Computerisation of the Icelandic State and Municipalities: 1964 to 1985

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Abstract. The paper relates how some key IT applications were developed in Iceland following the introduction of the first computers in 1964. The key applications treated are the National Register of Persons, real estate assessment, financial systems, centralised processing of bank checks, fish stock abundance computations, IT in fish processing plants, the control of hydroelectric power stations, and the challenge of adopting the Icelandic alphabet to the use of computers.

Introduction

The history of electronic data processing in Iceland began in 1949 when Hagstofa Íslands (Statistical Bureau of Iceland) obtained the first numerical Unit Record (punched card) equipment to facilitate the processing of import and export transactions. The National Register of Persons was established in 1952. It was based on the 1950 census and a special nationwide census taken in 1952.

Skýrr (Skýrsluvélar ríkisins og Reykjavíkurborgar - The Icelandic State and Municipal Data Center) was established 1952 by an initiative from Hagstofa Íslands, Rafmagnsveita Reykjavíkur (Reykjavík Electric Power Utility), and the Practitioner General of Iceland. The existing data processing equipment was enhanced to handle alphabetic data and then used to mechanise the National Register of Persons amongst other applications. IBM Unit Record equipment was used for the first twelve years (Kjartansson 2002.)

The first electronic computers came to Iceland in 1964 as Skýrr obtained an IBM 1401 computer and the University of Iceland an IBM 1620 computer. In the 1960s the unofficial policy of the government was that all administrative computation should be centralized at Skýrr and that the scientific, engineering, and educational computing should take place at the newly established Computing Centre of University of Iceland. In the early days computers were quite costly and difficult to operate and maintain. Furthermore only few persons had the know-how to develop and maintain computer applications. The advent of "inexpensive" minicomputers in the 1970s changed all this. The monopoly was broken and many larger concerns obtained their own computers such as DEC PDP-8, PDP-11, and IBM System/3. IT system development became common knowledge. In 1980 the University of Iceland acquired a VAX 11/750 system and the usage of interactive system development was realized there. Aside form the equipment already mentioned electronic office equipment or computers from Olivetti, Kienzle, Burroughs, Wang, and others was imported and fierce competition existed amongst the importers.

