The First Year's Experience with a Large Computer in a Life Assurance Office

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This paper is the text of a talk given to The British Computer Society on Tuesday, 5 January 1960. The author discusses some of the preparatory steps taken by Confederation Life Association before the purchase of a large-scale electronic data-processing machine—an IBM 705. He then deals with the successful, simultaneous, conversion of all ordinary policy operations to the electronic computer and the first year's experience of the new system, concluding with some remarks on problems resulting from the handling of world-wide business on a central computer installation in Toronto, with particular reference to the Association's British operations.

Introduction

In October 1956 my company, Confederation Life Association, decided to purchase an IBM 705, model 2, and we have recently finished the first year's processing of data, from our branches throughout the world, at our Head Office in Toronto.

Those few words sum up a vast amount of activity and I should like to describe in general terms how we have fared.

But first I must sketch in the background. The Association is a Canadian life assurance company and as both the quantity and complexity of material to be operated upon are major factors in assessing an electronic data-processing system, I should explain that on the North American scale we might reasonably be called a medium-sized company; we have some 370,000 policies in force for sums assured totalling to the equivalent of some £700 million. This business is both *ordinary* and *group*; we do business in fourteen countries including, of course, Great Britain and Northern Ireland, with nineteen different currencies and nine completely separate sets of premium rates. To adopt a different criterion, we wrote some £9 million new business last year in Great Britain and Northern Ireland, so in this country also we can claim to be medium in size.

Feasibility Study

It is necessary to give a considerable historical background before embarking on a review of the last year's activities. As a start we must consider the feasibility study, which was made by a group which consisted originally of an actuary, an accountant, and a systems expert, all three from our permanent staff; it is worth noting that the terms of reference of the group making the feasibility study were exceptionally comprehensive, and although at the beginning they confined their attention to ordinary business they did not forget that they were charged with examining the application of electronic systems to the Association's activities as a whole; for example, the system should include group life, sickness and accident, and pension work, all our investment records and our accounting in all its aspects.

Initial investigations showed that certain intermediate-size systems could carry out many operations for the Association in an improved manner, and could be justified in terms of cost. The type of work which such systems could handle, however, basically fell into the category of so-called scheduled operations, i.e. those in which it is known in advance that specific action must be taken, either because of the terms of the insurance contracts or because of company practice. It was not considered possible for intermediate-size systems to handle the other large part of the operations of a life assurance company the size of the Association, viz. the random or non-scheduled operations, which form a large portion of our day-to-day operations.

It became clear, at a relatively early stage of the group's investigations, that if the Association started with an intermediate-size system it would be necessary to effect a sizeable reorganization internally to handle the revised routines of a scheduled type. It was also concluded that it would hardly be feasible to keep a policy file in policy-number order, for a company the size of the Association, on an intermediate-size system, and this would certainly appear to be the only suitable means of keeping our records if we wished to handle non-scheduled or random operations. Also, if at a later date it were decided to install a large-size system, there is no doubt that the extra data conversion problem at that time would be just as formidable as the initial conversion problem, as well as involving substantial further reorganization internally.

As a result of these considerations, the Association reviewed the possibility of installing a large-scale system *ab initio*.

We were able to justify a large-scale system economically, remembering that we are a medium-sized company, provided our routines were arranged so that both scheduled and non-scheduled operations were handled by the system at the same time, and that we laid plans to handle the whole of the Association's activities as soon as possible. On this assumption, and in order to avoid second conversion and reorganization problems, it was decided to order a large-scale system.

The other fundamental recommendation made by the

feasibility study group, and accepted by the company's executive, was to convert all our ordinary policy operations for all branches in one fell swoop—the Consolidated Approach to Electronics. This is not the occasion to discuss the pros and cons of such an approach; it suffices to say that despite all our difficulties we would probably repeat our choice of a wholesale rather than a piecemeal shift of routines to the computer, if such a decision had to be made a second time.

