Liverpool Victoria Friendly Society (LVFS)

Programming the first computer based actuarial valuation on the ICT1301

These notes are based upon my memory of events that took place nearly 50 years ago. I may have some of the detail slightly wrong and for that I apologise in advance.

I joined the Actuarial Department of LVFS in 1960. We were based in London's Southampton Row, close to Holborn Tube, in a large forbidding building that somehow never looked welcoming. The Actuarial Department was a small oasis of excellence tagged onto the end of a huge general correspondence department that was presided over by a manager dozing quietly in a large glass fronted box. Watching the girls go by was fun!

The extent of our mechanisation was Monro-Matic semi-automatic calculating machines. LVFS boasted a large Hollerith punch-card centre that existed on a lower floor and concentrated upon processing the renewal premiums and claims for the penny-policies, for which LVFS was famous.

The ordinary branch policies (endowments and pensions and so on) that were fewer in number but that had much larger premiums were processed using a manual card system.

In 1963 LVFS decided to take its first plunge into the brand new world of computing. Because of their very strong links with Hollerith an ICT1301 was the chosen beast. The project was headed by an actuary called Les Munns and his able deputy Mick Corrigan, who also had an actuarial background.

With their actuarial bias it was inevitable that the complex ordinary branch policies would be tackled first. This wasn't so daft. The penny-policies were declining in popularity as people became more affluent and the Hollerith system coped well. The volumes were also much lower and thus more manageable on a first leap in the dark.

They ordered a machine with 1,200 words of Immediate Access Memory (IAS), a magnetic drum, four tape decks and of course a card reader, a card punch and a line printer for delivery in 1964.

The entire staff was given the opportunity to sit an aptitude test to see if they could be trained as programmers. One member of staff that I'm aware of was unofficially told he had to apply – me. The test took place in the large exam hall that was used for actuarial exams and I had no problem qualifying. I had been doing cryptic crosswords like the Times, Telegraph and Guardian from the age of 12 and lapped up the logic puzzles and having to draw a flow chart of "making a cup of tea".

In addition to me a second member of the Actuarial Department, John Chase, was co-opted onto the team along with three other members of staff, Lillian, Sylvia and Bob. John Chase and I were quickly despatched to the ICT Training Centre at Bradenham Manor, on the A40 west of High Wycombe, for four weeks of hard graft.

Suddenly a whole new world opened up. A world of calculating registers, numbers that were instructions to the machine (66+location=add 1; 67+location=subtract 1; and so on); indicators to test for >0, =0, <0, on or off; loops (repeating instructions) with counters to eventually stop the loop; block numbers to separate out chunks of program code; relative addressing to manage the allocation of available IAS space; how to count in hexadecimal; and so on.

We learned how to read cards, punch cards, print lines, write data to the drum or to tape and how to retrieve it. We learned the space limitations of the machine (1,200 words of IAS was 14,400 numeric characters or 7,200 alpha characters where both a zone and a numeric are required to define the character (2,1=A; 2,2=B and so on). Managing that resource was to be a key element in writing the actuarial valuation suite.

On our return to LVFS we learned that the delivery schedule for the machine was in place. A large square footage had to have an artificial floor built and air conditioning installed. Until it arrived our programs would be tested overnight at ICL Putney. This put a great emphasis upon accuracy because if a program was sent to Putney and never even managed to load into the computer then 24 hours had effectively been lost and we were on a tight schedule.

Whilst a good deal was said to Head Office staff about how the computer would account for renewals and look after policy records the driving thrust of the enterprise was the production of the actuarial valuation. I was tasked with creating three interlocking blocks of software.

The first would create the master file of policy records working from punch cards that had been created from the manual card records. The second would perform the valuation itself. The third, working once the valuation results were known, would do the bonus distribution runs that would culminate in bonus notices being printed and sent out to appropriate policy holders.

