PLANT OF THE FUTURE: SOME CONCEPTS

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Summary:

- Context: General ideas
- Vision from Manufacturing
- Industrial Ecoparks
- Conclusions

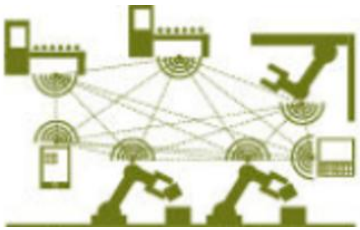
Plant of the Future: the 4th Revolution

1784:Heat steam Machine-hydraulics/Machine Manufacturing

1870: Electricity /Massive Manufacturing

1969: Automates and Robots /Robotic Manufacturing

2013: fully interconnected systems / Intelligent manufacturing



Plant of the Future

Plant of the Future: « generic » term very often used today with behind different ideas in mind

« We have to introduce new/newest technologies, processes and services with a higher speed in order to meet the demand and end-user satisfactory» (Robert Plana)

Integration of digital technologies embedded in the industries (4th revolution)

- New generation of factory: Cyber-factory, digital factory 4.0, "Integrated industry", "innovative factory", industry 4.0, intelligent industry

Digital factory: Factory which trust to Internet tools for the future

- Germany: plan “German manufacturing Industry”
- USA: "Advance Manufacturing"
- France: "Productivez« , Futurprod
- ……..

4th industrial revolution (2020): extreme computerization of productivity and economical exchanges

- interconnected global system: final product will communicate with the machines in the phase of production « smart product » with machines all interconnected
- up-to-date and updating technological evolution
- Industrial production system based on flexible units completely automatic and totally interconnected taking into account information coming from the integrated supply chain

4th industrial revolution (2020): extreme computerization of productivity and economical exchanges

- Existing technological blocks: intelligent sensors, automates, CAPO, PLM,…, ERP, internet of objects, Cloud computing, …. Big data

Industry 4.0 (German report)

- Factory more based on digital and more flexible systems
- Virtual simulation tools(immaterial simulation: Falcon 7X) and use of massive data treatment systems
- Factory very efficient and scarse in raw material consumption, energy using better exchanges with better coordination of needs and supplies

Industry 4.0: gain in efficiency by more automated systems and short circuit between the production and the market

- Notion of total communication between internal components and the market(external system)

TOOLS

- **intelligent sensors, basic elements for the 4.0:**
  - **More accurate and more autonomous**
  - **essential block for the e-maintenance(John Deere)**
- **interconnection in the Control/command system**
  - **Automats: component or software immerged in the production system with self-decision procedure**
  - **Interoperability in networks**
- **Supervision: collaborative platform**

Software aspects: Building blocks of the digital factory -----> convergence

- CAPD & Operability
- Product life cycle management(PLM)
- Manufacturing executive system(MES)
- Entreprise resource planning (ERP)
- E-maintenance
- Supply chain management(SCM)
- Consumer Relationship management(CRM),.....

Notion of « extended » enterprise

- New tools: Cloud computing, Big data, « social networks (private or public: « Open innovation»), 3D printing(prototyp, Fablab),….

Closed link between logistic aspects and the overall enterprise management

- Raw materials and Energy: to be secure and to download the cost ---> more « frugal industry », very secure supply, low cost system
- Industrial ecoparks versus clustering of smart industries

Products and services have to be really completely interconnected and designed all together

Benefits expected from digital industry 4.0

- To adapt the production system to the demography evolution and to the globalization
- To optimize consumption of raw materials and energy(Life cycle assessment/Circular economy)
- To get a strong link with partners and consumers
- Lean Manufacturing/production:

  « Enterprises have reached a new area with a permanent adaptation : A320/330 ---->Avion Neo/Neo plus, …»

Plant of the Future

inspired from Usine nouvelle 3370, March 2014

Novel concepts of Industrial Organization

- **Industrial Ecology (IE):**
  - **Industrial organisation more balanced and rational than conventional one**
  - **Emulation from natural ecosystems:**

