Plant Growth Scheduling

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EPFL

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Overview

Recall: GrowthBotHub

- Association at EPFL

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- Fully automated farm

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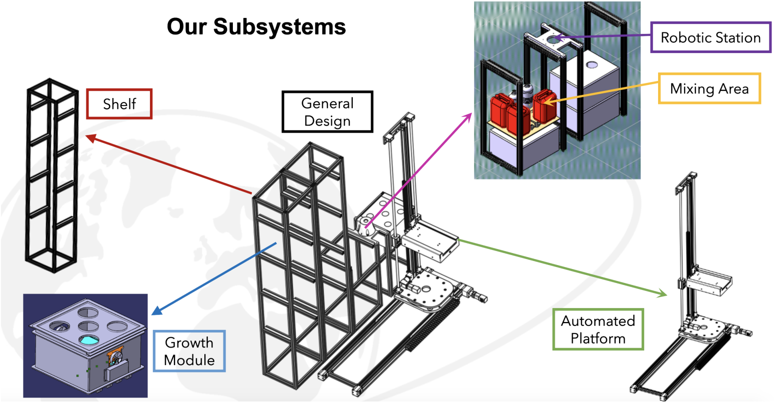

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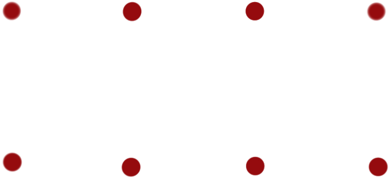
Multi-commodity flow and Time-expanded graph



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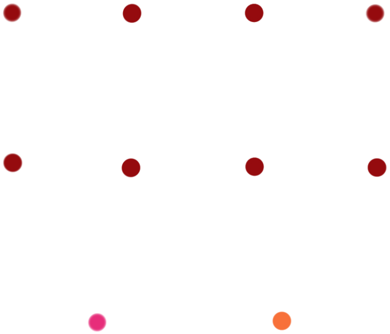

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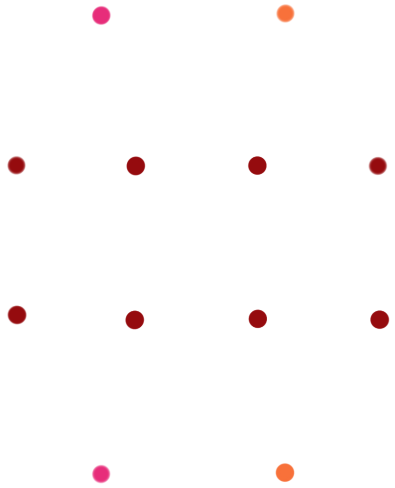

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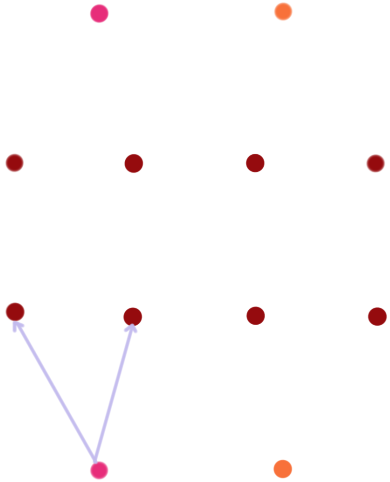

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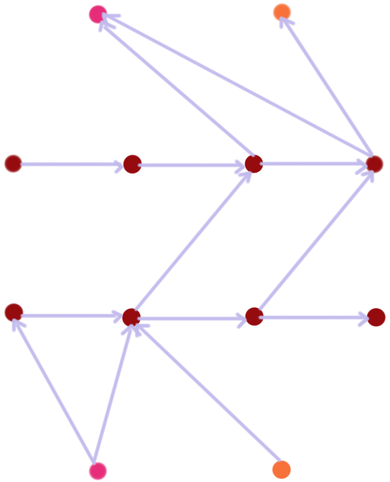

