

Machines, Programs, Languages

(An informal overview of the history of computing)

Paul E. Dunne
Dept. of Computer Science
The University of Liverpool

1

Overview

1. Some popular misconceptions.
2. Two motivating questions.
3. Representation and its significance.
4. Tools to simplify calculation.
5. From specific to general purpose.
6. 20th Century developments and ideas.
7. Recent Trends and Successes
8. Future Prospects.

2

Popular Misconception I

Computers make mistakes

A. Utility company sends out a six figure bill to pensioner demanding immediate payment.

Excuse: "*The computer made a mistake*"

B. Motorist is charged with driving at 80mph through a pedestrian only zone.

Excuse: "*The engine made a mistake*"

Computers are inanimate objects – people make mistakes not machines.

3

Popular Misconception II

Computers are intelligent.

- a. There are computer programs that play Chess to a high standard.
- b. Anyone who can play Chess well is regarded as "intelligent".
- c. (a) and (b) \Rightarrow "Computers are intelligent"
But, would someone who could *only* play Chess well and was otherwise "below average" be thought "intelligent"?

4

Two Motivating Questions

1. How do I do this?
2. How do I get *someone else* to do this?
 - One feature in the development of modern Computer Science, is the scope of what "*this*" means.
 - A second is the changing nature of what is required to "*get someone else to do this*"

5

How do I do "this"?

- Interpretations of "this":
 - a. Counting – cattle, population, etc.
 - b. Basic arithmetic – e.g. in construction, taxation, etc.
 - c. Evaluate "hard" mathematical functions – e.g. in navigation, astronomy, ballistics, etc.
 - d. Payroll management, analyse experimental data, long-range weather forecasting.
 - e. Satellite control, prove mathematical theorems, understand spoken language.
 - f. Secure communication, shop from home, publicise activities, etc.

6

“Getting someone else to do this” I

- Progression from –
Explaining “simple” process (Counting)
Describing “tools” (Arithmetic)
Operating a machine (Arithmetic, Maths.)
- to –
Communicating the steps needed in order to perform a task (Payroll, satellite, etc)

7

“Getting someone else to do this” II

- In other words, a progression from merely “machine operation with manual control” to “defining instruction sequence to be carried out”
- In effect this defines the distinction between “using a calculator” and “writing a program” to carry out some task.

8

Representation and its significance

- “Counting” and “arithmetic” are meaningless unless some method of “describing *numbers*” is used.
- Early system – “Roman Numerals”:

M	D	C	L	X	V	I
1000	500	100	50	10	5	1

12 = XII ; 19 = XIX ; 1994 = MCMXCIV

9

Problems

- Arithmetic is extremely difficult –
 $IX + V = XIV$
 $XC - XI = LXXIX$
 $XIV \cdot CXIX = MDCLXVI$
- The *Decimal number system* simplified number representation to the extent that basic calculating tools could be developed.
- Also promoted the innovation of including a representation of the value **zero**.

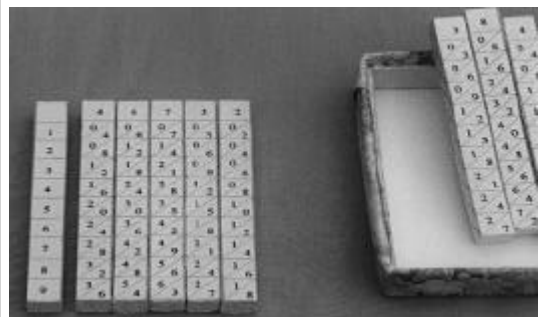
10

Basic Tools to Simplify Calculation

- *Abacus* – middle-east before 4th Century B.C.; oriental variation (*Soroban*) from this.
- *Chequer boards* – used in commerce and tax calculation – in Europe 11th Century.
- *Logarithms* and *Napier’s Bones* (Napier, Scotland 1614; practical table of logs, Briggs, England, 1617)
- *Slide rule* – (Oughtred, England mid-17th Century from ideas of Gunter, England 1620)

11

Napier’s Bones



12

Mechanical Calculators I

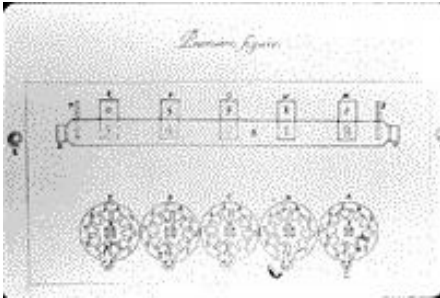
- All the tools just mentioned need some skill and dexterity for effective use.
- That is, they are not simply a matter of “entering numbers, turning handles, reading results”.
- First attempts to construct machines with such capabilities appeared in the early 17th Century.