Before leaving the feasibility study it is worth passing on some of the study group's later thoughts, looking back at the study. They stressed the value of the following four items.

(i) The need for sufficiently comprehensive terms of reference initially; i.e. the duty of examining the Association's whole O and M structure rather than being restricted to an examination merely of existing E.D.P. Machines—it is not just a question of fitting an E.D.P. system into an existing office structure.

(ii) The value of direction and explanation by the President to all operating heads right at the beginning; this greatly facilitated the study group's later investigations.

(iii) The importance of actual programming and machine operation, when testing different possible commercial systems. It is always difficult to compare one system fairly against another without doing considerable theoretical and practical work on both. Many of the factors which have a large bearing on the size of memory, and on the speed with which a system operates, are not apparent until some of the lengthier programs have been written and the many utility, sort and merge operations actually carried out on one's own data.

(iv) The importance of the manufacturer's reputation for service—using the word in a broad sense—when choosing the equipment to be used. It is not only a question of the maintenance and reliability of the actual hardware, though this is obviously vital, but it is also a question of the help that one can obtain in installing a new system, such help coming from the manufacturer's experience of similar applications.

Operations Planned for First Year

We may now turn to the basic operations which we intended to start at the beginning of 1959. These were as follows.

(i) The preparation of renewal notices and the corresponding accounting routines.

(ii) Policy loan accounting (I should explain that interest is calculated in the Association on policy anniversaries, and therefore the renewal notices have details of the outstanding loan and any capitalized interest, plus, of course, the current demand for interest).

For sterling policy holders, resident in this country, it is necessary to show income tax relief on loan interest and then the net interest due; this raised some nice problems in dealing with policyowners resident outside the United Kingdom, when the main classification for the run was the branch at which the policy was registered and which may well be within the United Kingdom.

(iii) Calculation of bonuses and appropriate accounting.

Our bonuses are derived from cash dividends payable at the policy anniversary, the dividends being converted into reversionary bonuses payable with the basic sum assured under the policy. This explains why our bonuses are closely tied in with the policy renewal procedure, rather than being referred to a fixed date such as 31 December in a particular year, as is more usually the case in this country.

(iv) Calculation of cash surrender values.

(v) The actuarial valuation of our liabilities.

(vi) Certain actuarial investigations (e.g. mortality experience).

(vii) Preparation of statistical returns for the various government departments in the countries in which we operate—in this country, the Board of Trade returns.

(viii) Agents' commission statements, and new business production returns for management.

(ix) General ledger accounting for policyowners' accounts.

Data Conversion

In order to carry out these operations we had to compile three new basic files on magnetic tape, as follows:

(i) A master file to be updated daily. This file contains all the basic information for each policy.

(ii) A name and address file divided into 28 parts according to renewal date. (We do not have any policies with renewal dates later than the 28th of any month.) As each daily cycle is carried out, only one part of the name and address file has to be processed in order to prepare premium renewal notices. This is, of course, purely in order to cut down the length of processing-time. A disadvantage is that there are limitations on obtaining a name and address in the event of random access to the file.

(iii) A calculation file, updated monthly. This file has two principal functions. The first is for computing once a month the cash surrender values and bonuses of all policies whose anniversaries fall in the subsequent month. Secondly, it is used for the monthly calculation of liabilities and the preparation of an in-force statement. We originally planned a separate calculation file in order to save processing time, just as we adopted twenty-eight separate name and address files, but

as it turned out eventually, it would have been impossible to combine the calculation and master files into one, even if we had decided to do so, because of limitation of memory (of which the capacity is 40,000 characters).

These three tapes had to be produced from six separate card files, one large addressograph plate (which contained a great deal more than just the renewal premium and name and address) and several small miscellaneous files. The six card files contained some $2\frac{1}{2}$ to 3 million cards in all.

