as one of the "basic application systems" along with "consultation systems, intelligent programming systems and an intelligent VLSI-CAD system." The aim is a multilingual system with a vocabulary of 100,000 words, guaranteeing "a 90% accuracy, with the remaining 10% to be processed through intervention by man, and with total costs... at 30% or lower than those of translation by man" (Moto-Oka 1983)

In many respects, these immediate objectives are not unrealistic – the Eurotra project has similar aims and they are expected to be achievable with present MT expertise in linguistics oriented approaches and with present computer technology (Ch.14.2 above). However, more distant objectives of the Fifth Generation appear rather more utopian. Yasuo Kato, general manager of systems research at the Nippon Electric Corporation, one of the consortium backing the project, predicts that "in 20 years you will have (an interpreting) machine that you can put in your pocket. The system will recognize your voice, translate what you say, and read it out in another language." (quoted in *Business Week*, Sept.16, 1985)

There is no obligation to accept such prognostications when acknowledging the future impact of AI in MT systems. A more sober assessment would predict a gradual integration of AI approaches in MT systems, leading to definite (perhaps highly significant) improvements over the next twenty years, but with the ultimate completely automatic system still a distant goal.

19. 4: MT quality and revision.

The goal of the MT 'perfectionists' of the 1960s was fully automatic high quality translation. While it may be true that some AI-inspired researchers are still aiming for FAHQT, this goal has long been abandoned by the great majority of those working in the MT field. It is recognised that revision is normal and expected for all translations, whether done by humans or by computers. Debates about what is meant by 'high quality' or 'fully automatic' are largely irrelevant. What matters is whether the MT output is satisfactory for its intended use (revised or not) and whether the operation is cost-effective. The question of translation quality is entirely relative to the needs of recipients, as Bar-Hillel (1971) acknowledged some years after his influential FAHQT pronouncements (Ch. 8.3). There can be valid uses of poor quality output in unedited form if it is produced quickly, cheaply and not intended for publication. If better quality is required then collaboration of man and machine is essential. As we have seen, this means in practice either post-edited or interactive MT.

What is meant by good quality MT output? It is a surprisingly elusive concept. Judgements of quality are primarily subjective. MT output is ranked lower than human translation generally because MT systems still make gross grammatical 'mistakes', select the wrong words and produce stylistic barbarisms. Objective criteria are difficult to establish. Van Slype (1982) has attempted to assess the value of different yardsticks: intelligibility (of output text, e.g. via readability scales, cloze tests), fidelity (to SL original, e.g. via measures of information transfer), acceptability (to recipient of translation), time spent in revision (post-editing), number of 'errors' corrected and type. Costing of MT in comparison with human translation requires careful accounting of all stages of the translation processes from receipt of SL text to final despatch of revised TL version. Evaluation of MT is made that much more difficult by the lack of any objective measures of human translation. As Van Slype (1982) comments, human translation has never been the subject of quality controls of the kind common in industrial enterprises. It has only been evaluated 'objectively' since comparisons began to be made with MT output.

There is now considerable practical experience of post-editing 'raw' MT output. Reports of 'professional' MT revisers have been presented at the annual series of Aslib conferences (e.g. Lawson 1982, 1985) The work rate of post-editors depends largely on their attitude to mechanisation and word processors and on their motivation; translators are trained to aim for high quality products, they find it difficult initially to accept low quality MT with equanimity. Translation is a creative activity; many find MT revision inhibiting: it is "not an aid, but a hindrance, because it limits their freedom of expression" (Wagner 1985). Others, however, rise to the challenge. Such differences in attitude can easily account for the wide ranges in productivity which have been reported, from 5 pages a day to 25 pages or more a day. But, the amount of revision is clearly very much dependent on the quality and difficulty of the original text. Nevertheless, it is the conviction of many translation services that MT with post-editing is a viable economic proposition. The experience of translation bureaux such as ITT, which has installed the Weidner system, is generally favourable: they claim increased productivity with no degradation of quality (Magnusson-Murray 1985).

Initially post-editors tend to be overzealous in their correction of MT texts, changing not only grammatical and lexical mistakes but also altering the style of texts. They have to learn to edit without complete rewriting. Some become very fast: the idea of 'rapid post-editing' has developed (e.g. in the translation service of the Commission of the European Communities) in recognition that not all users want 'purple prose' versions. There is now a growing realisation that for many recipients stylistic refinements are not necessary; it appears that on the whole users are more content with low quality texts than translators and post-editors. There would seem to be a growing market for rapidly produced low quality translation, which the advent of MT has opened up. There is undoubtedly a considerable latent demand for texts to be translated for information purposes which would otherwise not be translated at all.[2] But, of course, there is a natural fear by many translators that standards will be lowered and with a consequent detrimental impact on their professional image and social standing.

19. 5: Future prospects

Taube expressed the fears of an earlier generation about the insidious mechanistic and dehumanising influence of the computer (Ch.8.7). Weizenbaum (1976) has expressed the continuing fears of a later generation. It is not surprising that many translators should have similar fears about the potential influence of MT.