To create the master file we punched cards direct from the manual cardboard records. Under the advice of Shirley, who ran the punch room, manual records were put into batches of 100 policies (one policy to each manual record). Then a punch operator punched all of the type 1 cards for the bunch; then another operator produced all the type 2 cards; and so on (six card types I recall – not all of them present for every policy). This produced a batch of some 500 cards.

Every card contained the batch number and the policy number and was verified before being computer processed. This approach was taken as Shirley believed it would be quicker and would produce more accurate results than one punch operator trying to punch all six card types for any particular policy record.

The first program read the cards, did some editing of fields and wrote out tape records, one record per card to keep things easy. No validity checking was conducted at this stage. We then sorted the tape records into policy number-card type order.

The second program read the sorted tape records and constructed the new master file records (one record per policy).

The master file records were of variable length. The first ten words were of fixed format and contained fixed information that was common to virtually every record (policy number obviously, type of contract such as endowment or pension, premium, frequency of payment, name of policyholder and so on).

The last of the ten fixed format words was a key that indicated the content of the variable portion of the record. The first two positions gave the overall record length. Each of the remaining ten locations in the word was assigned to a type of variable record – the first as I recall was “correspondence address”. The location either contained a zero – which indicated there was no variable record corresponding to that location (so a policy without a loan on it had zero in the space in the key designated “loans”) – or a number that indicated the number of consecutive words of data devoted to that part of the record.

This approach meant that address information for example could be stored without the masses of blank spaces that would have been created by having fixed length format for say every one of a potential six line address. Likewise assignment records were only present on assigned policies. This complicated the program writing but dramatically cut down on the number of reels of tape required to hold the whole master file and thus speeded up master file processing.

Validity checking was conducted at this stage. We checked for the presence of mandatory fields, for correct values in such things as premium frequency, and for reasonable values in size of premium, size of sum assured, payment term, and so on. Any outright failure resulted in a line of print giving batch number and policy number followed by an English language explanation of the problem. We did not retain any of the data for a rejected policy, meaning it had to be corrected and completely resubmitted in a subsequent batch. This simple approach was very easy to manage and in the event the rejection rate was very low – a tribute to the clerical records and to Shirley and her punch girls.

The records that passed the testing phase were then written to tape and that tape was sorted by policy number.

The sorted tape was then run against a program that read the brought forward master file and merged its records in with the newly created records to produce a carried forward master file. Records were blocked up before being written to tape, a variable number of records per block of course because the records were of variable length. The maximum tape block size was 200 words and on average we had 8 policies per block. Using these techniques the eventual master file was around 12 reels long. Without such techniques we calculated it could have been twice that size.

It was left to my colleagues to write the suite of programs required to maintain the master file with my contribution limited to a few utilities. For example, I wrote the code that provided them with the IAS address at which they would find various pieces of a master file record. This could then be added to a “45 + variable IAS address, move n words to known IAS location” instruction to move the data to a predetermined location for the policy work to be carried out. Then a reverse of that would put the new data back to overwrite the old. Special additional code catered for a situation in which a main policy record would be either expanded or contracted by the update, when the record length and variable length key field had to be updated and other variable data moved to allow for the expansion or contraction.

My attention now turned to the actual valuation programs.

What is an actuarial valuation? It is an attempt to compare the value of the liabilities (that is to say the policies themselves) at the year end with the value of the assets (investments) at the same date. If the value of the assets exceeds the liabilities then the fund has a surplus, some of which can be distributed to with profit policy holders by way of bonus.

The value of the assets is relatively easy. Shares and gilts for example are quoted on the stock exchange and this side of the work is completed by the Investment Department.

It is the policies that are difficult and their analysis is where the computer really came into its own. Consider an endowment having a premium of £1200 per year payable for 10 years starting today with a sum assured on death of £9000. The first premium is worth £1,200. The second premium is payable a year from now so its value today V1 x (1 + r) = £1200 where r is the rate of interest the company can currently earn. At 4% V1=£1154; at 5% V1=£1143; whilst at 6% V1=£1132. Thus the higher the rate of interest the smaller the current value of future premiums. The formula is extended on so that the third premium of £1,200 due in two years’ time is today worth V2 x (1 + r) x (1 +r) = £1200 and so on for all ten premiums.

