
MANUFACTURING EXECUTION SYSTEMS
ICT in an MES

Summary

- An MES provides a vast set of primary and support functions
- In order to be able to carry them out, in a MES there are a number of ICT methodologies and technologies

SUMMARY

- Some of these are covered in this lesson in relation to some MES functions
- Data collection
- Production workflow management
- Work order / workstation management
- Statistical process control

DATA COLLECTION

- **Data collection**

Definition:

It is the storage of information elements concerning one or more events, in the place where the event occurs and at the same time (or almost) to the occurrence of the event

(J. Cohen)

DATA COLLECTION

- **Data collection phases**
  - **data entry**
  - **data communication**
  - **data storage**

DATA COLLECTION: INSERT

- *garbage in/garbage out*
- **Requirements:**
  - **Precision**
  - **Quality**
  - **Speed**
- **Technologies:**
  - **Keyboards**
  - **Bar codes**
  - **Sensors**

DATA COLLECTION: INSERT

- Voice coder/decoder
- Touch screens
- ...

- Bar code use
  - Identification of an item
  - Messages from a workstation to the central system

DATA COLLECTION: INSERT

- Architecture of a bar code system
  - Label
  - Scanner
  - Decoder
  - Interface/Computer
- Label
  - Production methods
    - Preprint
    - Print on-site

DATA COLLECTION: INSERT

- Code
  - 39 (3 of 9)
    - Each character (ASCII, 43 character) comes from 3 elements (made by bar and spaces) chosen on 9 available
    - It adopts a check digit (one character related to sum module 43)
    - Version with extension to 128 ASCII characters

DATA COLLECTION: INSERT

- 1 error on 1.7M (worst case);
  1 error on 4.5M (best case);
- Density higher than 9.8 char x inch

PDF417 (Portable Data File)

- Bidimensional (reduced bar code in a stack)
- 1 error on 10.5M (worst case)
  1 error on 612.4M (best case)
- It allows more characters coded on 1 byte on one label

DATA COLLECTION: INSERT

Informatica Industriale MES:

PDF417 **39**

Generated at https://barcode.tec-it.com

DATA COLLECTION: INSERT

- Additional technologies:
  - Vocal recognition
  - Vision systems
  - Device control systems
  - Touch screens
  - Other computers

DATA COLLECTION: COMMUNICATION

- Radio frequency data communication (RFDC)
- Radio frequency identification (RFID)
  - Antemna
  - Transceiver (with decoder)
  - Transponder electronically programmed with univocal information

DATA COLLECTION: COMMUNICATION

- Local Area Networks (LAN)

  Ethernet

  - CSMA/CD Access Method – IEEE802.3
  - Wireless LANs – IEEE 802.11

  TCP/IP (Transport Control Protocol, Internet Protocol)

DATA COLLECTION: STORAGE

- **Relational databases**
  - **Centralised**
  - **Distributed**
- **Relational database**
  - **Example of SQL query**

```
SELECT
ordini.cliente, ordini.quantità
FROM ordini
WHERE
ordini.due_date=#12/09/2002#
```

DATA COLLECTION: STORAGE

- Client/server
  - Relationship between two applications, in which a program (client) requests a service from another program (server), which satisfies the request
  - Examples:
    - Internet
    - Transactions
    - ...

WORKFLOW

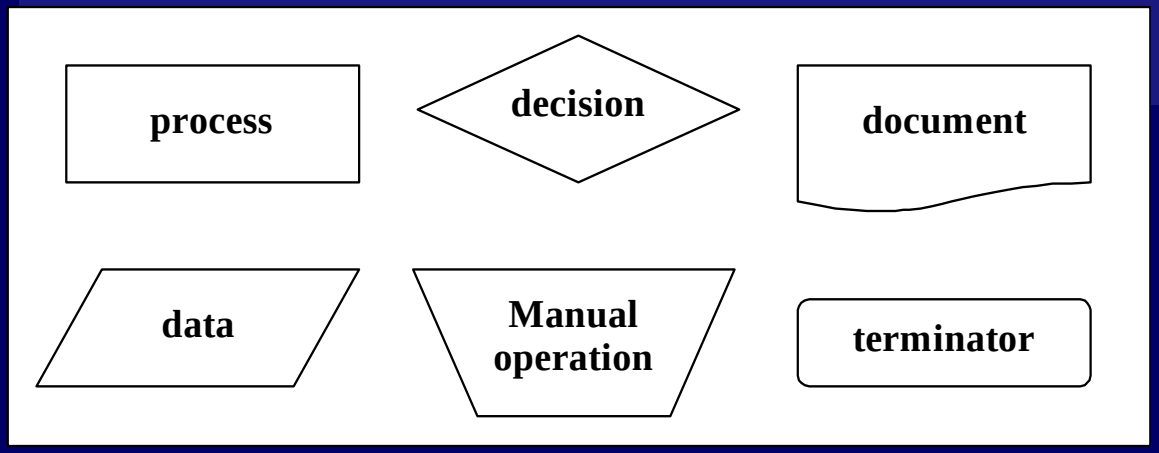
The workflow is defined as the automation, complete or partial, of a business process.