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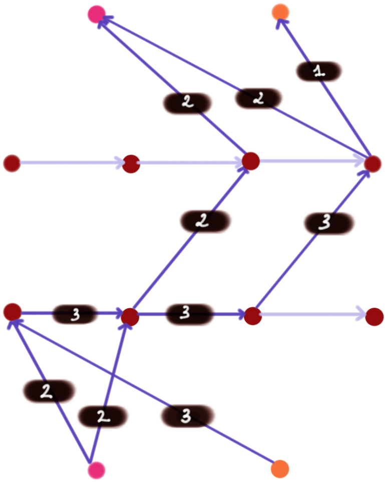

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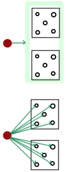

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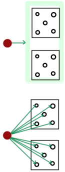

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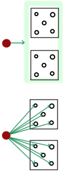

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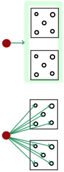

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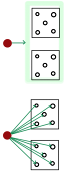

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$$\text{maximize} \quad \sum_{p=1}^{P} \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}}$$

$$\text{subject to} \quad \sum_{(i,j)\in\delta^+(n)} x_{ijk} - \sum_{(i,j)\in\delta^-(n)} x_{ijk} = 0 \quad \forall n \in V - \{S, T\}$$

$$\forall (i,j) \in E \quad \sum_{p=1}^{N} \sum_{d=1}^{size(k_p)} x_{ijk_{p_d}} \leq 5$$

$$\forall p \in \{1....N\} \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}} \geq \frac{\sum_{p=1}^{N} \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}}}{N} - \alpha$$

$\longrightarrow$ ensures that we have a long term diversity

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  $\longrightarrow$ penalize the objective function each day where we don't harvest a plant.

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$$\forall d \quad \forall p = 1 \ldots N \quad \sum_{d}^{d+3} y_{t_{p_d}} \leq 1$$

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- More cons than pros $\rightarrow$ dropped by the association

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Plant's size: architecture's precision

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- We need to have control over the arrangement of a growth module

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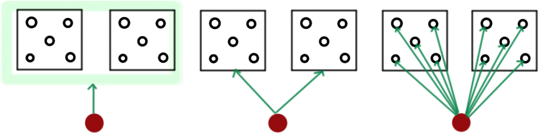

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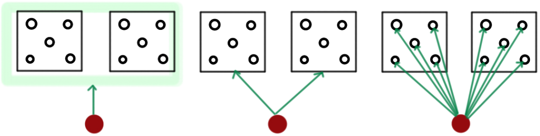

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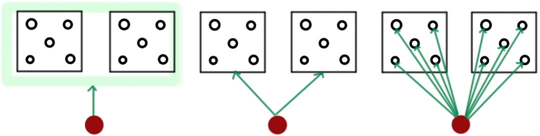

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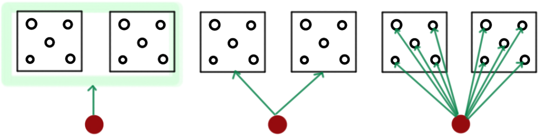

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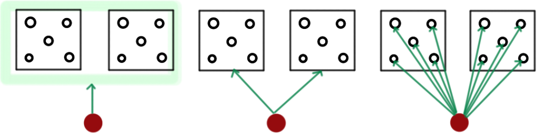

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$\longrightarrow$ they will cause problem in the growth modules of type 2

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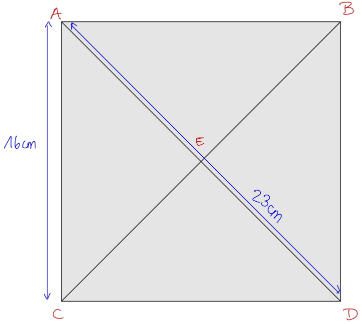

Figure: A growth module with its dimensions.

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- Number of plants remains the same
- Running time

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- use old algo version (1 node = 1 type of module)
- each iteration takes a few minutes instead of a few hours!