Technical advances in on-line interactive facilities may well dispel such fears. There is no need to assume that computerisation means either that translators will be no longer needed or that the translator will be a slave to a machine. There is ample evidence to show that there will always

[2] The need is now being met (at various levels of quality) by MT services on the Internet since the mid 1990s.

be a demand for the high quality product which only the human translator can achieve; not only in the translation of literary works where sensitivity to cultural and linguistic nuances is crucial, but also in such areas as diplomatic and legal translation where meticulous accuracy is of paramount importance.

The most likely development in the near future is a translator's workstation, on the lines envisaged by Melby (Ch.17.10), and exemplified by the recent SUSANNAH project at Saarbrücken (Ch.13.2). A workstation would combine a word processor, access to machine aids (not only dictionaries but other reference materials), a multi-level interactive MT system (of the ALPS kind), and a fully automatic MT system. The translator would select whichever method might be the most appropriate for a text to be translated. The technology is already available, and translators are likely to be attracted by a 'translating machine' which they can control.[3]

It is for such reasons that interactive MT systems can be expected to remain popular for a long time. There is also no sign that fully automatic systems will be able in the near future to resolve the semantic problems that prevent good quality output; interactive disambiguation and stylistic improvement will continue to offer an obvious solution, and one which satisfies the professional integrity of the translator.

At the same time, it is unlikely that the fully automatic systems which are now operative or under development will disappear in the near or even distant future. Large scale systems on mainframe computers will continue to retain a place in the larger translation services and in service bureaux. Systran is already available through bureaux to smaller translation agencies and individual clients. Free-lance translators already have access over public telecommunication networks to remote term banks (e.g. EURODICATOM). Remote access to mainframe MT systems is surely the next stage.

By then, it is to be hoped or expected that 'direct' systems such as Systran will be superseded by more sophisticated 'transfer' systems like Eurotra. There are signs already of quality degradation in Systran (at least in the Russian-English version, Ch.12.1); and there are good grounds for optimism that transfer systems (Eurotra, METAL, Kyoto) will produce significantly better quality output, even though the high quality anticipated by AI researchers may not be forthcoming in the near future.

Many of the interactive systems (ALPS, Weidner, Logos) are already available on microcomputers (mainly Wang and IBM PC). With progressive miniaturisation there is the future prospect of even larger translation program packages for personal computers, perhaps approaching the size and complexity of the present mainframe systems. Eventually perhaps, there will be genuine hand-held 'personal translators', which will be so useful for businessmen, travellers and students, and which should be substantially more satisfactory than the rudimentary 'phrase dictionary' types introduced abortively in the late 1970s by Nixdorf, Craig and other manufacturers (Smith 1984). In the more immediate future there is most likely the development of programs which combine the writing and composing of business correspondence and simultaneous translation; initially they will be 'restricted language' interactive systems on the lines suggested by the researchers at UMIST and Carnegie-Mellon (Ch.17.13), but later no doubt there will be systems with almost unrestricted input.

In the immediate future, a major problem still to be solved is that of cheap input to MT systems. The need for optical character readers has been recognised from the earliest days, and yet there are still no inexpensive machines capable of reading a wide variety of typefaces and fonts (Roman and non-Roman). Until they appear the costs of all types of MT will remain relatively high. Voice input is, of course, often mentioned as a future possibility; but the problems of phonetic

[3] The first commercial translator's workstations appeared in the early 1990s. Their rapid adoption was due not only to the facilities mentioned but also to the development of means for storing and accessing large databases of previously translated texts ('translation memories'). See: J.Hutchins 'The origins of the translator's workstation', *Machine Translation* 13(4), 1998, pp.287-307.

analysis and transcription, for more than highly restricted vocabularies, are almost equal to the problems of 'high-quality' semantic analysis.

Development of MT systems is no longer an exclusively 'academic' pursuit; it is in the hands of commercial companies (and as a consequence, much technical information is unavailable): Siemens, Philips, Fujitsu, Hitachi, Weidner, etc. But more importantly for the future, it is increasingly in the hands of translators themselves: as post-editors they provide feedback for system improvements (e.g. in the CEC Systran service, Ch. 14) and they can influence directly the direction of commercial MT development. It can be argued that one of the failures of earlier MT research was the neglect of what translators actually did and what they actually wanted from computer systems (Masterman 1979).

The centres of MT research since the mid 1960s have been in Europe (predominantly France, Germany and the Soviet Union), Japan, Canada and the United States. The pattern reflects the general concentration of scientific research in the major industrialised nations. It is not then surprising that there has apparently been no MT research in South America, Africa and India. But there have also been other omissions: Australia and Scandinavia (with the exception of the Danish contribution to Eurotra), Poland and East Germany. There is evidence of some activity in China again since the 1950s (cf. Ch. 15.5), although little is known of what has been achieved; and interest is growing in the Middle East, where it can be expected that MT projects will be established in the future. A model for the future might be the international collaboration of the Eurotra project; the political complexities of funding the research teams have been daunting, but if the project proves successful there will surely be others to come.