However, there is a chance that the policyholder will die, which we will call m(age). This will vary with age (and gender) so that at age 30 the value of m(30) will be very small whilst at age 60 m(60) will be a little bigger. So we have to change our formula to allow for that and the current value of that second premium of £1,200 payable in one years’ time becomes V1 x (1 – m(30)) x (1 + r) where m(30) is the chance that a policyholder aged 30 will die within one year. This concept is applied to all future premiums.

Finally we have to allow for the eventual payment of the sum assured, most likely at the end of the ten year term but potentially at any time during the currency of the policy. Using the values of m(age) already established the current value of sums assured to be paid in the first year is £9000 x m30 x (1 + r) – assuming for these illustrative purposes that all deaths occur on the first policy anniversary. Again this concept can be applied to the second year and so on to the tenth year when all those who have survived will also receive their sum assured. Again, for simplicity I have ignored the impact of interim and revisionary bonus on these computations as well as the impact of marketing, selling, underwriting and on-going office expenses.

A pension contract is treated in much the same way before the pensioner reaches retirement age, although the rate of interest assumed will be different to allow for the different tax treatments of life as distinct from pension funds. A pension in payment is the mirror image of that with a lump sum paid on commencement of the contract followed by regular payments paid to the pensioner until they die (single life), they and their spouse die (joint life contracts) or the guarantee period ends (death in the early years of a guaranteed annuity).

Prior to the computer the historic approach to the valuation was to only value the full fund once every five years because of the enormity of the task involved. A task force of several people would first gather data, analysing basic information like premium and term into groups (new ten year endowments owned by males aged between 30 and 34 for example). Then various formulae would be applied to each group to attempt to smooth out any wrinkles caused by grouping and to eventually derive the present value of these contracts – the object of the exercise. The whole thing would take 8 to 10 months.

The first step that I proposed was to value each policy in its own right. This might seem obvious now but it was radical thinking back then. The actuaries gathered, smoked several pipes, drunk the occasional dram and eventually decided that we would go for it. The major stumbling block was that whole rafts of actuarial formulae would need to be adapted to embrace this change.

The second step I proposed was to derive all formulae from first principles using just the interest rates and the mortality rates. Thus all the actuaries had to decide upon was the formulae they wished to apply. The computer would then build up those formulae for them. This approach had the enormous additional benefit that the entire valuation could be run and rerun over and over using different rates of interest – something that was simply impossible by manual means.

And so the stage was set. The first program in the suit read in and stored the rates of interest to use and the mortality factors m(age). Mortality is a fascinating subject because different subsets of the population have hugely different mortality rates.

Everybody realises the rates are different for men and women but it goes much further than that. A crude measure of all women in the population for example will include the congenitally impaired; those damaged by subsequent illness; smokers; scaffold erecters; and so on. Because some of these women are uninsurable their inclusion in our mortality rates would overstate our mortality risk so we have to use a more refined measure. The Institute of Actuaries has a continuous mortality investigation that provides mortality factors for insurable lives and it is those that the Actuary uses.

I wrote the factors out to tape and printed them out along with the rates of interest and these were passed to the Actuary to check, verify and authorise. Once that was done the tape was read back in and a complex program calculated a whole host of actuarial factors from first principles.

From a program writing point of view, the first lesson learned was to use the 56 function (shift data to the right generating sign) rather than the 57 function (shift data to the right generating zero). The former kept a negative number negative. The second turned a negative number into a massive positive number! The second was the creation of a subroutine that would divide one number by another correct to a given number of decimal points (the 1301 had no “divide” function). The number of decimal points was important because large numbers were involved so that even the fifth place of decimals could make a difference to the final outcome.

