The EDSAC Replica Project

Andrew Herbert, with thanks to Chris Burton, October 2011
The EDSAC Replica Project

The Proposition

Project Organisation

Feasibility Studies

Costs and Timescale
An enquiry by Hermann Hauser:

“Would it be feasible to build a replica of the famous EDSAC?”

EDSAC first ran a program in May 1949, and continued for nearly ten years.

Assume the goal is to replicate the machine as it was in May 1949.

Let it be a tangible tribute to Maurice Wilkes, though he was somewhat sceptical!
Overall Organisation

- EDSAC Replica Limited
  - A charitable trust
  - Sponsors + University of Cambridge + BCS

- Management Board
  - CCS + TNMoC + Project manager

- The Replica
  - Project manager + volunteers

- Fundraising
- Ownership
- Legal
- Overall operations
- Day to day operations
Key Facts for Programmers

- Two registers: accumulator and multiply
- 512 words of memory
- 35 bit memory: two 17 bit half words plus sandwich digit
- Fixed point arithmetic
- Paper tape input
- Teleprinter output
- Initial instructions embody simple assembler
### Order Code

<table>
<thead>
<tr>
<th>F (5)</th>
<th>-</th>
<th>n (10)</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A n</td>
<td>a += !n</td>
<td>• L $2^{n-2}$</td>
<td>a := a &gt;&gt; n</td>
</tr>
<tr>
<td>• S n</td>
<td>a -= !n</td>
<td>• E n</td>
<td>jmp if a &lt; 0</td>
</tr>
<tr>
<td>• H n</td>
<td>m := !n</td>
<td>• G n</td>
<td>jmp if a ≥ 0</td>
</tr>
<tr>
<td>• V n</td>
<td>a += m*!n</td>
<td>• I n</td>
<td>!n:=input</td>
</tr>
<tr>
<td>• N n</td>
<td>a -= m*!n</td>
<td>• O n</td>
<td>output:=!n</td>
</tr>
<tr>
<td>• T n</td>
<td>!n := a; a := 0</td>
<td>• F n</td>
<td>check</td>
</tr>
<tr>
<td>• U n</td>
<td>!n := a</td>
<td>• X</td>
<td>no op</td>
</tr>
<tr>
<td>• C n</td>
<td>a += m&amp;!n</td>
<td>• Y</td>
<td>round a</td>
</tr>
<tr>
<td>• R $2^{n-2}$</td>
<td>a := a &gt;&gt; n</td>
<td>• Z</td>
<td>stop</td>
</tr>
</tbody>
</table>
Feasibility Studies

- Documents & Knowledge Acquisition
- Physical Design
- Logic Design & simulation
- Electronic Design & experiments
- Acquisition of parts
- Areas of work not started
- Skills required
Documents & Knowledge Acquisition

- Original technical description & diagrams for Cambridge Computer Laboratory archives
- Original photographs
- Published papers
- Recollections of pioneers
Physical Design

♦ Scanning and measuring from photos
♦ 12 racks, 120 chassis
♦ An original chassis exists to measure
♦ The above chassis has been drawn up and a sample made
♦ We don’t know how many types of chassis there were, or where they were placed in the racks
Logic Design & Simulation

- Need to know how EDSAC works in detail
- Incomplete & inconsistent diagrams
- Need to extrapolate undocumented areas of logic
- Simulation essential to give confidence before committing to building anything
Major Cycle

Fig. 1. Constitution of Major Cycle

Repetition Frequency: 870 kHz
Repetition time: 1.15 milliseconds

Fig. 2. Systems of Regular Repetitive Pulses

From Edsac Report
From Edsac Report
Typical Timing Diagram

From Edsac Report
Bill Purvis has written a simulator for whole logic - can run a program, very slowly.

Several areas such as reader and printer modelled as ‘black boxes’
Electronic design

- Electronic design is incomplete and lots of redesigning went on during commissioning
- AC-coupled circuits - unfamiliar!
- AND-gate uses 3 pentodes and 3 diodes
- Main components: flip-flop, inverter, short delay, pulse amplifier
- Experiment shows stage delay is very short
- Requires many lumped-constant delays
Typical Circuit Diagram

Fig. 5. BASIC CIRCUIT OF FLIP-FLOP
Mapping Logic to Chassis
Mapping Logic to Circuits to Chassis

- Use photos to try to guess what each chassis does
- Physical location of more than half the logic is now understood - the easy bits!
- Some partial clues from logic diagrams
Memory Tanks

Maurice Wilkes with a battery of 16 storage tanks, each 16 x 36 bit words

The 5 ft steel tubes contain mercury as the acoustic delay medium
Replica Memory Tanks

- Risky and costly to use mercury, except perhaps in one example tank
- Could use wire acoustic delay lines as a reasonable alternative
- Perhaps use semiconductor shift registers to get off the ground quickly
Acquisition of Parts

- Many, but not all, valves are available and already to hand
- B9G valveholders will be problematic
- Authentic Rs and Cs may be difficult
- Lumped-constant delay lines need to be made
- Tag strips - make or buy?
Areas not yet looked at

- HT power supply - +250v at say 15 amp
- The ‘three oscilloscope unit’
- Negative power supplies
- Electrical Health and Safety
- Peripherals
Skills mix needed

♦ Understand logic and map to electronic circuits
♦ Map electronic circuits to individual chassis
♦ Wiring up 120 chassis - 3000 valves!
♦ Ability to track down lots of components
♦ Some circuit design capability for replica store
♦ Delicate manipulative skills for delay lines
Costs and Timescale

- Preliminary estimates indicate cost in the region of £250,000
- With adequate availability of volunteers to do the construction, it could take 3-4 years
Electronic Delay Storage Automatic Calculator

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