PRODUCTION WORKFLOW MANAGEMENT

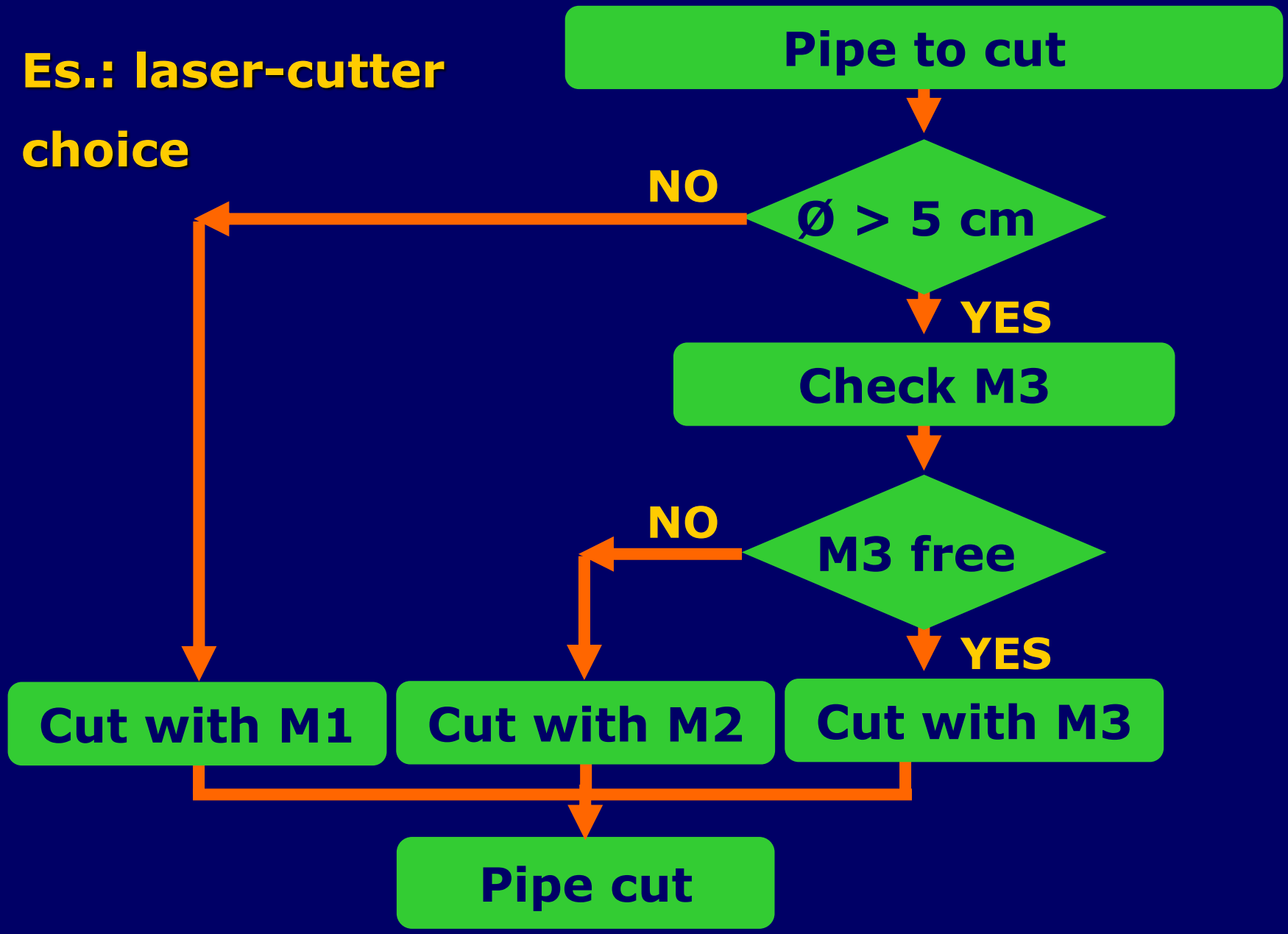
- Diagrams for its representation
- Messages
  - How to send messages
    - Centralised
    - Distributes
  - Message languages
    - XML, JSON

PRODUCTION WORKFLOW MANAGEMENT

- Diagrams for its representation
  - Flowcharts
    - Symbology to analyze decision-making processes to obtain the finished product