Apart from that it was a question of setting up arrays of zeros and filling the slots one by one as ages and terms and so on varied keeping track of it all by program count. Once an array was complete I printed it out and wrote the array to tape. This continued until all the factors had been calculated, printed and stored.

The print outs were passed back to the Actuary and exhaustive checking took place to ensure that the values had been computed correctly. This was an iterative process as calculations were tweaked, program adjustments made, and the routines retested. Eventually the whole thing passed muster and we were ready to go.

Three weeks after year end, in the third week of January 1965, we took the newly updated master file and made a copy for the archives. We then ran that copy against the next program in the valuation suite whose job was to create policy valuation records. Each policy record had all extraneous data such as name, address, and assignments removed to leave only key valuation data: gender, date of birth, start date, term, sum assured, premium, frequency of payment, and so on. These valuation records were written to a separate tape.

Most important was the alpha-numeric field table number. This defined the type of contract (whole of life with profits for example). These values were a bit random so we carried forward the actual field for subsequent printing purposes but converted the table number into a purely numeric reference that was used for program control purposes. That reference formed the first three characters of a sort key that headed up each valuation record. Next was gender and then term so that after the tape sort all the women with twenty year endowment policies for example were grouped together.

The next program brought the data and the actuarial factors together.

An overall control program read the first record rom the data tape and the numeric reference for table number was obtained. That was used to access a table of drum addresses. The drum address was used to find and load a “bootstrap” program and control was passed over to it.

The “bootstrap” program loaded the appropriate factors from the factor tape and calculation programs from the drum, wrote zero to all the necessary fields and then ran the calculation programs for this table-male. That continued until the gender changed whereupon the results for that table-male were punched out onto a set of punch cards. The “bootstrap” program then reset all the counts and values to zero, loaded the new factors and calculation programs for this table-female and started again.

When a valuation record for a new table was read the results for previous table-female were punched onto a set of punch cards and control was passed from “bootstrap” to overall control program. The new numeric reference for table number was used to find a new “bootstrap” address on the drum and load the program into IAS. Control was now passed to the new “bootstrap” program and the whole process was repeated to the end of the tape.

This approach both managed the scarce machine resources and enabled new table numbers to be accommodated with relative ease.

All that remained now was to read in the punch cards and use the data in them to print out the valuation schedules. This approach meant that the schedule for a single table number could be printed on its own simply by managing the punch cards.

The whole job was finished before the end of January – many months sooner than was remotely possible by manual means. Every policy had been valued in its own right and not as part of some statistical grouping. After Les Munns had reviewed the results I was asked to accompany him to the holy of holies – the Office of the Chief Actuary.

I was newly married at the time and living in a small terraced house. The floor space of this office was significantly larger than my living room and the wall to wall carpet far superior to anything I owned. In the far corner of the room, at an enormous desk set upon a raised dais, there sat a man wearing spats, a winged collar and pince-nez glasses. He beckoned us forward and I placed the small pack of banjo paper on his desk.

For half an hour he studied the results intently, comparing them with the previous valuation, asking actuarial questions that Les fielded. He asked if it was true that I could run the whole thing again at a different rate of interest, and I confirmed that was so. At the end of all that he folded the banjo paper back into a pile and passed it back across his field of a table to me.

“Young man” he said. “I can’t begin to imagine how you have worked this miracle. I don’t really know what it means for the future design of the insurance policy or the work of the actuary. However, I do know that since the days of the founding fathers actuarial valuations have been presented to The Board written in Indian ink on vellum. Please go and transcribe all the schedules accordingly and let me have them so that I can pass them to the Directors”.

It took longer to do that than to run the valuation and I was absolutely appalled.

Once the valuation results had been accepted and a bonus rate declared I ran the bonus allocation programs and printed the bonus notices. A very simple affair compared with what had gone before. I then resigned shortly afterwards in disgust. Life was so black and white in those days!

Jim Biggin

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