We first put the data on the addressograph plate on to punched cards—this was carried out by twenty inexperienced clerks specially recruited for the purpose and supervised by two of our permanent staff; looking back on it, this operation appears to have been carried out reasonably satisfactorily. The only real criticism we can now make is that the work was started too soon; it would perhaps have been preferable to have waited until nearer the starting date of the new electronic system and done the job with a larger staff (thus reducing the number of amendments because of subsequent movements) but this was impossible for us because of limitations of floor space.

We checked the six card files for consistency in certain fields and then sorted them into order. We now regret that we did not spend more time at this stage in checking and purifying the card files. A point of interest to us was that one of the fields checked was the total renewal premium; this was not done for British policies because some files had the premium in decimals and others in shillings and pence, and this variation could not be covered by the modest number of program steps available in the small "plug-board" computer we were using at that time.

Our general approach to conversion was to make the greatest possible use of the 705 system itself, doing the minimum at the punched-card level, and as I have just said, we are now inclined to think that in purifying our card records we set that minimum at too low a level.

Our plan was to build up two conversion records on tape; one, a conversion master record containing relatively permanent items of information about each policy, and the other a conversion variable record. The master record required about 1,300 digits and the variable record about 600 digits.

In April 1958 we received the first part of the new system, namely two tape units and a card reader. We then took our data, which by that time was all on cards, sorted into policy number order, and put the data on to tape. In spite of the fact that the greatest possible care was taken to sort the cards into order correctly, we subsequently found, when we had the full 705 system available, that the cards had not always been in correct order. This point is worth expanding; we felt that better than usual precautions had been taken to be sure that the files were in sequence. They were passed through an IBM 101 statistical sorting machine just prior to conversion, this operation being only a matter of a few trays of cards ahead of the card-to-tape conversion, and yet we subsequently found some policies out of sequence on tape.

We decided therefore that we would subsequently sort on tape; this has certain advantages in that more complex sort-criteria can be developed on tape than are usually worth attempting on conventional equipment so that simpler programs can sometimes be adopted; also, by sorting on tape, the input can be in completely random sequence. On the other hand, computer sorting can be very time-consuming.

The first production run on the complete computer installation was to take the data from the separate files, which were now on tape, and produce a single tape record of some 1,300 digits for each policy; i.e. the conversion master record. The program we wrote for this included some 125 different types of cross checks and compatibility comparisons between the various sources of data. We found some 125,000 discrepancies. We eventually reduced these to approximately 500 and these cases were finally recoded and fed into the system as new business items. In all some 4,500 hours of overtime were worked sorting out these discrepancies. Great use was made of qualified clerks from other departments who worked extensive overtime.

We then wrote a program to produce the conversion variable record which was generated from such sources of input as outstanding premium records, loan records, etc. Because of the variable nature of this file we held its production off until the last possible minute in order to cut down the number of subsequent movements which would occur before the computer took over entirely. As it turned out we actually ran this program one month too soon.

The third conversion run was to amalgamate the conversion master and the conversion variable records and produce our master tape record ready for the commencement of the whole electronic data-processing system.

We had our share of problems. By the time the files were available for processing the November and December movements, we had an accumulation of five weeks' movements to process. We found cases where errors in programming had set up incorrect information. Fortunately most of these could be corrected by further programming, as the necessary criteria were present on the files. Some of our regular programs did not recognize certain conditions. We then went through a period of setbacks and frustrations until we decided that we were in a position to produce renewal notices on the new basis beginning on 1 February 1959, which was just one month later than our original target date. During the rest of 1959 we have been checking our renewal notices against our basic records, making all necessary corrections so that we believe that we shall start our second year of computer-produced renewals in February 1960 with very few omissions or errors.

Let no one ever underestimate the problems of bringing

together information and generating new records on magnetic tape for the first time. We believe that our records were as good, if not better, than most, but when we amalgamated our records we had, as I have already said, some 125,000 discrepancies. The majority of these are simple to put right, but one is left eventually with a hard core and it requires individuals with a profound knowledge of the system, plus programming experience, to put these right—such people are hard to come by.