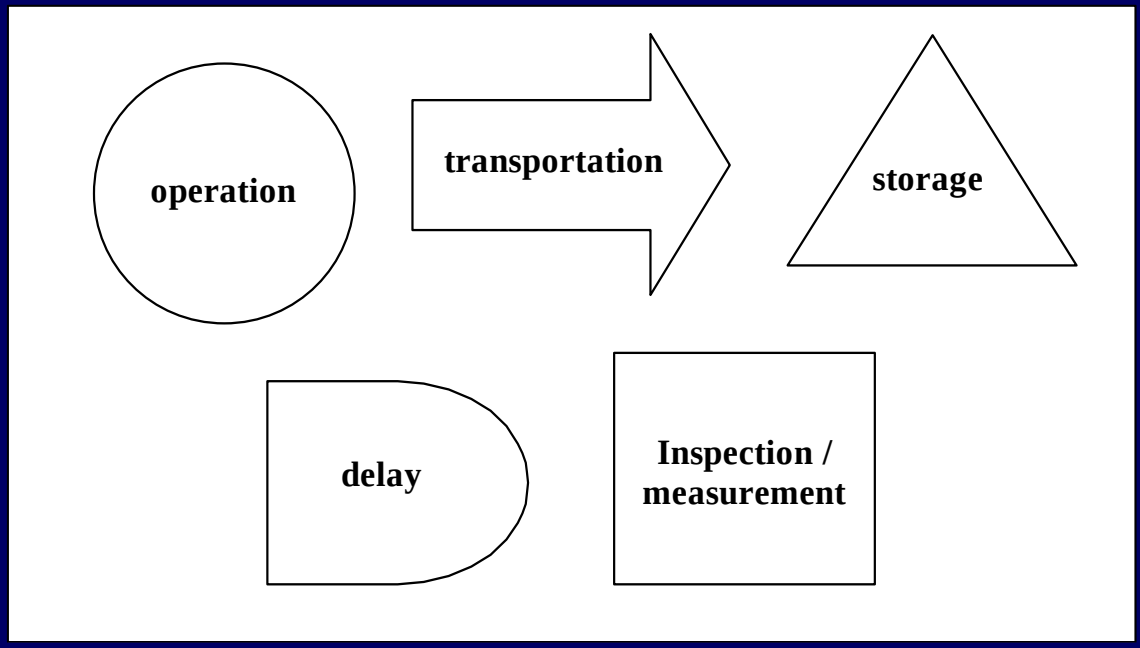


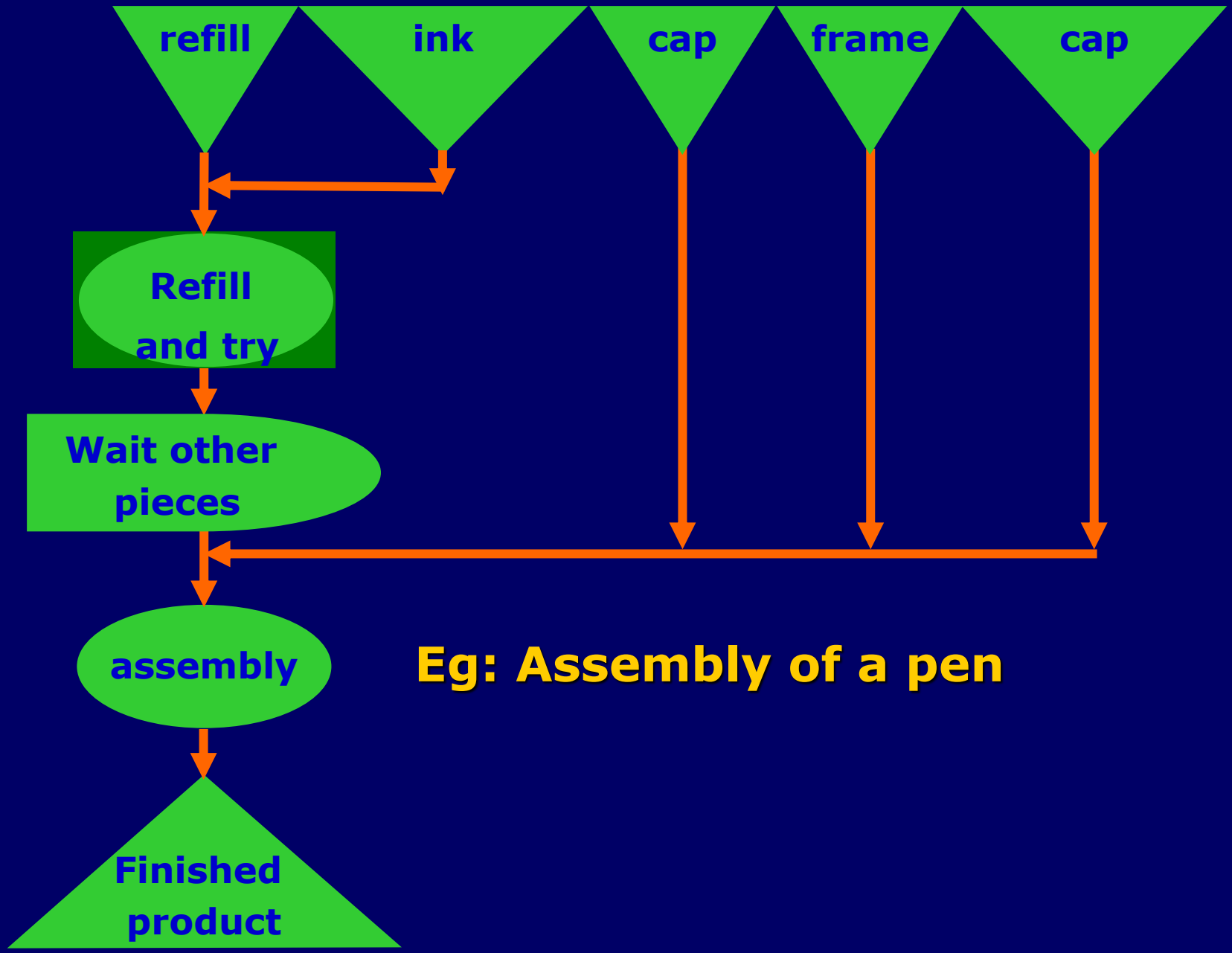
Es.: laser-cutter choice



PRODUCTION WORKFLOW MANAGEMENT

- Symbology to analyze the production process





Eg: Assembly of a pen

PRODUCTION WORKFLOW MANAGEMENT

- UML (Unified Modeling Language) is a general-purpose visual and graphic language, useful for