13

Mechanical Calculators II

- Early devices used systems of rotating gears, similar to present-day odometers, to mimic arithmetic.
Schickard (Germany, 1624) – *Calculating Clock*
Pascal (France, 1640s) – *Pascaline*
Leibnitz (Germany, 1670s) – *Stepped Reckoner*
- The *Pascaline* implemented *subtraction* using a convention still used in modern computers.
- The *Stepped Reckoner* is the first attempt to carry out the operations of *multiplication* and *division*, as well as addition and subtraction

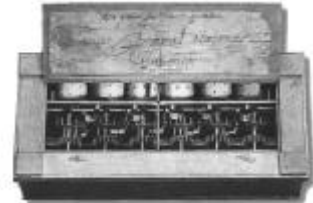
14



Pascal's Original Design for Pascaline

15

Internal Design



Front Panel

16



17

Mechanical Calculators III

- None of these had significant immediate impact.
- Schickard's machine destroyed (1620s), detailed surviving sketches only rediscovered in 1956 – working reconstruction made 1960.
- Pascal's machine viewed as an expensive curiosity in his lifetime. Fewer than twelve of these still exist.
- Only one version of Leibnitz' Reckoner built (expense) and this failed to work – error in the design not discovered until 1893 – over 200 years later.

18

Specific to General Purpose I

- The machines described so far were intended for the *specific purpose* of carrying out arithmetic (+, -, ^, *).
- Some 19th Century ideas extend this range:
Jacquard Loom (Joseph Jacquard, France)
(1801, complex textile designs on cards)
Hollerith Tabulator (Hermann Hollerith, USA)
(1880s, Collation of census data on cards)

19



Jacquard's Loom

**Punched Card
Pattern Design**

20

**Portrait of Jacquard
Produced by
Jacquard's Loom
and a set of 10,000 cards.**



21

Specific to General Purpose II

- These, together with more sophisticated mathematical function calculators, e.g. those built by,
Georg and Edvard Scheutz (Sweden, 1840s)
Charles Babbage (England, 1830s)
(The Difference Engine)
are still concerned with solving a limited range of problems.

22



**Remnants of
Babbage's
Difference Engine**
(Science Museum,
London)

23

Specific to General Purpose III

- The idea of *programming* a machine to perform "more general" tasks was first put forward by Babbage (*The Analytic Engine*, 1840s). Significant contributions to its theory and design were made by Augusta Ada Byron, Countess of Lovelace (1816-52).
- The Analytic Engine was never finished, despite 20 years work and an investment of almost £40,000 (personal fortune and substantial Government sources).

24

What went wrong?

- Babbage's model for the Analytic Engine assumed –
Numbers processed in Decimal form
All computation by rotating metal gears
Powered by steam
- These demands were beyond even the advanced capabilities of late 19th century engineering technology.

25

20th Century Developments

- Overcoming the problems faced by Babbage became possible following two insights – one logical, the other technological –
Use Binary (0 and 1) instead of Decimal
Use electrically powered components

26

Why do these make a difference? I

- Decimal is “easy” for humans to process as a *notation* but
“computers are not that ‘clever’”
Binary, while cumbersome for people is “easy” for machines.
- Using *electronic* devices, e.g. switches and relays, is a “natural” way of encoding the values **0** = OFF = False ; **1** = ON = True *and* complex sequences of operations on these.

27

Why do these make a difference? II

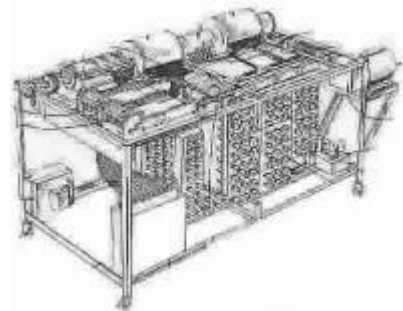
- The formal theory indicating that *binary* was “sufficiently general” had already been formulated in the 19th century by George Boole in his 1854 monograph –
An Investigation of the Laws of Thought
- The ideas proposed in this work began to be put into practice (together with the use of electrical mechanisms) from the late 1930s.

