Ecologie industrielle et économie circulaire

GI-4-S2-EC-EIE 2024-25

13.&14. Disassembly

Disassembly Steps

- **Product Analysis**
  - Determine the value of the product after disassembly
  - The value includes: possibility of reuse of the product/components, risks of disassembly, service life after disassembly, etc.

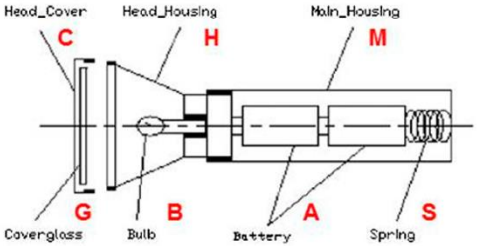
- **Assembly Analysis**
  - The assembly plan is essential for disassembly
  - The analysis will determine: the tools needed, the time and skills needed, knowledge of the components to maximize value, etc.

- **Analysis of product/component usage and condition**
  - Determine the value of each component/sub-component after disassembly
  - Operating status after disassembly
  - Which channel for maximizing the value of the component/sub-component

→ Need to properly manage disassembly operations to maximize value recovered

Selective disassembly sequencing problem

- Objective :
  - Finding the best sequences to disassemble a product and obtain the desired components
  - Minimize the cost of operations
- Constraints
  - Respect precedences between disassembly operations
- Case study: disassembling a torch

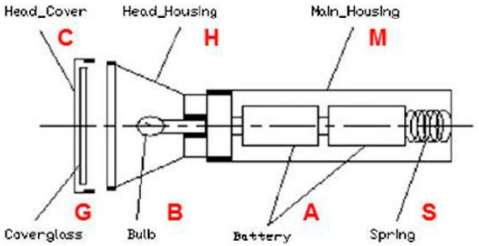


Kim, H. W., Park, C., & Lee, D. H. (2018). Selective disassembly sequencing with random operation times in parallel disassembly environment. International Journal of Production Research, 56(24), 7243-7257.

Selective disassembly sequencing problem

- Exercises :
  - Exercise 8 : Find the sequences that minimize the cost in the deterministic case
  - Exercise 9 : As the disassembly times are random (depending on the operator), find the best sequences in a desired time

- Exercise based on the study of Kim *et al.* (2018), but simplified (Exercice 8.xlsx available on Moodle).



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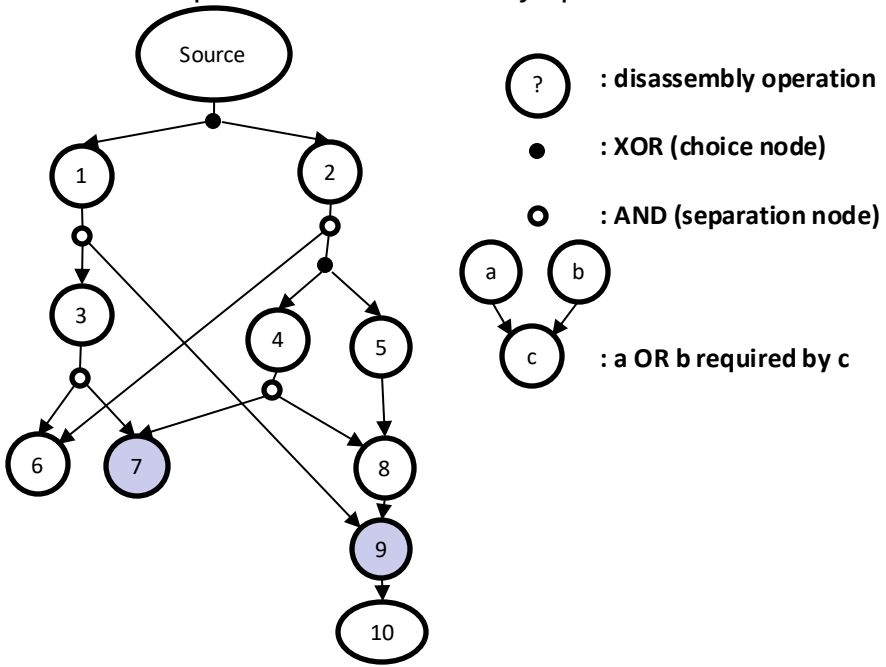
Graph of precedences, between operations

For our exercise, the desired components are obtained by operations 7 and 9.