The estimated man-years required to plan and program the ordinary consolidated function routines, including supervision, was about forty, of which five and a half were devoted to conversion work.

Reorganization of Office Routines

At the same time as we were converting our records into a form suitable for the computer, we were engaged in an activity which has not, I believe, received the emphasis it deserves. I refer to the reorganization of office routines necessary to make the best use of a computer. In our case we have had to make significant changes in practically all departments both in Head Office in Toronto, and in Chief Office in London. Corresponding changes have, of course, been required in all our branches.

This reorganization has been an exceedingly large and complicated project; in addition one must not overlook the planning, and printing, of numerous documents, forms and lists required for computer input and output. Finally, there is the question of training office staff in the new routines, with particular reference to the much higher standards of accuracy required when preparing computer input.

It is appropriate to consider, at this point, the question of parallel operations; i.e. running both the old and new systems independently and simultaneously so that one ends up with the same result and checks at that stage. This is usually the ideal final check before abandoning an old system and switching over entirely to a new one. In our case we had had to reorganize our office systems so completely that we found that full parallel operations were exceedingly difficult to arrange.

We had perforce to conduct random tests and comparisons—a great deal of this was done; we also calculated on the computer certain figures and totals at given points of time and compared these with comparable results produced on the old systems. A particular example was the year-end valuation which was carried out on the old systems as at 31 December 1958, and subsequently reworked on the computer and checked policy by policy.

Inception of New System

What is the right time to start the new system? There is no clear-cut answer. Some companies in America were as advanced as we were at one time, and yet they are still finding problems and are talking of not starting operations for another year or so. Obviously they will have to face fewer problems in actual operations than we have had to face, but then it is likely that many of those very problems will never be found until you do actually start operations in earnest. It is a nice decision. In retrospect we might perhaps have delayed our starting by a month or two, but the enthusiasm and morale of the computer staff was such that to delay starting might have caused more problems than it saved. In any case, when you once start delaying the start of operations you will forever be tempted to have additional short delays for further improvements, whether apparent or real.

The New System as applied in United Kingdom

This is, perhaps, the stage to explain a little about our United Kingdom organization. We have branches throughout Great Britain and Northern Ireland, with a Chief Office in London. All premiums are collected centrally at Chief Office where, broadly speaking, we do everything that would be done in the Head Office of a home company except for the actuarial valuation of our liabilities which, even in pre-computer days, was done for us in Canada.

Premium Renewal Notices

The first of the basic operations to be started in 1959 was the preparation of renewal notices on the computer in Toronto. These were, in fact, produced as for 1 February 1959, and the British ones were checked in Chief Office in London against our own records before dispatch. In the United Kingdom we have a lead-time of fifteen days, so that we have had to set up a simple routine to take care of such things as deaths or surrenders in the period immediately preceding a premium-due date. The renewal notices are three-part forms, and apart from the obvious items they show details of any policy loan balance, gross interest, tax, net interest and total amount due; in addition they show the bonus attaching to the policy, and also that just declared if this is appropriate.

The top copy is posted to the policyowner, the second copy is for the representative or agent, and the third copy, in the form of a receipt, is for Chief Office records. In addition to the renewal notice printed by the computer a card is also punched and sent to Chief Office. This is interpreted and gives the policy number, policyowner's name, and details of the premium due. Each day a report is compiled in Chief Office summarizing the transactions which are to be handled by the computer. As I said earlier, all premium payments are handled centrally in Chief Office and, therefore, on each daily report there is a total credit item representing premiums paid, and this figure is supported by that day's pack of punched cards, each one representing the payment of a premium. With each daily report goes another pack of cards, this time either for policies to be written off as lapses, or else to be handled by the particular policy's non-forfeiture routine (usually the automatic loan of the

outstanding premium or else the automatic conversion to a paid-up policy), and finally the punched cards for renewal premiums which had not been paid because of death claims and surrenders which had happened in the three weeks (roughly) before the renewal date.