specifying, displaying, building and documenting the static and dynamic information used in an information system or, in general, in an organization

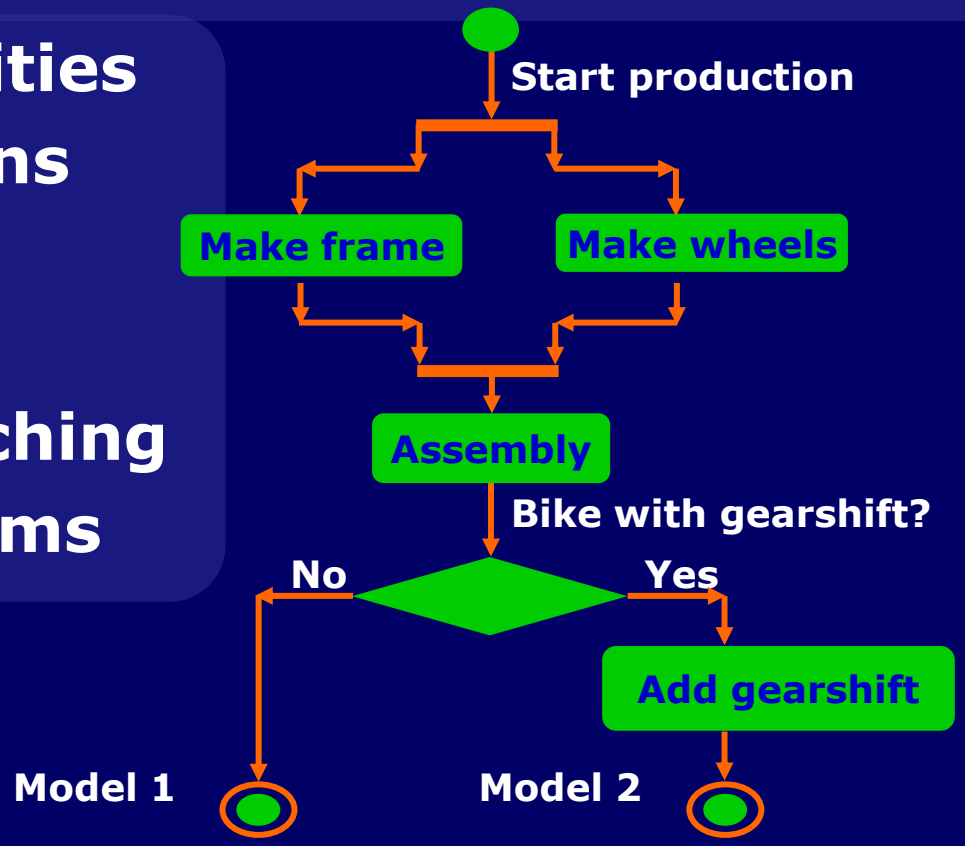
PRODUCTION WORKFLOW MANAGEMENT

- If a software development follows, the UML notation allows the automatic creation of code in the most well-known object languages