    Wastes ⟷ Raw materials
  - **PSE inputs: material and energy balances in industrial systems**

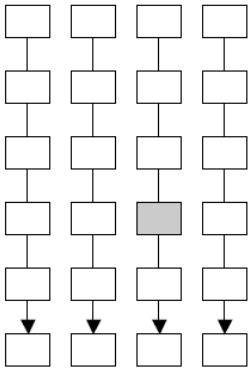
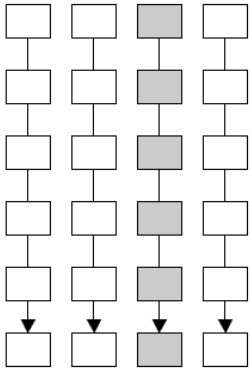
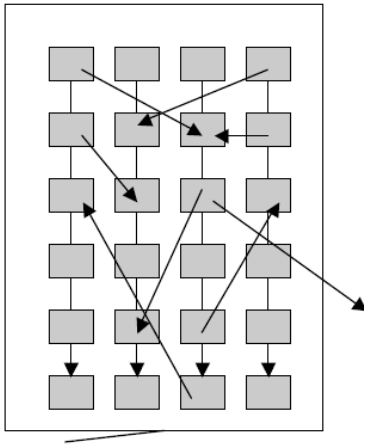
Industrial Symbiosia

- **Eco-industrial parks (EIP):** a particular application of IE

  Enterprises in a same geographic area sharing at mimimum their energetic ressources and raw materials

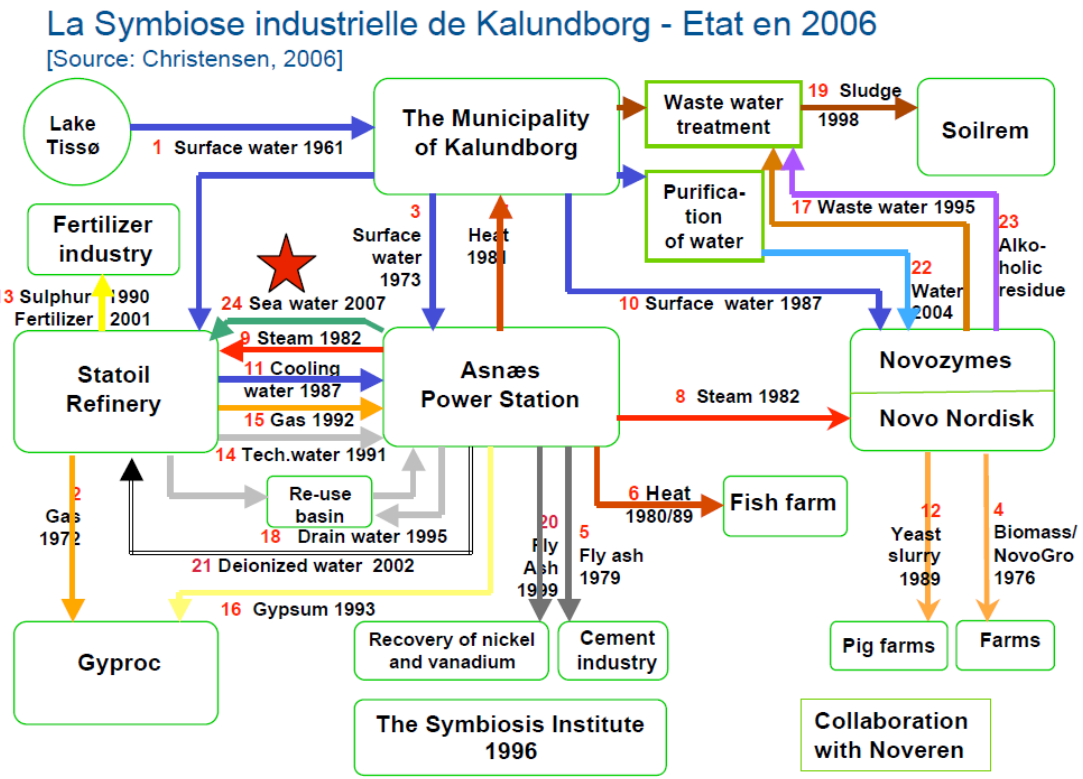
Novel concepts of Industrial Organization