So far as Chief Office is concerned the system is simple and effective; there were some difficulties to begin with, particularly in connection with renewals of policies for which premiums were paid by banker's order, but subsequently these difficulties were overcome and now the renewals are in good shape. It was intended that renewals should be produced on a daily run, but so far this run has been carried out twice or three times a week only; in other words, two or more days' renewals are processed in one run. In practice this has not been any disadvantage and, except for one or two occasions in the very early days, we have always had the renewal notices checked and ready for posting before the due date. A point worth noting is that the adoption of a fifteen-day lead-time means that our renewal notices are posted only a few days before the renewal date.

Certain Output Forms

For existing policies the computer produces quite voluminous output and for simplicity's sake I will refer to three forms only.

(i) A *Status Card*; this shows the exact financial position of a policy; it shows the cash surrender values at the last and next anniversaries, loans, bonus additions, etc. The computer stores the actuarial function N_x for seven different tables and can calculate about 98% of United Kingdom cash surrender values. This status card is produced whenever "anything happens to the policy" which could alter any of the information shown, with the exception that, if premiums are payable more frequently than once a year, a new status card is not produced following a premium payment other than on the policy anniversary date.

Each status card shows the date when prepared and the reason for a new one being produced. We keep the old ones in date order for each policy number, so it is simple and easy to see the "life history" of a policy.

When we in Chief Office carry out any transaction (e.g. pay the cash value of bonus or make a loan) we mark the current status card manually and this serves as a temporary warning until the new card reaches us from Head Office.

(ii) A *Policy Information Form* which gives brief details of the policy and is used largely as an authority for Chief Office to carry out a "scheduled operation" (which, of course, is detailed on the form), for example, to pay a cash dividend.

(iii) A *Particulars of Policy Form*: this is a print-out from memory of practically all the information held in memory for a particular policy at a given moment. This is supplied on request and it is also produced automatically for certain "scheduled operations" when the policy information form, just referred to, yields insufficient data. We use it in particular for maturities.

New Business Routines

Turning now to new business, the routine is that when a proposal is submitted by a branch to Chief Office for underwriting, an "Invoice" is prepared too. This invoice is a form prepared for direct card punching and the data shown thereon must be entered *strictly according to certain rules*. These invoices are checked in Chief Office and are sent to Head Office, where they are further scrutinized and then form the basis for new-business input for the computer. Needless to say, this invoice must be completed completely and absolutely accurately —the least deviation will result in rejection by the computer. We have had to train the clerical staff to adopt much higher standards of accuracy than is necessary for forms used for wholly manual processing. The computer checks and edits the new-business input both for the Association's regulations (minimum S.A., minimum premium, etc.) and also for premiums to be charged.

The new-business output which concerns Chief Office is basically:

(i) a *Policy Writing Document*: this prints out all the information necessary for the policy to be typed in London and is arranged in the desired sequence and format;

(ii) record and index cards for Chief Office and the branches;

(iii) an entry on the representative's commission statement for that month.

Contrary to North American practice all our new business is placed, i.e. the first premium is paid in full before we send the invoice to Head Office. The policy writing document is worth a few more words; we could easily prepare the policy from the proposal form, but we do not: we wait until the policy writing document reaches us from Head Office; this illustrates the basic tenet that right or wrong *all* records, without exception, stem from the computer's master record. This is a basic concept throughout all phases of our system. Policy writing documents now reach us in daily batches, and we believe that we issue our policies as quickly as most home companies.

Experience in 1959

It is only now at this late point that I can turn to what is strictly the subject of this paper, namely our experience in the past year. We got the system going on time (although renewal notices were on the pre-E.D.P.M. basis for the first month), we have kept going and we have made progress. We have indeed had troubles and some are only now, after one year, showing signs of evaporating. May I deal with some of the points in detail?