Although in comparison with the 1960s the range of languages involved in MT has greatly expanded, there are still notable gaps. The earlier neglect of Spanish (Ch.8.11) has been rectified by Systran, PAHO and a number of interactive systems; but there is still a relative neglect of Arabic, Portuguese and (since the mid 1960s) Italian. Some major languages have yet to be treated in MT systems; in particular, the languages of India and Africa (e.g. Hindustani, Bengali, Panjabi, Swahili) and most Southeast Asian languages (Vietnamese was a short-lived exception). On the other hand even some European languages have not yet been tackled in MT systems: Polish, Swedish, Greek. Involvement in the Eurotra project will entail MT research at some future date on some of these 'neglected' languages: Portuguese, Italian, Greek, and Danish. For other languages, however, it would seem that what is required is some economic or political incentive; for good or ill, international understanding and cooperation have not in the past been sufficient motivations for financing substantial MT projects.

Advances in computer technology and programming have made possible the proliferation of MT projects. Whereas until the mid 1970s MT research demanded large scale computer facilities, it is now possible for anyone with a microcomputer to experiment. There is evidence of this happening already, and it will no doubt increase. In the past, MT programming was almost exclusively in assembly code for specific machines; now increasingly, MT programs are written in high level languages (at present, the most popular are LISP, Prolog, and Pascal) and this itself will encourage more interest by many who otherwise have no opportunity to do MT research. It is notable that many AI projects have involved small numbers of researchers, often no more than two or three.

While small projects have made valuable contributions and will no doubt continue to do so in the future, it is equally indisputable that major advances in MT will probably come primarily from the larger projects of the size of GETA, Eurotra, Kyoto, and so forth. Only these have the capacity to test new linguistic and AI techniques on a sufficiently large scale. The lesson from the past ought to be clear enough: the complexity of MT derives from the complexity of language and the huge variety of text types. Small scale projects often seem initially of great promise, but there are frequently disappointing results when methods are tested on larger systems. The history of MT reveals how difficult it is to achieve success: of the many projects in the past thirty years, only a

handful have resulted in operational systems. However, much has been learned and there is genuine and well-founded optimism for future progress.

19. 6: Generations and periods.

In computer science it is common practice to refer to generations of computers: vacuum tube computers, transistorised computers, integrated circuit computers, and very large-scale integrated computers (VLSI). In the anticipated 'fifth generation', the basic serial von Neumann design of computers until now is expected to be replaced by parallel architectures, new memory organisations and new programming languages.

There has been an inclination among MT researchers to refer also to generations of systems. For some the first generation is represented by the simple word-for-word systems, the second generation added syntactic analysis and the third incorporated semantics of some kind (Locke 1975, Toma 1977). For others, the first generation is represented by the 'direct translation' systems, the second by the 'indirect' systems and the third by systems based on AI approaches (Vauquois 1976, Hutchins 1978). As a result Systran, for example, is sometimes classified as a 'third generation' system because it incorporates some semantic analysis, and sometimes as a 'first generation' systems because it adopts the direct translation approach. In addition, however, there is no place in either classification for the interactive systems, unless they are regarded as 'transitional' stages between generations, as does Melby (1980) with the Brigham Young system, or as 'hybrid' forms - i.e. CULT would belong to the first generation as an interactive 'direct' system.

It may be more appropriate to see the development of MT in terms of evolutionary periods. The first period extended from the end of the Second World War until the mid 1950s (the Georgetown-IBM demonstration and the MIT conference in 1956). The second period, which lasted until the ALPAC report in the mid 1960s, was characterised by vast US governmental and military support, great enthusiasm and considerable disappointments. The third period was MT's 'quiet' period when research concentrated on 'indirect' systems and when the first operational systems became well established. The fourth period began in the mid 1970s with the interest of the Commission of the European Communities in the possibilities of MT (Systran), the first public MT system (METEO), the reorganisation of MT activity in the Soviet Union, and shortly afterwards, the appearance of commercial systems, increasing research on AI approaches and the revival of Japanese interest.

The periods are roughly decades, and so it is tempting to believe that a new decade is now beginning. If so, it may possibly be marked by a burst of activity associated with the Japanese 'fifth generation' project and by a resurgence of MT research activity in the United States, for which there are already signs (conferences at Georgetown and Colgate University in 1985, and the foundation of a new specialist journal *Computers and Translation*.) Whether entering a new period or not,[4] the future of MT is secure: it satisfies a genuine urgent need, it is the subject of worldwide research and development, and it is becoming a commercial product like other technical aids and office equipment; the application of the computer to translation is a reality, for many it is already as much a part of life as the computer itself.

[4] A new era began in 1989/1990 with the appearance of corpus-based approaches to MT (statistics-based and example-based machine translation), the first translator workstations, and, shortly afterwards, the beginnings of MT on the Internet. See references in footnote 1.