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Mathematical model

N	set of nodes in the extended process graph, $i,j,\ k \backslash in\ N$
A	set of arcs in the extended process graph, $(i, j) \in A$
T	set of target components, $t \in T$
OR	set of choice nodes
or_{ij}	representation of OR, *i.e.* or_{ij} = 1 and or_{ik} = 1 iff you can do j XOR k after i, but not j and k together
c_{ij}	disassembly cost for operation j immediately after performing operation i, i.e. sum of the corresponding sequence-dependent set-up and operation costs that satisfies the triangular inequality, i.e. $c_{ij} \leq c_{ik} + c_{kj}$ for all $k \neq i, j$
PR_{ij}	=1 if disassembly operation j must be done immediately after disassembly operation i, and 0 otherwise

Decision variables

x_{ij}	= 1 if disassembly operation j is performed immediately after operation i, and 0 otherwise
y_i	= 1 if disassembly operation i is performed, and 0 otherwise

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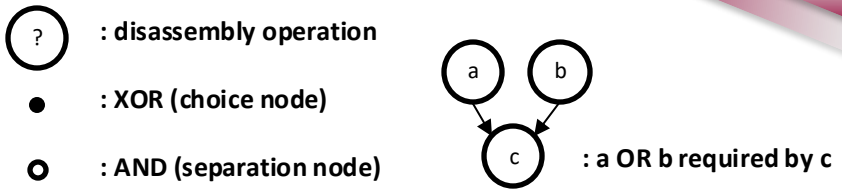
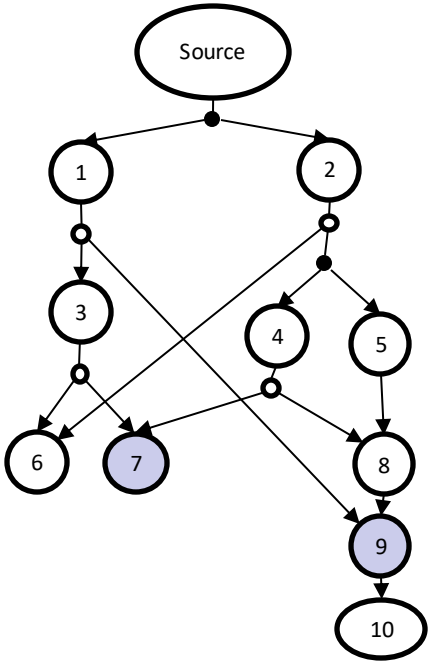
Mathematical model



Minimize Total Cost: $Minimise\ z = \sum_{(i,j)\in A} c_{ij}.x_{ij}$

Subject to :

1. Retention of the incoming flow: $\sum_{i\in N} x_{ij} \geq y_j$ $\forall j \in N\backslash\{\text{Source}\}$
2. Retention of outgoing flow: $\sum_{j\in N} x_{ij} \leq M.y_i$ $\forall i \in N$
3. Target Operations: $y_j \geq 1$ $\forall j \in T = \{7,9\}$
4. Loop Prohibited: $x_{ii} = 0$ $\forall i \in N$
5. Relationship of precedence : $\sum_{i\in N} PR_{ij}.x_{ij} \geq y_j$ $\forall j \in N\backslash\{\text{Source}\}$
6. XOR on choice nodes : $\sum_j or_{ij}.y_j \leq 1$ $\forall i \in OR = \{\text{Source},2\}$
7. Binary variables: $x_{ij} \in \{0,1\}, y_j \in \{0,1\}$ $\forall (i,j) \in N^2$



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