PRODUCTION WORKFLOW MANAGEMENT

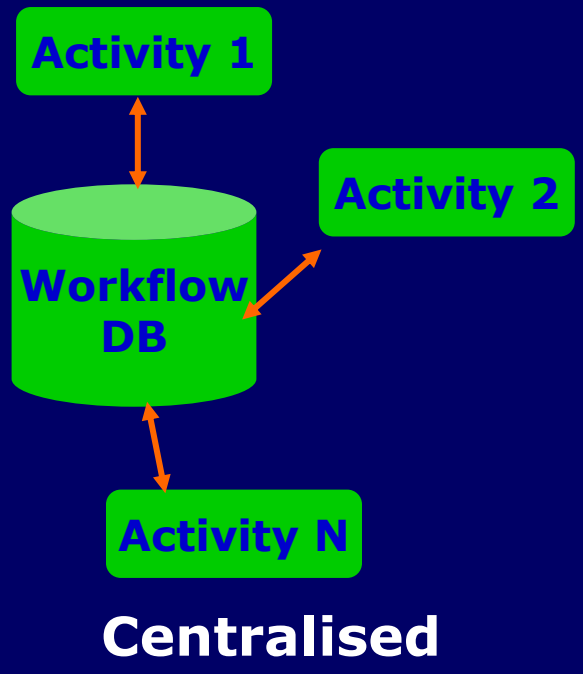
UML Activity diagram

- Activities
- Actions
- Fork
- join
- Branching
- Streams

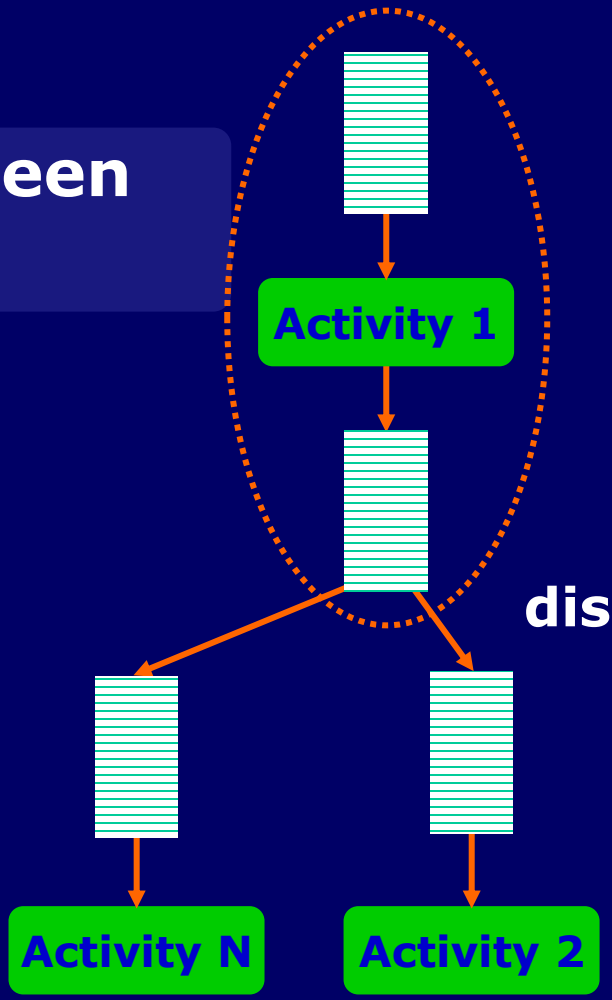


PRODUCTION WORKFLOW MANAGEMENT

- Database
- Messages between processes



Centralised



distributed

WORK ORDER/WORKSTATION MANAGEMENT

- Scheduling (on-line)
- Knowledge base

WORK ORDER/WORKSTATION MANAGEMENT

- **Scheduling**
  - Assign operations (jobs) to machines
  - Sequencing operations on machines
  - Timing operations on the machines

WORK ORDER/WORKSTATION MANAGEMENT

- **Classification of scheduling problems "n / m / A / B"**
  - **n number of jobs**
  - **m number of machines**
  - **A workflow between machines:**
    - **F flow-shop** non puoi invertire l'ordine esempio: lavare una camicia
    - **G general job-shop**
    - **if not present m=1**

WORK ORDER/WORKSTATION MANAGEMENT

- **B: performance index; eg minimize n_T, the number of jobs that are late**

- **Moore algorithm $n/1//n_T$**
  1) **Sort the jobs according to *earliest due date*; let $J_1 \ldots J_n$ be the sorted sequence**
  2) **Find the first job which is late J_m; if not existing go to 4)**