Different approaches

Clean Production	Eco Design	Industrial Ecology
		
Process	Product	system

Source: www.ntnu.no/IndEcol

Novel concepts of Industrial Organization



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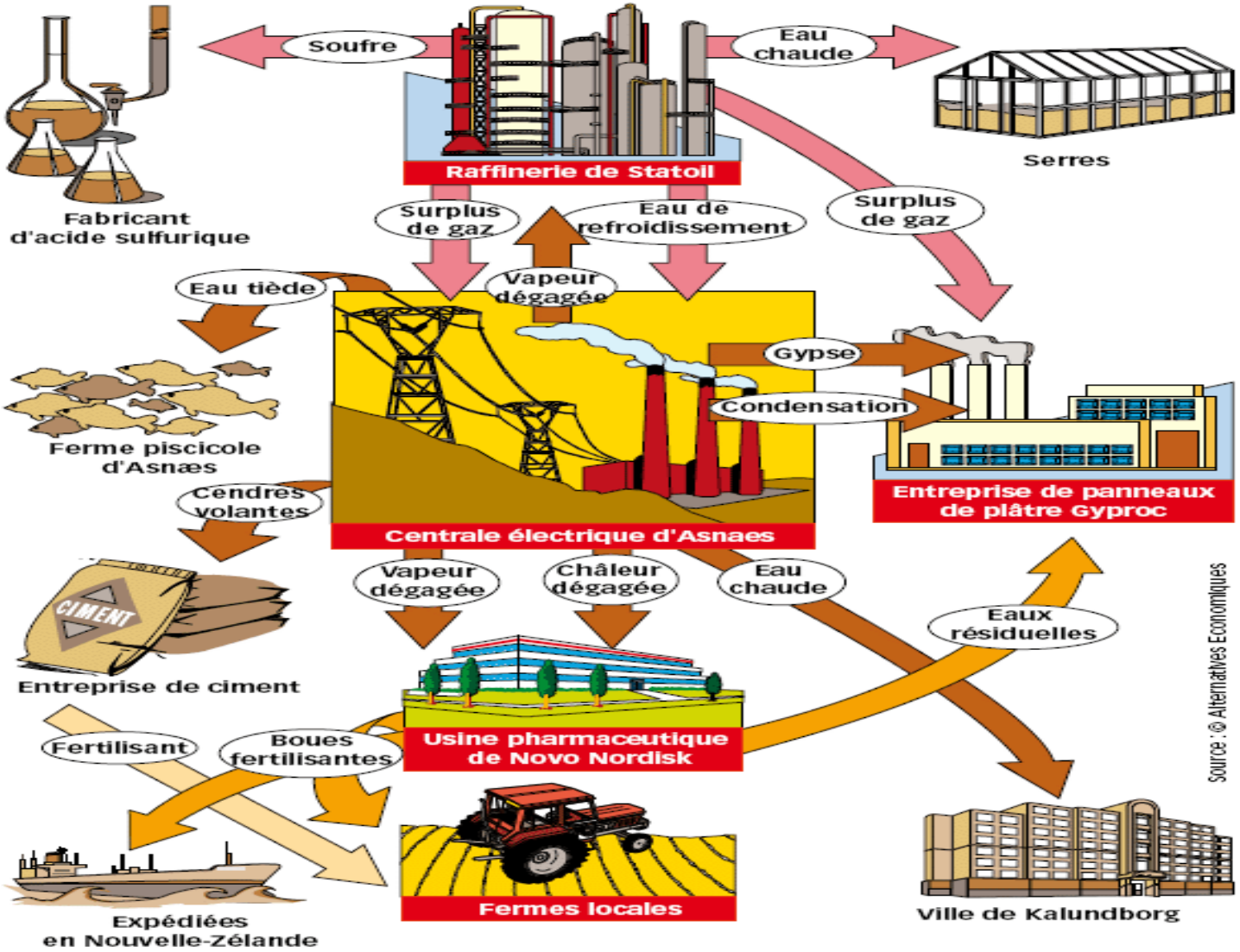
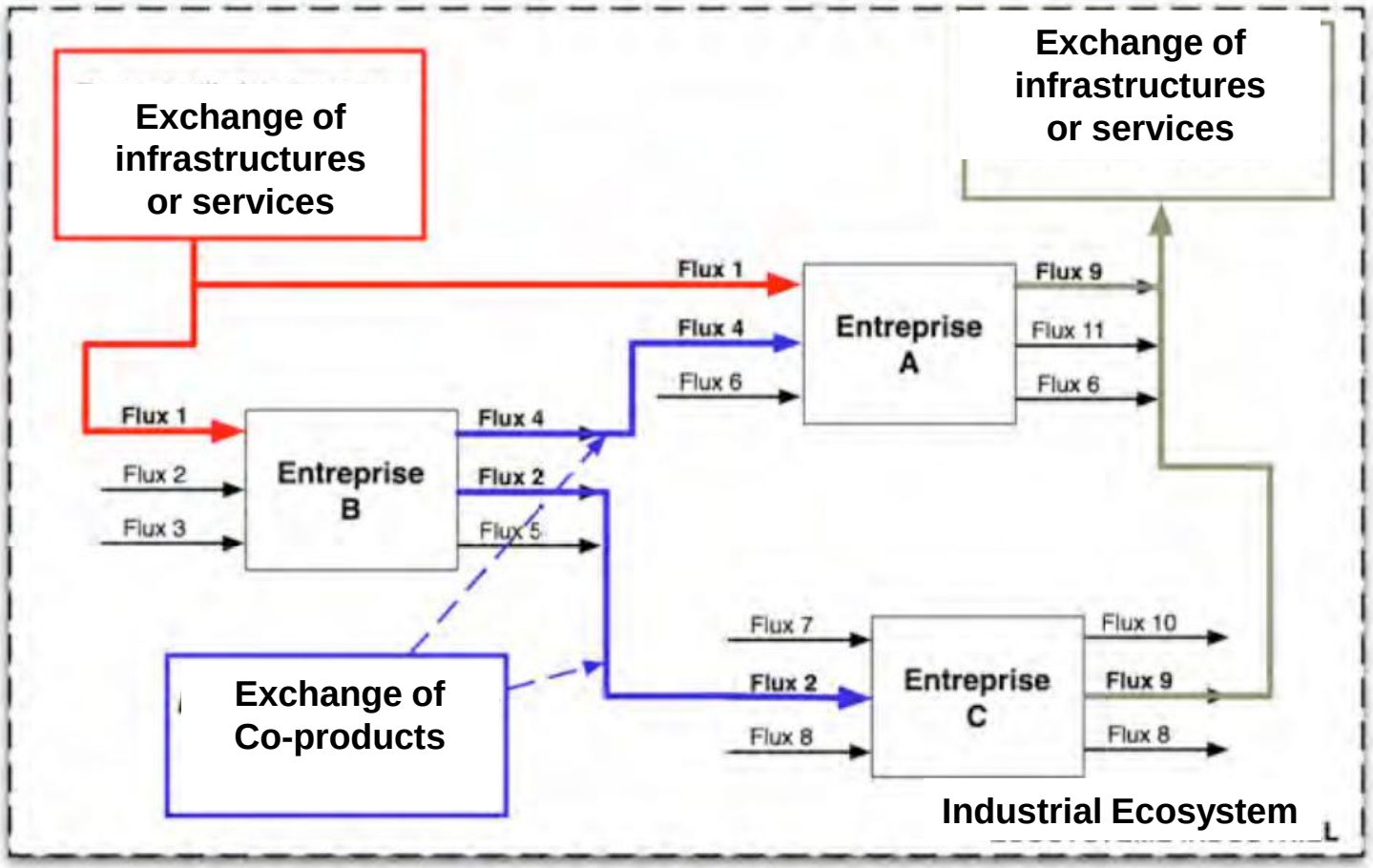
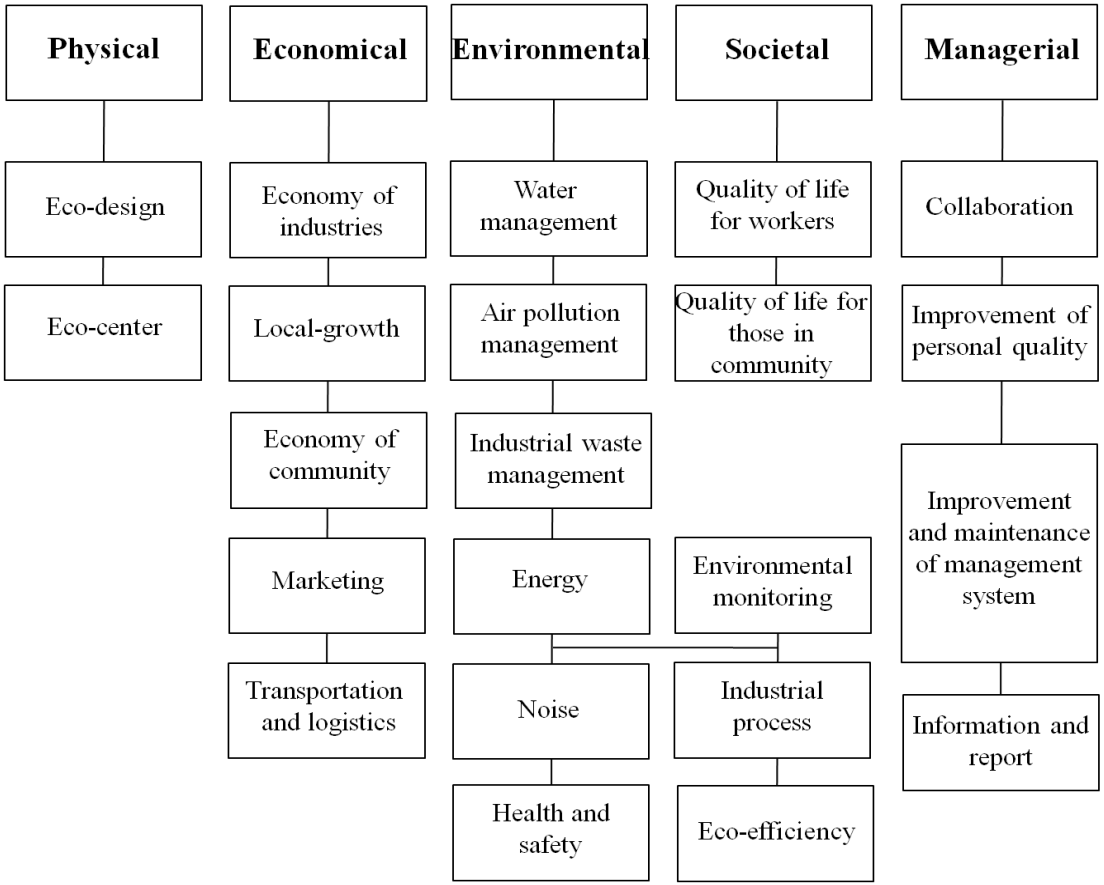