Programs

Writing programs (as opposed to merely coding machine instructions) and their perfection is a major problem. It requires a high degree of talent and with us, as, we believe, with the majority of computer installations, the number of effective man hours required to accomplish a major reorganization of routines such as ours has been *underestimated*. Systems of so-called automatic programming, such as the IBM 705's "autocoder," are a great help, but they are only means to an end.

Most of our data-processing programs are exceedingly complex, and in our key programs we are memory-bound.

When we started programming we divided up the major runs and assigned them to particular individuals, sometimes just to one person. This has resulted in our original programs being largely individual creative efforts and, because of their complexity, it is often quite impossible for anyone other than the original author to make changes. We recognized the position we were getting into initially, but with our lack of experience we were not always in a position to lay down uniform principles to be used by all programmers in order that there would be a consistent pattern throughout, so as to make it possible for a programmer unfamiliar with the details of a run to carry out amendments and changes. However, in the second half of 1959 we have been able to establish certain principles to be applied uniformly—largely, of course, at the block-diagramming stage—and we have been re-writing all our programs on these lines. This is largely a matter of deciding, for example, whether you have subroutines which can be brought into use in the main program as and when required, or whether you write out your subroutine each time you require it and build it in to your main program as you go along. In our early stages we had both extremes, and indeed many intermediate positions, but we have found through experience that it is usually worth the extra program steps to adopt the latter course and build each subroutine into each main program as required, so that the main program is largely self-contained.

To be quite frank, many of our earlier difficulties stemmed from alterations to subroutines without our fully appreciating all the effects that such alterations would have on the main program at other, perhaps distant, places.

Programmers

Programmers were drawn from our own staff almost entirely; they were divided into three groups, with suitable supervision. The first group was responsible for writing the programs for the conversion of former records to the new system. The second group was responsible for the preparation of programs which were of a data-processing nature, while the third group was responsible for programs associated primarily with calculation work, mainly, of course, of an actuarial nature. The three groups' work was integrated by a senior member of the staff to ensure that all three were moving similarly towards the common goal.

We have now come to believe that the optimum number of programmers to be directed by one senior official is about twenty. With a number such as that it is quite possible for the senior executive to know the strengths and weaknesses of the programmers in some detail. We hope we can keep to this number because, in such a situation, we find that we do not need to organize the programmers on too formal a basis. Generally we believe that it is preferable in many ways if the number of programmers is small, because it means that an individual can be used to the limit of his ability in those aspects of the work for which he is best suited. It also results in much more challenging and varied tasks for a particularly good individual. Although we have not quite attained this stage yet, we visualize some four or five units of programmers, suitably supervised, in which the combined functions of a certain amount of fact finding, systems-analysis work, and machine instruction writing will be done.

Records and Controls

Another thing which we have learned the hard way is the necessity of keeping information for several cycles of operations. We had thought in the early days that, by checking control totals from one run to the next, and balancing, we would then be able to destroy the former records. In theory this is satisfactory, but in practice accidents occur; for example, a batch of renewal notices being forwarded to a branch are lost in the post. If you have destroyed the relevant tape it can be very expensive to reproduce a relatively small amount of lost output.

Controls are, of course, of vital importance in an electronic data-processing system; they are required internally to ensure that data is processed completely, and they are required externally for audit purposes. We set up, initially, too many controls, and the number of these has been reduced after some months of operation, since certain ones proved to be of little practical use. Equally we have learnt from actual experience that the nature of many controls has had to be changed considerably, and certain items in which we had originally no intention of installing controls have now had controls built in. We fancy that it will be another six months before we will have satisfied ourselves that we have the optimum number of effective controls. It is worth noting, in passing, that we are installing a device on the console which will record every operation performed by the operator, so that those operations can be reviewed later for their effects on processing.

Equipment Operation and Performance

We have found in practice that far more time than we had bargained for was being taken up in setting-up operations on the machine. Only later, after considerable experience and improvement in programs was the amount of lost console-time reduced.