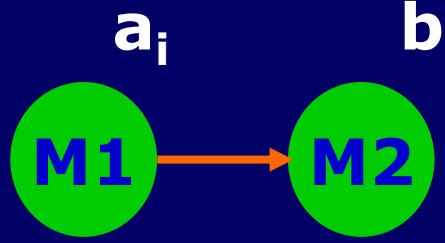
WORK ORDER/WORKSTATION MANAGEMENT

3) In the sequence $J_1 \ldots J_m$ find the job with the longest working time and remove it from the sequence. Go to 2)
4) The optimal scheduling that minimizes the number of late jobs n_T is given by the sequence left and executing the rejected jobs in any order

WORK ORDER/WORKSTATION MANAGEMENT

- Johnson algorithm for $n/2/F/F_{max}$ (it minimizes the flow time through the 2 machines)

1) K=1; l=n
2) Unscheduled jobs={J_1, J_2,...J_n}
3) Find the minimum between a_i and b_i



WORK ORDER/WORKSTATION MANAGEMENT

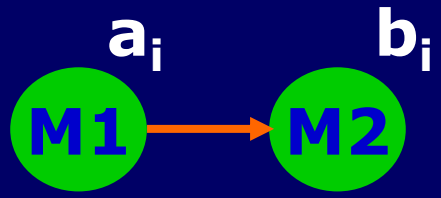
4) If the minimum was a_i corresponding to J_i:
   - Put J_i in position k of the scheduled jobs
   - Delete J_i from the unscheduled jobs
   - k=k+1
   - Go to 6)

WORK ORDER/WORKSTATION MANAGEMENT

5) If the minimum was b_i corresponding to J_i:
   - Put J_i in position i of the scheduled jobs
   - Delete J_i from unscheduled jobs
   - l=l-1
   - Go to 6)

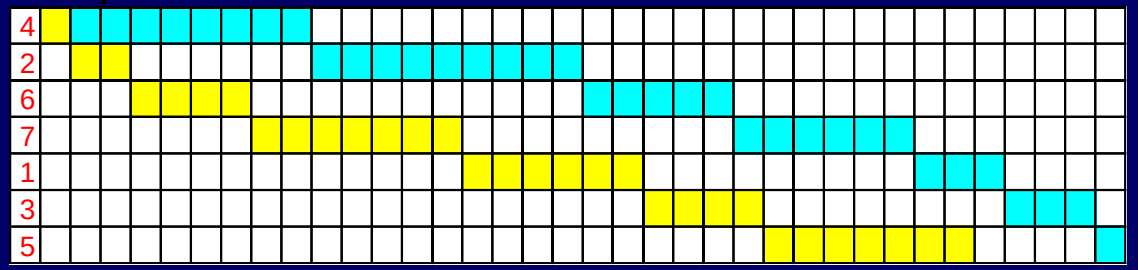
6) If the list of unscheduled jobs is not empty go to 3; otherwise the list of scheduled jobs is optimal according to F_{max}

WORK ORDER/WORKSTATION MANAGEMENT



job	a_i	b_i
1	6	3
2	2	9
3	4	3
4	1	8
5	7	1
6	4	5
7	7	6

Job 4 scheduled	4						
Job 5 scheduled	4						5
Job 2 scheduled	4	2					5
Job 3 scheduled	4	2				3	5
Job 1 scheduled	4	2			1	3	5
Job 6 scheduled	4	2	6		1	3	5
Job 7 scheduled	4	2	6	7	1	3	5



WORK ORDER/WORKSTATION MANAGEMENT

- The common scheduling models are static and deterministic
- MES often has to deal with dynamic scheduling and stochasticity problems. Example:
  - New jobs are constantly arriving
  - Processing times are uncertain