Différents types de symbioses



Novel concepts of Industrial Organization



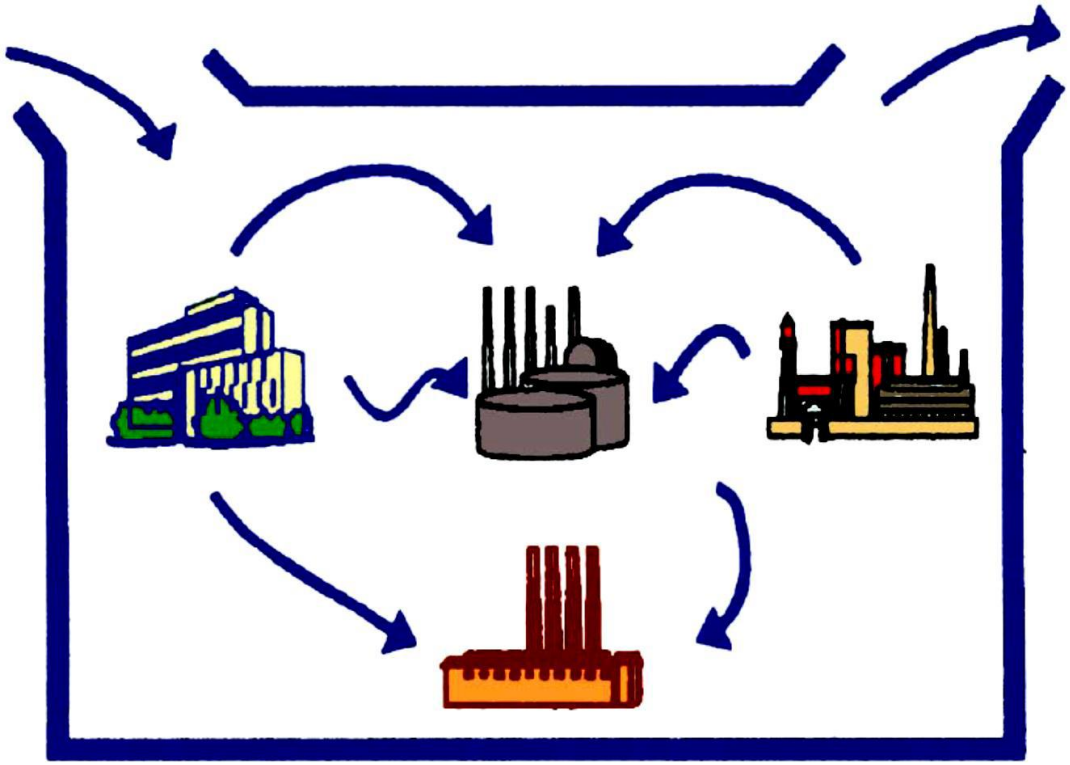
Panyathanakun, V., Tantayanon, S., Tingsabhat, C., Charmondusit, K., 2013. Development of eco-industrial estates in Thailand: initiatives in the northern region community-based eco-industrial estate. Journal of Cleaner Production, 51, 71-79.

Plant of the Future

- **Economy :**
  - Total annual cost — Min
- **Management and Societal aspects:**
  - Satisfaction of each participant of the EIP — Max
  - Jobs creation — Max
- **Topology :**
  - Number of interconnections in the network — Min
- **Environnement:**
  - Ressources utilization (water, energy) — Min
  - Environmental impacts — Min
  - Water footprint — Min