28

Recognisable as Computers I

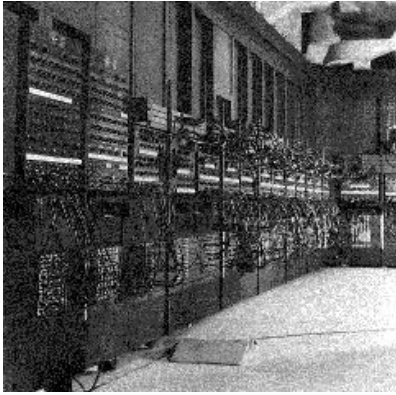
- A number were developed independently, often driven by military applications –
Zuse & Schreyer (Z1 – Z4, Germany, 1936-44)
Turing and others (Colossus, UK, 1944)
Aiken (Mark 1, USA, 1943-44)
Atanasoff & Berry (ABC, USA, 1940s)
Eckert & Mauchly (ENIAC, USA, 1943-45)

29



Design of Atanasoff-Berry Computer (ABC)

30



Some bits
of the
ENIAC

31



EDSAC – The first computing service
Cambridge Univ. (UK) 1950s

32

Recognisable as Computers II

- The basic structural principles of these were formulated by John von Neumann (USA, 1948), giving rise to the term *von Neumann Machine (model)*
- Until very recently (late 1980s) almost all practical computers could be described in terms of this model.
- Subsequent developments – transistors, LSI and VLSI (silicon chips) etc. – led to smaller, cheaper, and much more reliable computers.

33



2003 plaque marking von
Neumann's birthplace in
Budapest.

(AMS/Janos Bolyai society)

34

“Getting someone else to do this” III

- a. The *effective use* of general-purpose computers ceases simply to be a matter of “*explaining how to operate a calculator*” (in the sense of, say, an *abacus*).
- b. Explaining detailed operations in terms of manipulating 0 and 1 (*binary*) is needed, but this is tedious and error-prone (for humans).
- c. Dealing with (a) and (b) motivated the development of the first *high-level programming languages*

35

Some Historical Examples

- **FORTRAN** – developed late 1950s for Scientific and Numerical programs.
- **COBOL** – developed for Business Computing – payroll and personnel programs.
- **LISP** – Early Artificial Intelligence language.
- **ALGOL60/68** – general-purpose languages.
- **PASCAL** – “advanced teaching” of program.
- **BASIC** – “easy to learn” programming.

36

Trends and Successes I Personal Computers (PCs)

- Up until the early 1980s powerful computing facilities, were in effect, only available in industry, government, and universities – the concepts of “*home computing*”, “*the internet*” or “*being on-line*” were unheard of.
- By 2000 a significant proportion of UK homes owned or had easy access to a PC.
- The memory capability, speed, and functionality of home computers available for less than £1000 today vastly exceeds that of “state-of-the-art” computers costing *several millions* in the late 1970s.

37

Trends and Successes II Growth of the Internet

- Before ca. 1980 sending information between different computer users at physically distant locations (e.g. Manchester and Liverpool) was (effectively) “impossible”.
- ARPANET a U.S. Defense supported project led to a network of links between computing facilities across North America in the late 1970s; UK and European sites were connected by 1983.
- Today the global network provided via the “*Internet*” (developed by Cerf and Kahn) can be used by anyone with a home computer and access to a telephone to allow remote communication (*e-mail*, *video conferencing*, etc.).

38

Trends and Successes III The World-wide Web

- Created by Tim Berners-Lee as an information sharing resource at CERN (early 1990s), building on the structure established by the internet.
- Number of distinct web-sites, pages, range of information, services, etc difficult to estimate.
- Arguably the single most important factor in the growth of home computing by non-specialist users.
- One development is the increase in e-retail.

39

Future Prospects I

- Much current research in Computer Science is concerned with issues arising as a consequence of such developments.

Security and Reliability

Mobile Computing

Autonomous Computing

Reasoning and Negotiation

40

Future Prospects II

- Among the related fields to which Liverpool is making significant contributions are,
 - Algorithms for radio networks*
 - Agent-based systems*
 - Verification and validation*
 - Automated reasoning*
 - Argumentation and Decision-making*
 - e-auction mechanisms*
 - e-democracy and Legal reasoning*

41