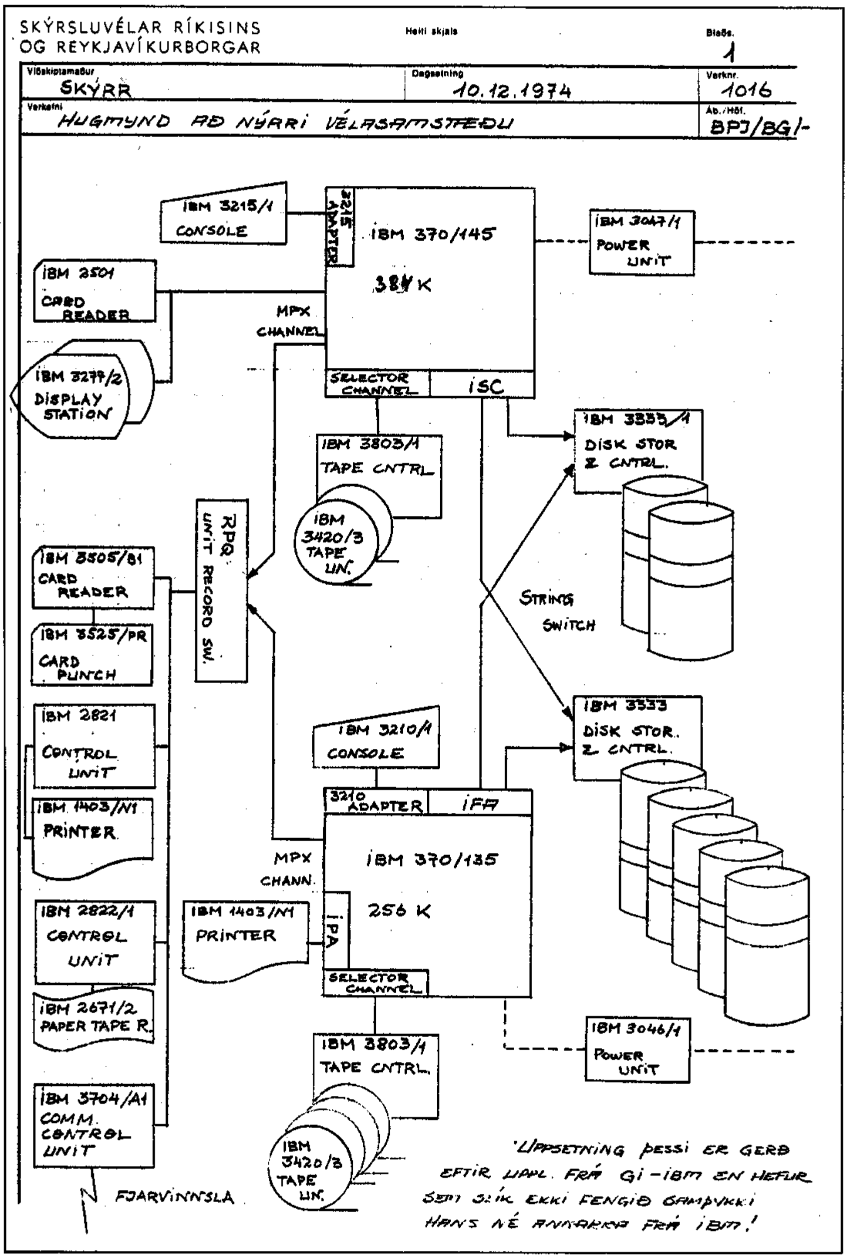
[1] Retired

Skýrr

Skýrr was established 1952 in cooperative effort between the Icelandic State and the City of Reykjavík The main purpose was to share the costs of operating a data centre with IBM Unit Record equipment for administrative data processing applications. Unit Record equipment was employed for the first twelve years. Skýrr obtained an IBM 1401 computer in 1964. It had 4K core memory (see appendix) and punched cards were used as data media. This system was as such a direct extension of the Unit Record equipment but with the advent in 1968 of an IBM 360/30 with tape and disk stations Skýrr started to convert from the punched cards to the magnetic tapes and disks as storage and processing media.

The number of applications housed at Skýrr grew rapidly in the first years. Some of the applications were based directly on the National Register of Persons such as the voting registers, taxation applications as well as invoicing for the various utilities i.e. electricity, telephone, thermal water, and state radio. Vehicle registration register was established and real estate register together with real estate assessment. Salary systems were established etc. To meet the processing needs the computer configuration at Skýrr was updated progressively. See figure 1 as an example of a proposed computer configuration at Skýrr in 1974.

Figure 1. A diagram of proposed computer configuration of Skyrr in 1974



By 1985 Skýrr was using two IBM 4382-2 mainframes. The number of employees at Skýrr was 5 in 1955. It had reached 18 in 1965, 64 in 1975, and 122 in 1985. These figures exemplify the escalating increase in computer usage in the early years.

The software development tools used at Skýrr followed the generations of computers employed. During the IBM 1401 usage (1964-68) programs were written in the 1401 Symbolic Programming System (SPS). With the advent of the IBM 360/30 system the programming languages Assembler, RPG and PL/I came into use and greatly facilitated the software development. In 1982 the Adabas data base system was taken into use together with the fourth generation language Natural.

First attempts at teleprocessing

The first steps towards teleprocessing at Skýrr were taken in 1973. Then the University of Iceland gained access to Skýrr's IBM 370/135, running the APL programming system over remote terminals. The university APL application was not successful and was abandoned after 3 years. The main reason for the failure was limited processing capacity in the 370 computer, which had 96K of memory. A year later the Reykjavík City Hospital installed a terminal for RJE (Remote Job Entry) connected to the IBM computer at Skýrr to facilitate data processing for the clinical laboratory at the hospital. The requests for laboratory tests and the test results were punched in cards and processed over night when workload was low at Skýrr. The next morning various working lists and printed reports were ready at the RJE terminal. Subsequently the ever increasing need for teleprocessing was to have a profound effect on the telephone infrastructure i.e. both the connections and equipment inside Iceland as well as the equipment connecting Iceland to other countries.

Computers in the Icelandic Administration

Some of the key computer applications for the Icelandic state in the early days centered on the National Register of Persons, taxation, accounting, budget planning, and real estate assessment.