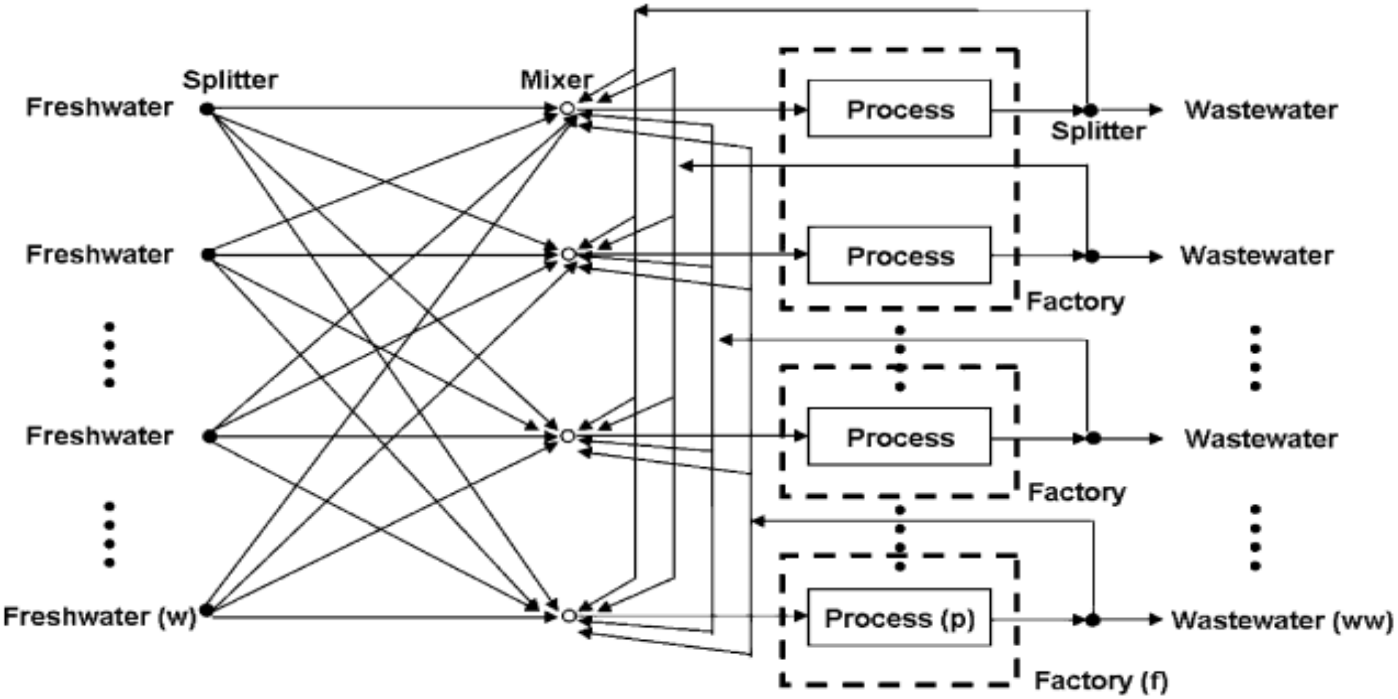
► Optimization :

- Goal: Finding the optimal design of process units and interplant exchanges.
- Key point: modeling detail of each compagny

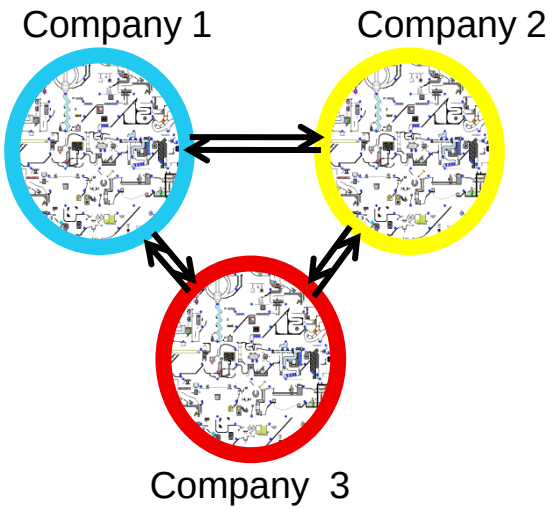


► Superstructure concept:

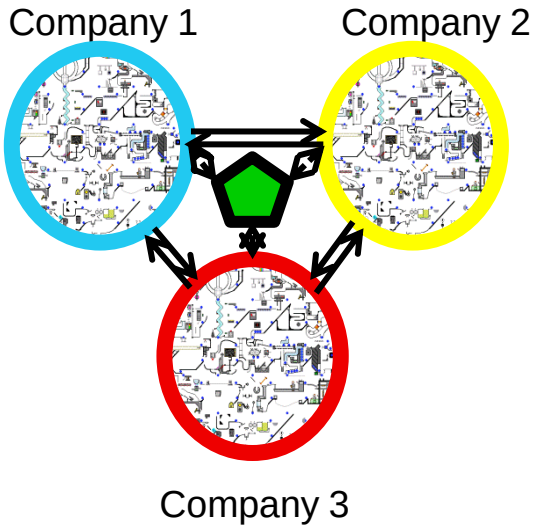
- Systematic approach for the **modular representation** of process design
- Mathematical programming: choice of the **optimal network** among the different solutions