Conclusion

	Last semester	Now
Size of the graph	(14412 , 212'490)	(2892, 38'280)
Number of modules	8	16
Running time	MemoryError	5h30
Constraint Diversity	✖	✔
Plant's size	✔	✔
Number of plants	MemoryError	206

Table: Comparison of the scheduling algorithm before and after our project

$$\text{maximize} \quad \sum_{p=1}^{P} \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}} - \sum_{d=1}^{D} z_p - v \sum_{(i,j)\in E} y_{ij}$$

$$\text{subject to} \quad \sum_{(i,j)\in\delta^+(n)} x_{ijk} - \sum_{(i,j)\in\delta^-(n)} x_{ijk} = 0 \quad \forall n \in V - \{S, T\}$$

$$\forall (i,j) \in E \quad \sum_{p=1}^{N} \sum_{d=1}^{size(k_p)} x_{ijk_{p_d}} \leq 5$$

$$\forall p \in \{1 \ldots . N\} \quad \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}} \geq \frac{\sum_{p=1}^{N} \sum_{d=1}^{size(k_p)} \sum_{(i,j)\in\delta^+(s_p)} x_{ijk_{p_d}}}{N} - \alpha \quad \alpha \geq 0$$

$$z_d \geq 0$$

$$z_d \geq 1 - \sum_{p=1}^{N} x_{t p_d}$$

$$\forall (i,j) \in E \quad \forall p \quad \forall d \quad x_{ijk_{p_d}} \leq 5 y_{ij}$$

$$\forall i, j \quad y_{ij} \in \{0, 1\}$$

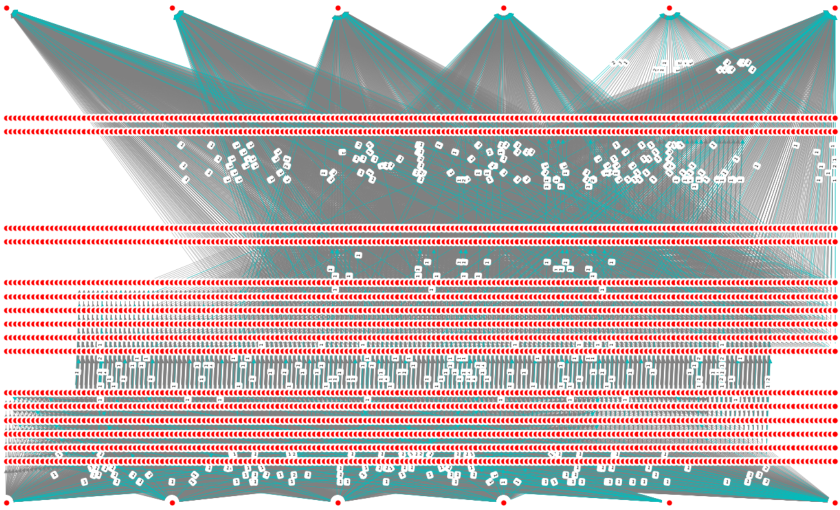
$$\forall d \quad \forall p = 1 \ldots . N \quad \sum_{d}^{d+3} y_{t p_d} \leq 1$$

$$x_{ijk_{p_d}} \leq 2$$

The inputs

- 4 types of growth module
  - 6 trays of module 1 ("seedling")
  - 6 trays of module 2 ("vegetative")
  - 2 trays of module 3 ("flowering")
  - 2 trays of module 4 ("development")
- Total number of days: 180 (6month)
- 6 types of plants
  - Lettuce: 30 days in module 1, 25 days in module 2
  - Endive: 20 days in module 1, 40 days in module 2
  - Cabbage: 20 days in module 1, 30 days in module 2
  - Fennel: 20 days in module 1, 30 days in module 2
  - Raddish: 15 days in module 1, 15 days in module 2
  - Strawberry: 49 days in module 1, 21 days in module 2, 28 days in module 3, 19 days in module 4

Graph of the optimal solution of the scheduling problem



Results

- Total number of lettuces:
- Total number of endives:
- Total number of cabbages:
- Total number of fennels:
- Total number of raddishes:
- Total number of strawberries:

$\longrightarrow$ Total number of plants: 168

Snippet of the instruction file

Snippet of the content of a module on a given day