The National Register of Persons

The National Register was established by law in 1956 for persons and in 1969 for firms. The register evolved from the original punched card system to a computerised system in the 1960s and by 1985 it had become an on-line system reflecting the status of the population on a daily basis. The first application for the register was to preprint tax returns in the year 1954. The original usage of the register was for population tracking, for use as a voting register, for official administration, for medical research, and for population statistics (Þórhallsson and Zóphaníasson 1985 and Kjartansson 2002). The Personal Identification Number used was composed of the birth date of a person concerned as nine digits DDMMYYNNH (day, month, year sequential number within the date, and year hundred i.e. 8 and 9.) With the advent of the computers a check digit was added making the PIN a ten-digit number. This number permeates all data processing in Iceland concerning persons and firms. It is used as identification in official administration, schools, hospitals, pharmacies, banks, on drivers licens, Visa cards etc.

Computers and the Tax Authorities

The first task performed by Skýrr for the tax authorities in Reykjavík was printing names and addresses on tax declaration forms in 1954, using the punch card based National Register of Persons as a basis. Later that year taxes were calculated and related documentation prepared for the tax collectors. Within few years, all other tax districts had been computerised in this manner. After its establishment in 1962, the Directorate of Taxes assumed responsibility for the development of computerised tax systems.

When the first electronic computers arrived in 1964, the processing methods of the Unit Record era were transferred to the computer with minimal change; the punched card was called Unit Record. This immediately increased speed, but did little for the part of the process that required deskwork. On the other hand, one of the first really labor-saving features in the tax processing system came in 1978 when it became possible to automatically compare employees' tax declarations with employers' statements of paid salaries. As the data entry devices of those days, i.e. card punches and later diskette recorders, were quite expensive, it was not considered economical to install such devices in the small tax offices in the countryside. The result was that most of the data entry was performed in Reykjavík. In 1982, when the tax offices around the county were equipped with inexpensive personal computers

(Tandy TRS80 with simple file transfer programs) programmed for data entry and so the workload was distributed out to the local offices.

The Government Accounting and Planning System

The expenditure accounting system

The Treasury started using computers in 1978. That year a simple batch based expenditure accounting system programmed in RPG and run on the Skýrr computer was put to use. Output was in the form of printed lists with no possibility for on-screen viewing of data. This was primarily historic accounting with very limited management information. In 1983 it was decided to take up on-line processing. For that purpose a complex system for financial accounting, (MSA, Management Science of America) was purchased. It turned out that the accounting key of MSA and it's arrangement and in fact various other features did not fit Icelandic requirements, and it proved cumbersome if not impossible to adapt.

In 1985 the use of the MSA system was discontinued. Instead it was decided to develop a new system from scratch. This new system, called BÁR (Bókhalds- og Áætlanakerfi Rríkisins), went into service in 1986 and was considered a success by its users right from the beginning. In the design, heavy emphasis was put on error checking and reconciliation of transactions. There were provisions for on-screen management information, both ad hoc summary screens from almost every conceivable view, and comparison against budget, which is crucial in the Administration as the State budget dictates what can be spent. This system had built-in teleprocessing possibilities. The BÁR accounting system has undergone considerable changes and has had new features added through the years. It is to be replaced with a new and modern financial system, the Oracle e-business suite, during 2003.

The Revenue Accounting System

On-line data processing had a slow and cautious start in the central administration. A revenue accounting system was designed at Skýrr and became operative in 1979. This was the first on-line system used in the administration. This event also marked the advent of SNA (Systems Network Architecture, the communications protocol invented by IBM in the early seventies) in Iceland. Initially, remote terminals were installed at the Reykjavik Tax Collector's Office (Gjaldheimtan í Reykjavík). At this time, the tax collector's offices in Reykjavík and 5 other townships were owned and operated by the municipalites, collecting for both local and central authorities. Elsewhere, these operations were separate. In 1981 four additional tax districts, Akureyri, Kópavogur, Hafnarfjörður and Keflavík were connected to the on-line system. The remaining tax districts were brought on-line during the subsequent years.

