DISCRETE EVENT SIMULATION-BASED ON REAL-TIME SHOP FLOOR CONTROL

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Summary

1. Shop Floor Control [SFC]
2. Discrete Event Simulation [DES]-based on SFC
3. Manufacturing Execution System [MES] for SFC
4. Main specifications for on-line simulation
5. Experimental platform and outline
1. Shop Floor Control [SFC]

“All the activities of short-term production in agreement with the objectives established by the production control, by adapting the production to the disturbances which can occur on the level of the workshop” [APICS,05], [Grabot,97]

- Shop order priority
- Planned decision

- Shop orders status info.
- Real time data info.
- Resources efficiency
- WIP information

SFC (Order / Monitoring)

- SFC definition & its sub-functions
- A classification of SFC
- Control tools to aid decision-making
- Advantage to use DES and MES for SFC
## 1. Shop Floor Control [SFC]

<table>
<thead>
<tr>
<th>Off-Line Control</th>
<th>On-Line Control</th>
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| **Predictive Control**  
To prepare  
Estimated data | Experience feedback |
| **Existing System**  
Before Execution | **System in execution** |
| **Proactive Control**  
To anticipate | **Reactive Control**  
To correct  
Unforeseen events and critical drift of system variables (e.g., cycle time) |

- **Very weak probability of events occurrence**
- **Experience feedback**

### Experience feedback

- SFC definition & Its sub-functions
- A classification of SFC
- Control tools to aid decision-making
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### Experience feedback

- Shop Floor Control [SFC]
  - a. SFC definition & Its sub-functions
  - b. A classification of SFC
  - c. Control tools to aid decision-making
  - d. Advantage to use DES and MES for SFC

### Experience feedback

- System in execution
  - Unforeseen events and critical drift of system variables (e.g., cycle time)

### Experience feedback

- Reactive Control
  - To correct
  - Experience feedback
1. **Shop Floor Control [SFC]**

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<th>Re-engineering</th>
<th>Execution</th>
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- a. SFC definition & Its sub-functions
- b. A classification of SFC
- c. Control tools used to decision-making aid
- d. Advantage to use DES and MES for SFC
Design Re-engineering Execution

| CAD, CAM, CAE (DESIGN, MANUFACTURING, ENGINEERING) | COMPUTER-AIDED PRODUCTION ENGINEERING Specific to the Production Systems | ERP
Scheduler
Supervision
Monitoring (PLC) |

1. Shop Floor Control [SFC]

- SFC definition & Its sub-functions
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1. Shop Floor Control [SFC]

**DES**
- Allows to project in the future
- but does not allow a direct connection to a real system during execution

**MES**
- Brings a lot of information allowing to make decisions
- but does not allow to make sure that they are the good decisions.

Use **On-Line Discrete Events Simulation** for the decision-making aid in **Reactive and Proactive Control** of workshop by coupling with **MES**.
2. DES-based on Shop Floor Control

*Example:*

**Orders:**
- Product A, Qty. 100
- Product B, Qty. 150

**Shop Floor:**
- 3 machines, 3 queues, 3 conveyors

**Control parameters:**
- Orders sequencement or scheduling
- Queues capacity
- Priority rules on conveyors

**Obj.:** Minimize makespan or leadtime with Discrete Event Simulation
2. DES-based on Shop Floor Control

- **Predictive Control**
  - **Off-Line Simulation** *(before execution)*
  - Estimated data (machine cycle time) deterministic or probabilistic
  - Simulation runs to determine control parameters to reach the obj.

- **Proactive Control**
  - **Off-Line Simulation** *(before execution)*
  - Take into account machine breakdown, cancelling order, …
  - Simulation runs to determine alternative scenario

- **Reactive Control**
  - **On-Line Simulation** *(during execution)*
  - Take into account normal or critical events and drifts (cycle time)
  - Simulation runs to check if the objective is reached
  - In case of not, simulations runs to optimize control parameters
2. DES-based on Shop Floor Control

Macroscopic process of on-line Simulation (reactive control)

- Monitoring the real system
  - An event occurs?
    - yes
      - Simulation initialization
        - Simulation
          - Simulated objective = Planned objective
            - yes
              - Control parameters correction on the real system
            - no
              - Control parameters optimization
                - Simulation
                  - Min. gap / planned objective
                    - yes
                      - Control parameters correction on the real system
                    - no
3. MES for real time Shop Floor Control

- Executes the orders.
- Delivers relevant information on the follow-up and the realization of the orders in real time.
- Decision making aid
4. Main specifications for on-line simulation-based SFC

- **Real time connection to MES (data acquisition and correction)**
4. Main specifications for on-line simulation-based SFC

- **Initialization of the model**

  Characteristics of OF-LINE simulation software :

  √ *When simulation starts, model is empty and idle.*
  √ *Classical method of warm up period is not adapted :*
    - the state of the model does not correspond exactly to the state of the real system
    - warm up is reached after simulation runs (response time)

  Specifications for ON-LINE simulation software :

  √ *When an event occurs on the real system (breakdown) :*
    - the state of the model must correspond to the state of the real system in a minimal response time
4. Main specifications for on-line simulation-based SFC

- **Minimal response time of the runs**
5. Experimental platform and outline

Operating System

On-line Simulation

MES

In construction…

http://193.50.91.173/control/userimage.html
Thank you for your attention