WORK ORDER/WORKSTATION MANAGEMENT

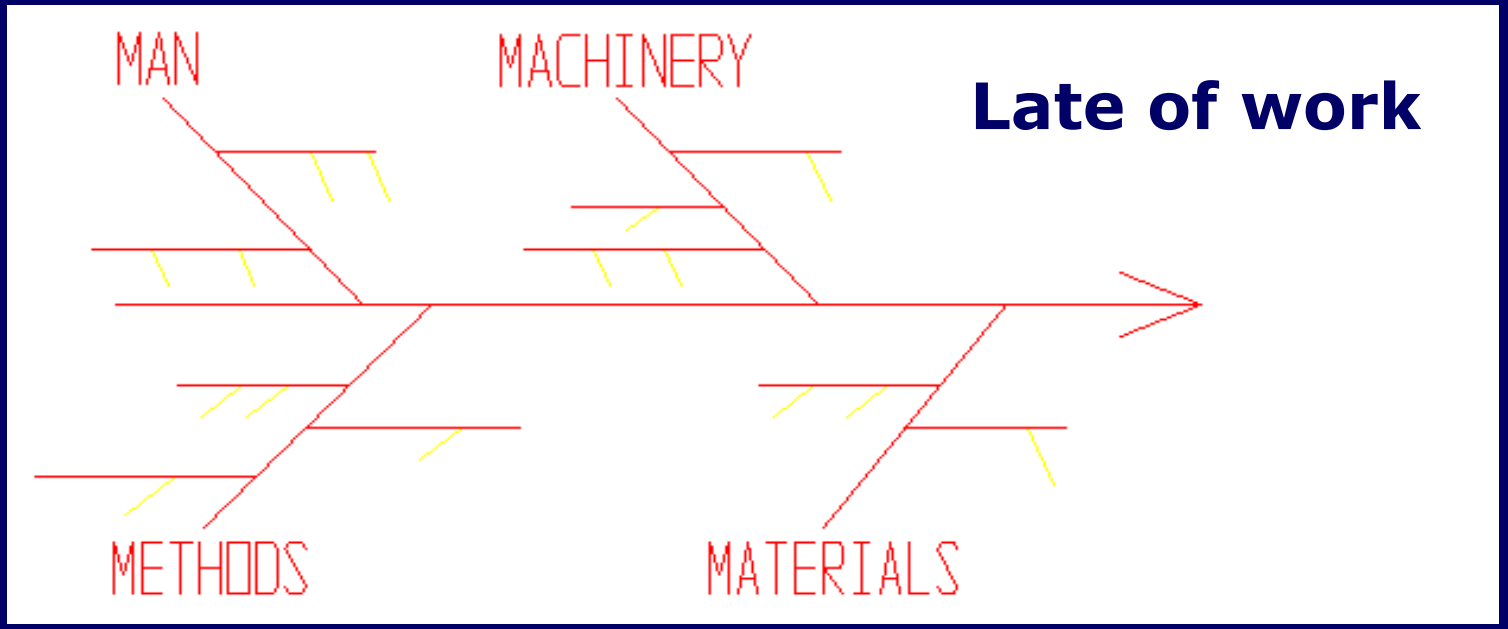
- Machines may stop due to unforseen events

➲ Rescheduling problems are very complex problems to be solved in a short time.
Approaches:

- Queue theory
- Optimisation
- Simulation
- ...

WORK ORDER MANAGEMENT

- **Knowledge base**
  - **Cause effects diagrams (Ishikawa), also used for quality control**



WORK ORDER MANAGEMENT

- Expert systems
  - Rules (knowledge base)
    - Left hand side (Facts)
    - Right hand side (Actions, Facts)
  - Inferential engine
  - Examples

```
(manpower < 10) => (Late_of_work)
(Machinery1 is broken) and (Machinery2 is OK)
and (Lots_in_queue > 10) => (Late_of_work)
(Late_of_work) and (Curr_lot_salience >10) =>
(message_to_ERP)
```

STATISTICAL PROCESS CONTROL

- It is a set of methods for quality control based on the continuous monitoring of a process rather than on the inspection of a finished product
- Methodologies for process modeling and quality control are needed