Real estate assessment

In 1966 work was initiated to computerise the real estate assessment process. The availability of computers clearly showed the benefit of automating registration, maintenance and printing of the description and assessment values. At the same time the opportunity was seized to automate the assessment process of residential buildings. A model was constructed that took in dozens of parameters from an assessment record describing the structure and state of the building and computed an estimated building cost. This value was then depreciated according to building age and adjusted to the estimated market value. The model was developed in FORTRAN II for IBM 1620 and run initially at the University of Iceland Computing Centre in 1970. Unique property reference number (block number) was also developed initially for City of Reykjavík and surroundings by the city planners and the numbers attached to the land and buildings from the first planning stages. A revised model was developed in 1976. It was based on a set of unit prizes collected by the Central Statistical Bureau on a continuous basis in order to compute the "building cost index" and a model built at the Building Research Institute for combining the unit prizes into cost of building units. The new assessment model was implemented in Fortran IV for a Data General minicomputer. Samples of real estate sales and later registration of all sales are registered on ongoing basis and used to compute the relationship between depreciated building costs and market values. These models have served as the basis for the levy of property tax and for planning purposes as well as a registry for real estate properties and their ownership.

Municipalities in Iceland

In 1970 the municipalities in Iceland (except Reykjavík) were using Burroughs General Ledger machines to account for the local income tax. Each taxpayer had his or her own ledger card where the payments were recorded. The Skýrr center (see above) calculated the individual tax assessment and the property rates as computed from the computerised real estate assessment (see above).
The municipalities started to cooperate in the early 70's to find a common solution to their need for improved data processing. The minicomputers had appeared on the scene, making it feasible to manage the tax collection locally. The solution adopted was based on a standard software from IBM, called the "Taxpayer's Account" system (gjaldendabókhald), running on an IBM system S/3. The state taxes and property rates were computes centrally by Skýrr with local taxes and adjustments performed in the Taxpayer´s Account system. The Taxpayer's Account systems were in use well into the 1980s the and were then all centralised at Skýrr.

Reiknistofa bankanna

The larger banks in Iceland started to use punched cards systems for data processing in the 50's and some had acquired computers by the late 60´s. The growing use of cheques was rapidly becoming an unsolvable task for the banks using traditional methods.
In the year 1970 the public banks in Iceland embarked on cooperation project to find a common solution to their core data processing needs and in particular to the mounting problem of clearing cheques. Subsequently Reiknistofa bankanna (Icelandic Banks Data Centre) was established and the common processing started in 1975 after extended period of training and preparation. The first application involved processing of cheques using Optical Character Reading of numbers imprinted at the bottom edge of the cheques. By 1976 a bank customer could make cheque transaction in any bank office and the transaction would be recorded into the relevant account with electronic document interchange and with the account balance entered into the account of each Bank at the Central Bank of Iceland. Thus, every evening, RB returned the same results as obtained earlier with the "spot checks" of the Central Bank. The spot checks had been carried out 3-5 times a year at considerable cost and effort. The level of automation achieved by this was unprecedented worldwide as best known. The volume of entries in the cheque system during the first complete operating year was 13.6 million transactions.
By 1981, the electronic booking of transactions and electronic transfer of funds was in effect for all of Iceland. Bank customers could then cash a cheque from any bank at any bank branch in the country and the clearing was instant. This put an end to the fraudulent practice of covering one bad cheque by the issue of another. The first expedition system was taken on-line in 1982, when the cheque system and the main general ledger system developed by the Industrial Bank were incorporated and integrated with other applications at RB. The following year saw negotiations with computer companies for the purchase of on-line front-desk equipment, and the Icelandic Savings Banks' Association became a full partner. Most of the electronic records of RB became accessible for on-line queries in 1984. The first on-line teller system was taken into use in 1985 in the Landsbanki-Breidholt branch and by 1987 paper-free payment exchanges were affected in the Reykjavík metropolitan area.
In the year 1985 the total number of transactions in the common applications of Reiknistofa bankanna was 52.4 million records. The same year the number of employees reached 81. The computer system used was an IBM-4381 mainframe, IBM-DOS operating system, using PL/I as the main programming language. Two years later the IBM-MVS operating system replaced the DOS requiring major updating of all systems and applications. In 1987 centralOCR reading of cheques ceased at RB as all the required data was entered at the on-line teller terminals.

Scientific computing and software development methods

The scientific and engineering community in Iceland started to use the first computer that the University of Iceland obtained in 1964 as soon as it was installed. A few had learned to use computers abroad at universities. A steady stream of courses in FORTRAN II was offered locally. In a year or two a number of applications had been written or acquired from the IBM Program Library or other sources. From the start research was conducted on software development methodologies (Benediktsson 1967, 1974, 1977.) Meteorologists, astronomers, geophysicists, fish- and livestock researchers, medical researchers, statisticians, and many more brought in their programs and data to be run at the University Computer Centre and sought expert advice. On the engineering side the use of the computer proved particularly advantageous for surveyors and naval architects with their needs for massive computations. A number of operation research models were built and simulated such as to optimise the control for water reservoirs for hydroelectric power stations and to find the optimum size of a trawler in Icelandic waters. For further information see Magnusson 2003.