Originally the computer operators and the programmers were the same people, but when these functions were separated we found it advantageous for those in

responsible positions, connected with actual operations on the computer, to have had programming experience. Firstly it helps them to deal with machine stoppages, and secondly it enables them to co-operate more effectively with the programmers in trying later to account for any machine stoppage.

The equipment over the past eighteen months has met every statement of the manufacturer in performance and reliability; for all intents and purposes it has been 100% accurate, and we have had only three breakdowns when the machine was out for more than a few hours.

The latest details of operating times which I have are for October and November 1959—a period of 61 days or 1,464 hours. In that period the installation was used for 1,424 hours, and the balance of 40 hours was made up of 5 hours' idle time, 8 hours due to breakdowns, and 27 hours due to preventive maintenance. You will see, therefore, that the installation was switched on for virtually 24 hours a day, 7 days a week, for the 2 months for which I have figures. Expressed as percentages, the time available in October and November was used as follows:

Idle time	0·3%
Breakdowns	0·6%
Preventive maintenance	1·8%
Time available to the manufacturers	3·9%

The remaining 93·4% of the time was fully used by the Association, but, as I explained earlier, we are in the process of re-writing and improving many of our programs, and testing these took up 16·2% of the available time. In addition certain special runs took up an additional 7·8% of the time. It will be seen, therefore, that there is little enough spare time in the schedule, and that careful management will be necessary in order to make available machine time for several other aspects of our work which so far have not been put on to the computer.

It should be mentioned that the maintenance time of 27 hours was only on average about half an hour a day throughout October and November, and this was a calculated risk deliberately taken because we were engaged in those months on a great deal of our year-end work and preparation for this. Actually the time spent on maintenance was considerably more in October than November, and I understand that the figure for December is equally low, but for the future it is fully intended that at least one hour every day will be made available for regular maintenance work.

Communications

Working in this country with input and output of a computer in Canada has been really quite successful. The difficulties have been two-fold, and I will deal with the easiest one first. It is the question of the timing and transportation of material to and from Canada. We have adopted a 15-day lead-time (i.e. the computer prints out a renewal notice 15 days before the due date) and it is a nice problem to be decided whether a longer or shorter lead-time would be better. The longer the lead-time the greater the number of movements ignored and, therefore, the greater the amount of manual checking needed. On the other hand, a short lead-time increases the expected number of correct output documents, but equally it increases the chance that they will be late because of physical transportation delays. We have got quite adept at getting material quickly through the formalities at London Airport! For the time being we have not had reason to alter the original decision of a 15-day lead-time for the United Kingdom. I have already mentioned that one of the consequences of the 15-day lead-time is that renewal notices only reach our policyowners a day or so before the due date.

The second and more profound difficulty is that of semantics.

A programmer has first to analyse his problem or task, and then to amass factual information. For a successful program for processing material such as ours, of which the volume is such that virtually all theoretical possibilities are actually found in practice, the programmer has to ascertain in advance precisely what all these possibilities are. Now our practices in the United Kingdom have been influenced a great deal by the practices of home companies, and they differ substantially from those obtaining in North America. Here, clearly, was there an opportunity for programmers in Canada to fail to comprehend all aspects of British problems and, as personal contacts and inquiries had necessarily to be restricted, the programmers have had to rely very largely upon correspondence. Initially some sad mistakes were made, and these could have been avoided had greater care been taken in the very early stages in our explanations of United Kingdom practices. One particular difficulty could, I now believe, have been resolved at an earlier date had we in the United Kingdom, or our colleagues in Canada, realized that a particular phrase which we were both using bore substantially different meanings in the two countries.

