01 Introduction

01.01 Automatic information processing

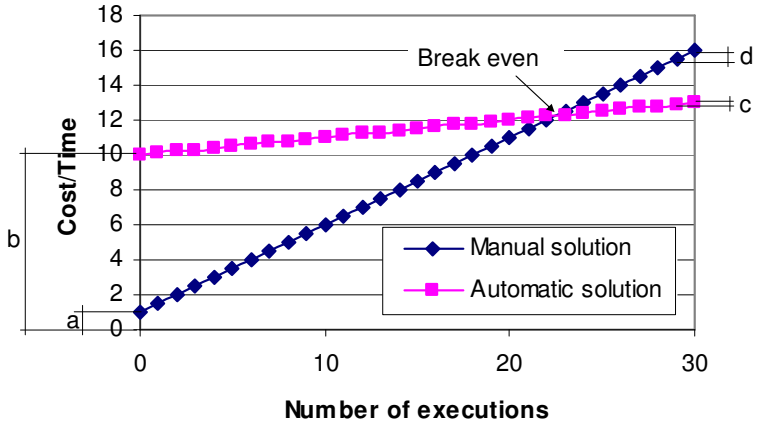
- What is automation?
- Economic aspects of automation
- General purpose *vs* Special purpose systems
- Reconfigurable and programmable machines
- The origin of computer systems
- Course organization
- Recommendations

What is automation?

A few definitions:

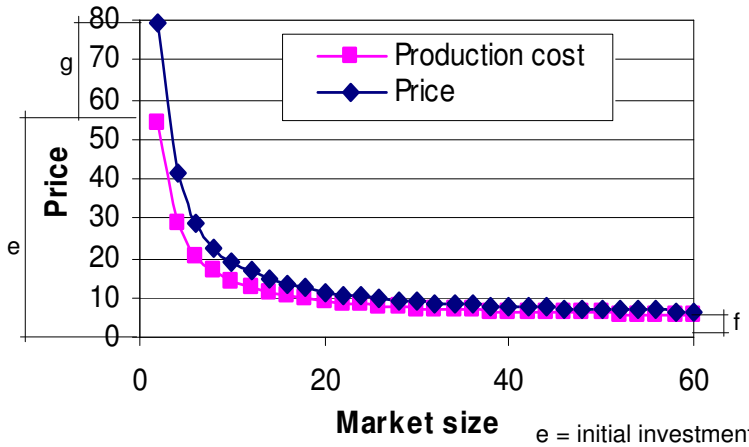
- Techniques and equipments used to achieve automatic operation or control of a process
- Automatic operation and control of machinery or processes by devices, such as robots, that can make and execute decisions without human intervention
- The replacement of manual operations by *computerized* methods

Economic aspects of automation 1



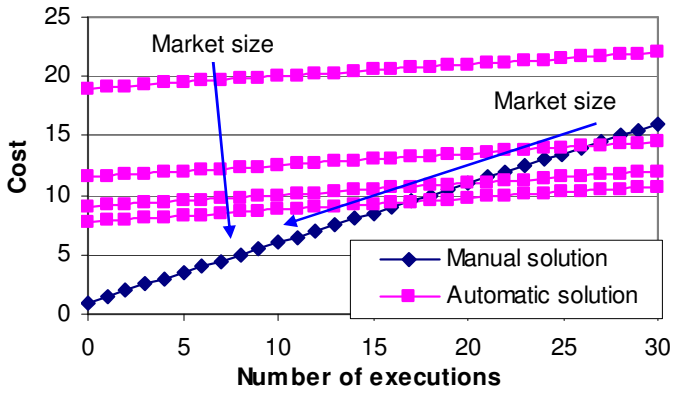
a = manual setup cost/time
b = automatic setup cost/time
c = cost/time per manual execution
d = cost/time per automatic execution

Economic aspects of automation 2



e = initial investment
f = marginal cost of production
g = target production profit

Economic aspects of automation 3



General vs Special purpose

- The broader the range of applications of an automatic equipment
  - the larger its market
  - the lower its price
  - the larger the number of executions
- Using a general purpose equipment has two main advantages
  - lower costs reduce the breakeven point
  - broader applicability makes it easier to reach it