Computing the herring stock

The Marine Research Institute started using the punch card system in the late 1950s. The very first fisheries research data that were transferred to this system were on herring tagging.

The most important herring fishery at Iceland traditionally took place during the summer off the north coast and was based on the so called "Norðurlandssíld" i.e. the herring of the north coast of Iceland. When repeated attempts to locate this herring outside the summer season failed Árni Friðriksson (1935,1944) suggested that this herring migrated to Norway each autumn to spawn there in the early spring. According to this theory it followed that the well-known winter and spring herring fishery off the west coast of Norway was based on the same herring stock as the summer fishery of Iceland. In order to test these revolutionary ideas Icelandic and Norwegian scientists started mass tagging of herring in 1948. By the late 1950s about 100.000 herring had been tagged at Iceland and about double that number at Norway. The processing of these data were greatly facilitated by the new Automatic Data processing (ADP) methods. Friðriksson´s ideas on trans-oceanic migrations between Norway and Iceland were quickly verified but in addition it was decided to use the tag-returns to assess the abundance of this internationally important herring stock. The results were presented at an ICES Herring Symposium in 1961 and formally published two years later (Dragersund and Jakobsson 1963). Thus primarily due to tagging and the new ADP methods it proved possible to elucidate the decline of the stock from the high level of twelve million tons during the early 1950s to five million tons in 1959. These results were received with severe skepticism at the time but later assessments have verified how accurate these first abundance estimates were. See below table.

Table 1. Abundance estimates of adult Norwegian Spring spawning herring in millions of tons for the years 1953-1959 based on the results from tagging experiments at Iceland and ICES "best estimates" based on the Virtual Population Analysis (VPA) method.

Year	Tagging Results 1961	VPA 1999
1953	12.5	12.0
1954	12.2	9.7
1955	13.9	14.7
1956	12.0	13.5
1957	9.3	10.9
1958	6.6	9.8
1959	5.0	7.6

As mentioned above, the first computers came to Iceland in 1964 when Skýrr obtained an IBM 1401 computer and the University of Iceland an IBM 1620. Prior to this the landings of the major species of fish had been sampled for several decades with regard to various biological and biometric parameters. When the appropriate programs had been designed the new computers were used to tabulate these accumulated data and combining them to corresponding catches of the fishing fleet the annual catch in numbers of each year class was calculated.

A new method the so-called Virtual Population Analysis (VPA) for assessing fish stock abundance was introduced during the late 1960s. The basic data required for VPA were already available due to the employment of the IBM 1620 and 1401 computers and the new method could be applied e.g. for the cod and herring stock size estimation at Iceland already at the beginning of the 1970s. Subsequently in the years up to 1980 programs were developed to routinely estimate the abundance of fish stocks interactively on PDP-11 computers, eventually running Unix variants. In 1984-85 the Icelandic marine scientists obtained access to mail and news feeds when the Marine Research Institute first established a dial-up link to Sweden and subsequently became the first Iceland backbone-link to the predecessor of the Internet. This quickly developed into an invaluable link to several key colleagues and sister institutes worldwide.

Fish processing plants

The Icelandic economy is mainly based on fishing and fish processing industry. Around the year 1970 fish processing plants started paying bonus to employees for efficiency in production and utilization of raw material.

In the early 70's the company Rekstrartækni s/f computerised the bonus calculation for the larger fish processing plants in Iceland. In 1972 Rekstrartækni purchased an IBM System/3 system and IBM Iceland helped them to write RPG programs for a salary system. They started servicing the processing plant Ísbjörninn (with around 100 employees), and were so successful that soon they had 16 plants to serve. Monthly meetings were arranged with the plant managers to coordinate this new technique. The managers took care not to disclose any critical information about their plants to the competitors and the Rekstrarækni staff had to sign a non-disclosure agreement. Based on the operative data obtained in the plants the utilisation of the raw material was computed and measures taken to improve it. As a result the utilisation of the raw material for cod, for example, increased from 36% to 42% in the period 1974 to 1980 resulting in 18% increase in packed products.