STATISTICAL PROCESS CONTROL

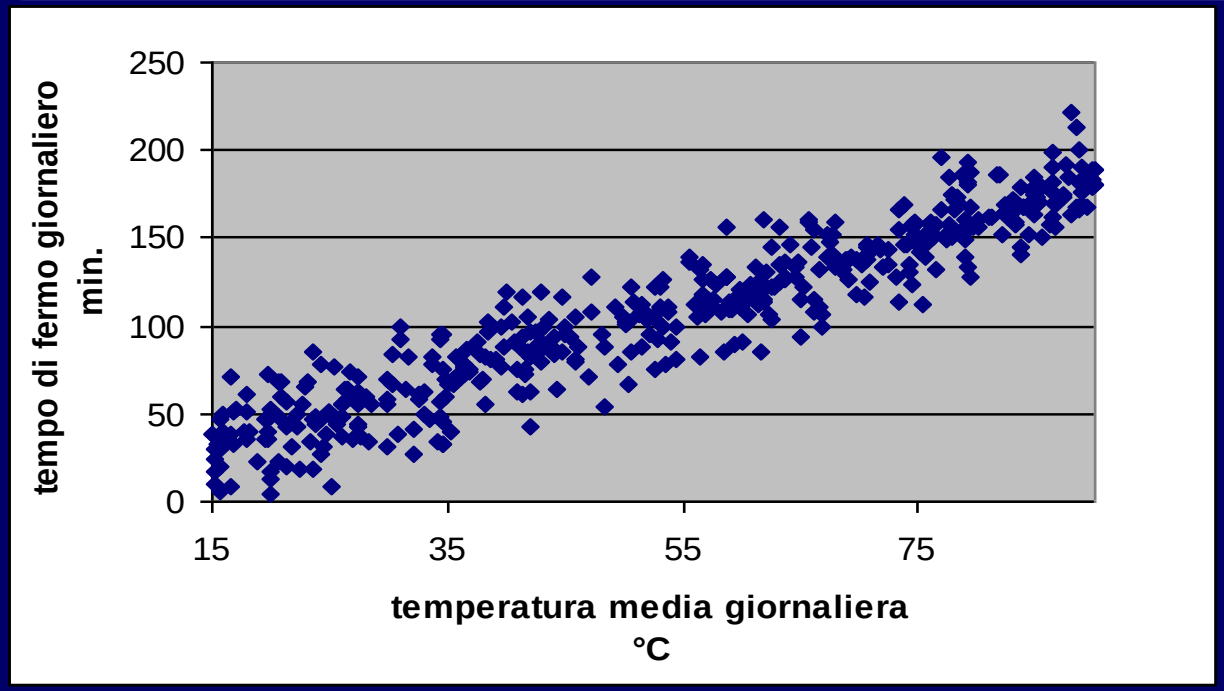
RUN CHARTS/TIME PLOT/TREND CHART

- Used to study the trend over time of a phenomenon

STATISTICAL PROCESS CONTROL

SCATTER DIAGRAMS

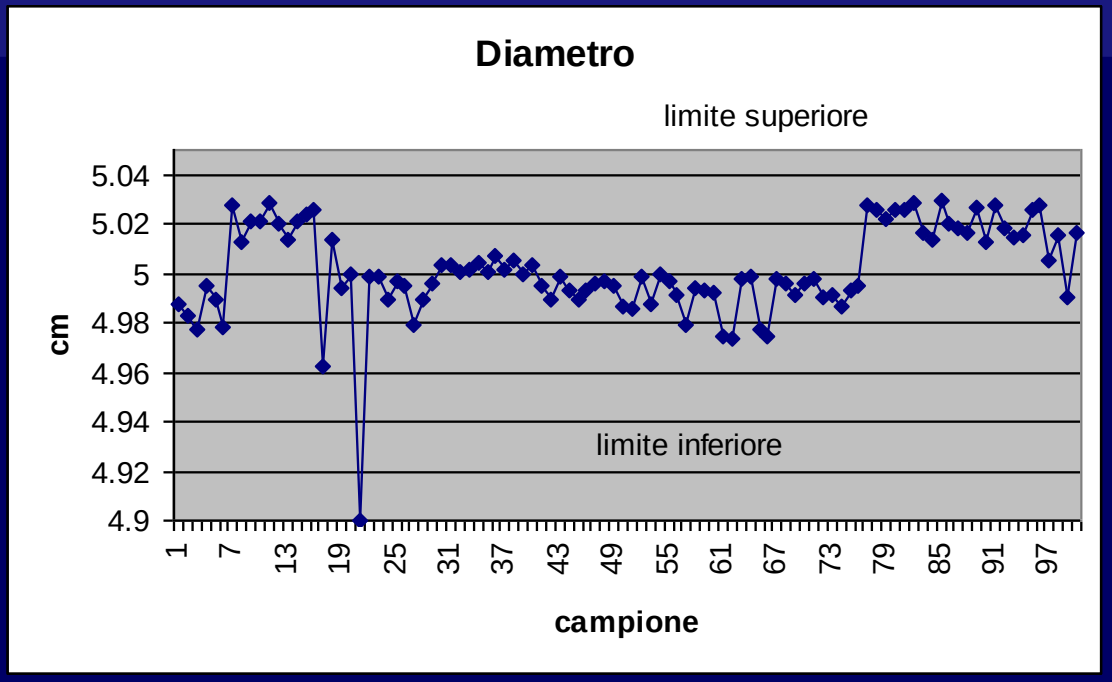
- Used to study a possible relationship between two variables



STATISTICAL PROCESS CONTROL

CONTROL CHARTS

- **They allow to control the stability of an observed variable and its ability to satisfy process specification limits**



CONCLUSIONS

- MES is an information “hub”
- It requires numerous methodologies and technologies for :
  - Modeling processes
  - Manage your data
  - Support decisions

CONCLUSIONS

- In a MES the information undergoes transformations parallel to the transformations of raw materials towards the finished product
- Different information methodologies and technologies allow these transformations