My point is, of course, that communications between human beings which had hitherto been found sufficient for business purposes often prove woefully inadequate when dealing with an electronic data-processing system, for which they must be no less than perfect. An analogy is that of completing an input form for the computer. If, say, the code for July is the four letters "JULY" it is quite useless to write only the three letters "JUL" as the computer will reject this as wrong, whereas, had the form been processed manually by another clerk, he would have dealt with the variation without any appreciable effort. This is not to say, of course, that a computer cannot be programmed to deal with variations within predetermined tolerances—obviously it can, but the point I am trying to make is that it is often not realized until too late that the standard of communications required for a system of electronic data processing must be of a much higher level than many people have been content with so far.

Conclusion

As you will have gathered already, we have had numerous difficulties causing much annoyance and embarrassment—the fact is, however, that these difficulties, though real and big enough at the time, have been superficial—so much froth on the surface. The fundamental skeleton of the system has proved entirely satisfactory; the lesson to be learned here is undoubtedly that when once you have set up an electronic data-processing system and convinced yourself that it is basically sound, stick to it—you will need a lot of tenacity, but do not be put off by criticism. You will find that it is easy for those not connected with electronic computers to lose their sense of proportion; relatively small troubles get magnified. This is not to say, however, that you must not be ready to set up temporary systems to keep things going until the appropriate program can be patched—we have had to do this on several occasions, but that is now something of the past.

Much remains to be done by the way of improving our systems and programs, but even at this early stage in the use of these new techniques it is clear that there are definite possibilities for extending the scope of the new systems and improving our service to the public, coupled with ultimate reductions in cost to ourselves.

This brings me to my conclusion. I have deliberately omitted many points—I fear that I have already spoken for far too long—but the fact is that we *have* made this wholesale switch to electronic data-processing, and it does work.

Acknowledgement

I should like to explain that much of what I have said is not my own. A great deal has been based on the work of my colleagues in Canada, and although it may have appeared that I was speaking from personal experience that has not always been so. I wish to put on record my thanks for the unstinting help afforded me by all my colleagues.

Note on a Test for Repeating Cycles in a Pseudo-random Number Generator

When a computer is generating sampling numbers by a deterministic process for use in a Monte Carlo problem, it is desirable that the numbers should satisfy certain tests of randomness and, in particular, it is undesirable that the sequence should repeat itself during the problem.

Some processes for generating pseudo-random numbers inevitably return to the starting number, while others are capable of returning to an earlier member of the sequence, not necessarily the starting number. In either case a repetitive cycle occurs which may or may not contain enough different random numbers for the process to be useful in a particular problem. To detect the formation of such a repeating cycle, the following empirical test is proposed. For each new member of the sequence compare a certain number, n, of its digits with a fixed pattern of n digits; the probability of a random binary number matching the fixed pattern is 2^{-n}, and n can be chosen so that this probability is of such a size that matches in a random sequence will occur neither too frequently nor too rarely. When a match is found the number of members of the sequence, generated since the previous match, is printed.

If cycles do not occur, the printed numbers are expected to be about 2^n on the average. If a cycle occurs in which no member matches the selected pattern, printing will stop and it will become more and more certain that a cycle has been found as time goes on; if a cycle containing one matching member occurs, all the printed numbers will be equal from then on.

There is a difficulty if a cycle occurs which contains many matching members, and this is that the printed numbers will themselves form a repetition which must be recognized by the programmer. If n is small the trouble involved in doing this is very great since the printed repetition is so long; if n is large, however, it may happen that no printing has occurred by the time that the machine has produced the number of random numbers needed in the particular problem, and, therefore, the occurrence of an unwanted cycle is not disproved.

It is suggested as a compromise, that 100 numbers would not be too long a printed record in which to detect repetitions by inspection, and, therefore, if N random numbers are needed one should choose n accordingly.

$$\text{Setting } 2^{-n} = \frac{100}{N} \text{ gives } n = \log_2\left(\frac{N}{100}\right).$$

Alternative methods are available for matching, and appear to be equally good for the purpose; either the n selected digits, which need not be consecutive ones, are matched against an n-digit pattern, or the n selected digits of the random number are required to be all ones. This latter method is simpler in some machines.

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