In 1981 Rekstrartækni had four large IBM System/34 computers, when they purchased one IBM System/38 to take over all their data processing. By then they were by far the largest mid-range computer installation in Iceland. Subsequently the fish processing plants began purchasing their own midrange computers and started running their own salary and accounting systems.

Landsvirkjun

One of the earliest minicomputer based real time control applications in Iceland was installed in late 1974 in Landsvirkjun (The National Power Co.). This "Supervisory Control and Data Acquisition (SCADA) System" was manufactured by Leeds & Northrup Co and was installed to control and monitor hydroelectric power stations and substations in the Landsvirkjun power system, which at the time covered the South-Western part of Iceland. The system, labeled the Conitel 2050, consisted of a computer based master station and several hardwired remote stations. The master station was based on a dual configuration of a Lockheed MAC-16 minicomputer. A similar system was installed at Reykjavik Municipal Electric Works (Now Reykjavik Energy). Both these systems were in operation well into the eighties.

Computers and the Icelandic alphabet

Áá Ææ Ðð
Éé Íí Óó Öö
Úú Ýý Þþ

The basic character set for the early data processing consisted of the 26 characters in the English alphabet together with the 10 decimal numerals. The Icelandic language has 10 letters that do not occur in English, which means 20 when both upper and lower case are considered. This, together with the tiny market, has cost the Icelanders much worries, workload and ingenuity to make printed alphanumeric data look reasonable on printed output and display devices. Throughout the Unit Record period (1952 – 1964) the repertoire was limited to 37 or 38 characters, which meant that compromises had to be made. Out of the 10 additional Icelandic letters, four were considered essential for printing understandable names, namely Ð, Þ, Æ and Ö. The remaining 6 are vowels written with acute accent. In the tight situation it was decided to accept the plain unaccented vowels as substitutes as it would normally not cause misunderstanding. It is clear that not everybody was happy, though, to have their names "mutilated" in official documents. By dropping Q, which is not used in the Icelandic alphabet, and using the same glyph for 1 (one) and I as well as the same modified glyph for 2 and Z, this was possible.

The IBM 1401 computer was capable of handling 48 characters, and so was the first generation of the IBM 1403 printers, which meant that it was no longer necessary to have the same glyph stand for two different letters/digits, but there was still only room for two of the accented Icelandic letters and the characters Á and É were selected. On hindsight, it was of course rather useless to take on only 2 of the 6 accented letters.

A revolution can be said to have taken place with the Extended Binary Coded Decimal Interchange Code (EBCDIC), introduced by IBM with the 360 computer line. This was an eight-bit code with 256 different code points and thus plenty of room for letters specific to other languages than English. So,

with the IBM 360/30 we got the capacity for a full Icelandic alphabet without sacrificing anything else.
It is a remarkable coincidence that at almost the same time the American Standards Association (ASA, which later changed its name to the American National Standards Institute, ANSI) published the first version of it's 7 bit ASCII code (American Standard Code for Information Interchange), which was adapted by all American computer manufacturers except IBM[2]. To adapt ASCII to languages using accented letters there were 10 open code points for national adaptation. In Iceland, a version using a so-called floating accent was used, where the accent was actually stored separately, ahead of the letter it was supposed to sit on top of. This solution meant difficulties when sorting. Also a special adaptation to most printers was needed in order to combine the two. This solution was incompatible with EBCDIC.
The 7-bit limitation was a general problem in Europe and many other countries. An extension to 8 bits was needed. In the seventies, ECMA, the European Computer Manufacturers Association, started working on an 8-bit code table that would address the needs of the various European and other languages for which ASCII was not sufficient. A code table was proposed by Wilhelm Friedrich Bohn, the IBM representative in the ECMA working group on code tables and keyboards[3]. This table, nicknamed the Bohn Code was released in 1985 as the ECMA-94 standard. It was adapted by ISO and is widely known as ISO 8859-1, or Latin -1.
Mr. Bohn was familiar with the requirements of the Icelandic language, and since there were not at that time, contrary to what later happened[4], other serious contestants for the code points in question, the complete Icelandic alphabet was part of his proposal for what later became known as the Latin-1 code page. The Icelandic government has duly acknowledged Mr. Bohn's contribution to the Icelandic information society.
As personal computers, IBM PC and clones, capable of handling 8-bit character sets appeared on the Icelandic market, each importer created its own version of an Icelandic code table. By around 1985 there were at least four versions in circulation, plus one for the Apple Macintosh, causing difficulties in exchanging data. Jóhann Gunnarsson, then manager of the University Computing Centre in Reykjavík, called some meetings between the importers and a number of key users. Eventually, he proposed a compromise code table, sometimes named the JG Code, which was adopted by all PC and PC clone importers. Jóhann's attempts at persuading the Apple community to adopt the same code points for the Icelandic letters were not successful, however.
In due time, the JG Code was slowly replaced by IBM's Code Page 850, which, as far as placement of our letters is concerned, is identical to ISO 8859-1.