Reconfigurable equipment

- Reconfiguration enables re-use
- The same equipment can be used to solve different problems (or to execute different processes) at the cost of a simple reconfiguration
- If an in-house reconfigurable equipment can be used to solve a new problem, the setup cost of the automatic solution for the new problem reduces to the reconfiguration cost

Programmable equipments

- Programmable devices can accept, interpret and execute instructions taken from a given instruction set
- A complex process can be specified step by step in terms of instructions by means of a program
- A programmable device is a truly general-purpose machine

The origin of computer systems

Information theory

- Any information can be represented as a sequence of a finite number of binary digits (at the cost of a possible approximation) taking value 0 or 1

info	representation
ON	"1"
OFF	"0"

info	representation
0	"0000"
1	"0001"
2	"0010"
3	"0011"
4	"0100"
5	"0101"

info	representation
A	"01000001"
B	"01000010"
C	"01000011"
D	"01000100"
E	"01000101"
F	"01000110"

The origin of computer systems

Boolean algebra

- Logic operators AND, OR, and NOT are defined on the Boolean set **B**={0,1} [Boole, 1848]
- Any logic function f:$\mathbf{B}^n \rightarrow \mathbf{B}$ can be expressed in terms of AND, OR, and NOT and evaluated by performing a sequence of elementary operations

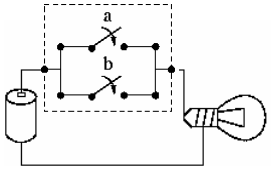
a	b	f=a+b
0	0	0
0	1	1
1	0	1
1	1	0

f = (a AND (NOT b)) OR (b AND (NOT a))

The origin of computer systems

Switching theory (1)

- Assigning logical values to the states of an electrical signal, it is possible to implement elementary logic functions by means of switching networks [Shannon, 1938]

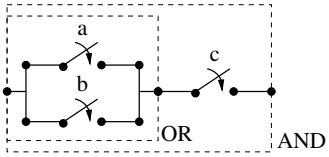


f(a,b) = a OR b

The origin of computer systems

Switching theory (2)

- Any logic function can be implemented by a switching network



f(a,b,c) = (a OR b) AND c

- A programmable switching network, that can compute at least AND, OR and NOT, can be programmed to evaluate any logic function

The origin of computer systems

Technology

- Digital integrated circuits are micro-fabricated devices that contain networks of up to one hundred million transistors (i.e., switches)
- The minimum feature size of today's transistors is 0.09µm
- The large scale production makes digital integrated circuits very cheap

The origin of computer systems

The big picture

- Any information can be represented by sequences of 0s and 1s
- Any processing of binary values can be performed by switching networks
- Programmable switching networks can be used to perform any kind of information processing
- Computer systems are automatic information processing systems based on programmable switching networks

The origin of computer systems

The big picture

- Computer systems are truly general purpose information processing systems
- Using a general-purpose computer system to solve a specific problem entails writing a specific program

The origin of computer systems

The big picture

- Software development/purchase is the only setup cost
- The cost of the computer system that executes the software is usually negligible since
  - Computer systems are cheap thanks to their market
  - Computer systems are assumed to be already in house thanks to their wide applicability
- Automation is defined as
  - the replacement of manual operations by *computerized* methods

Course organization
Main topics

- Digital representation of information
- Logic networks
- Computer systems
- CPU
- Memory
- Communication

Course organization
Exams

The exam entails three steps:

1. Report on a project assigned by the instructor
   mark a: $0 \le a \le 33$, passed with $a \ge 18$
2. Written (online) test covering the entire program
   mark b: $0 \le b \le 33$, passed with $b \ge 18$
3. Oral exam
   mark c: $-5 \le c \le 5$

Rules:

- You must have passed (in any order) steps 1 and 2 to take step 3
- Partial results of steps 1 and 2 hold for the entire Academic Year
- Project reports must be submitted at least one weak before the date of the first oral examination you want to take
- The final mark is computed as: $(a+b)/2+c$

Course organization

Recommendations

- Attend new courses during the second semester rather than studying the old ones (use the summer to recuperate)
- Take the exams of the courses taught in the second semester in June (use the fall session to recuperate)
- Read learning materials as soon as they are published
- Attend at least one classroom per week to keep in touch with students and instructors
- Ask questions in chats and forums
- Organize with other students to make sure that at least 10 people attend each classroom, or otherwise the transcripts of the classrooms will be useless