Conclusions

In this paper we have discussed the onset of the Information Age in Iceland. The applications that we selected for discussion are considered to have been instrumental in transforming Iceland from a rather backward society at the end of the Second World War to a modern day society. Iceland has a very small population – in 1980 the population totaled about 230.000 persons. Yet the degree of administrative computerization in Iceland can be compared with that of many larger western nations. In a small country the complexity of application can be brought under control and therefore development costs kept down. Stefán Ingólfsson has observed that the cost of developing a system in Iceland can be as small as one fifth or even one tenth of the cost of developing equivalent system in the other Scandinavian countries (Kjartansson 2002.)

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[2]Steven J. Searle. A Brief History of Character Codes in North America, Europe, and East Asia http://tronweb.super-nova.co.jp/characcodehist.html
[3] TrueType Fonts, http://www.norasoft.de/tt-fonts.html
[4] Turkey, for instance, has tried to persuade the standards community to exchange at least two of the Icelandic letters in ISO 8859-1 with letters from the Turkish alphabet.

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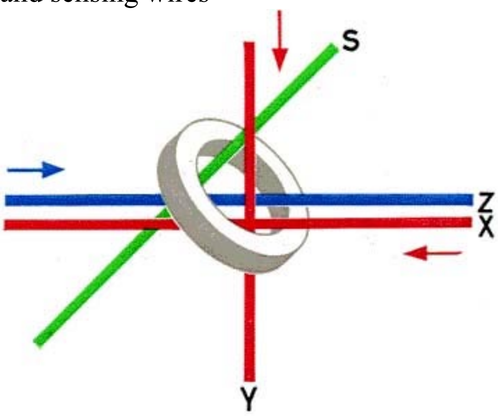
Appendix

Magnetic core memory

The IBM 1401, 1620, and 360/30 computers mentioned earlier were all equipped with magnetic core memory, a much more compact and reliable technology than earlier vacuum tubes and mercury delay lines. Jay Forrester, who was head of the Whirlwind computer project, invented core memory at MIT in the late 1940s. IBM then licensed the technology and core memory became commonplace in much of the first and second-generation of IBM computers. Semiconductor memories largely replaced magnetic cores in the 1970s, but they remained in use for many years in mission-critical and high-reliability applications. The Apollo Guidance Computer, for example used core memory, as did the early versions of the Space Shuttle. (Source: http://web.mit.edu/6.933/www/core.html).

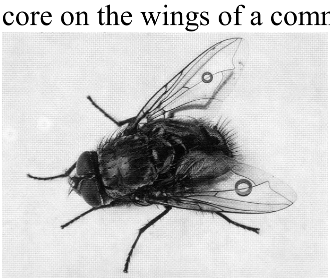
Figure 2. A Magnetic core with its control and sensing wires



Magnetic core memory had some interesting features. For instance it did not need constant current to keep its contents. In some cases, after a night's rest it was possible to start with the program and data from the previous day.
Also, it emitted electromagnetic waves, which could be detected in the near vicinity of the memory unit. It was discovered that a certain way of programming the IBM 1401 computer made it possible to play some simple melodies that could be heard in a radio receiver put on top of the memory unit. A sequence of NOP (No operation) instructions dictated the pitch of a tone, and the number of times that sequence was repeated determined the length of the tone.

Magnetic core memories were expensive to produce, amongst others because it was not possible to automate the production. All the wires had to be threaded by hand.

Figure 3. A 20 mil and 30 mil magnetic core on the wings of a common house fly.



The illustrations are by the courtesy of F. Doherty, Glasgow.