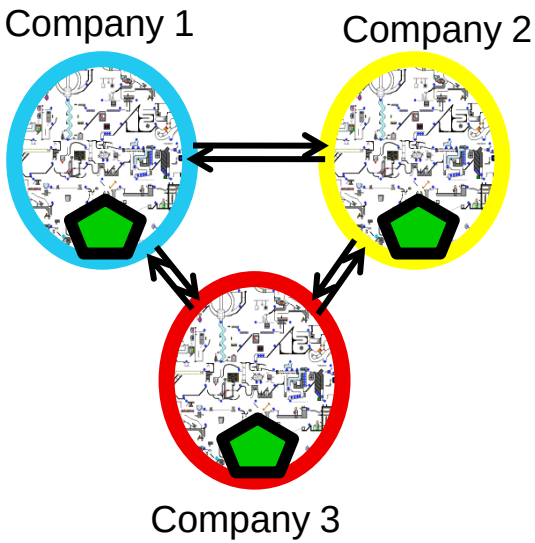
Mono-objective approach…



Profit+4.3%



Profit 65%



Profit +70%

Multiobjective optimization

► Antagonist objectives:

$$min\{f1(x,y), f2(x,y), \dots, fn(x,y)\}$$

s.t $h(x,y)=0$, $g(x,y)=0$

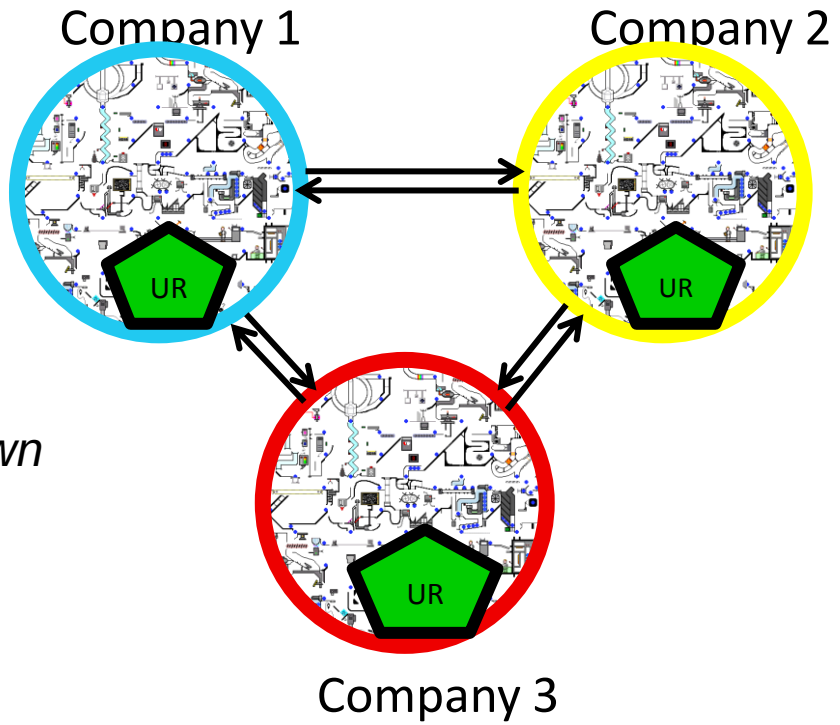
$x \in \mathcal{R}^n$, $y \in \mathcal{R}^m$, $h \in \mathcal{R}^p$, $g \in \mathcal{R}^r$

► Resolution methodologies:

- Building the Pareto Front and *a posteriori*, using MultiCriteria Decision Making (MCDM) tools.
- Directly using methods to obtain a compromise solution.

Case 1

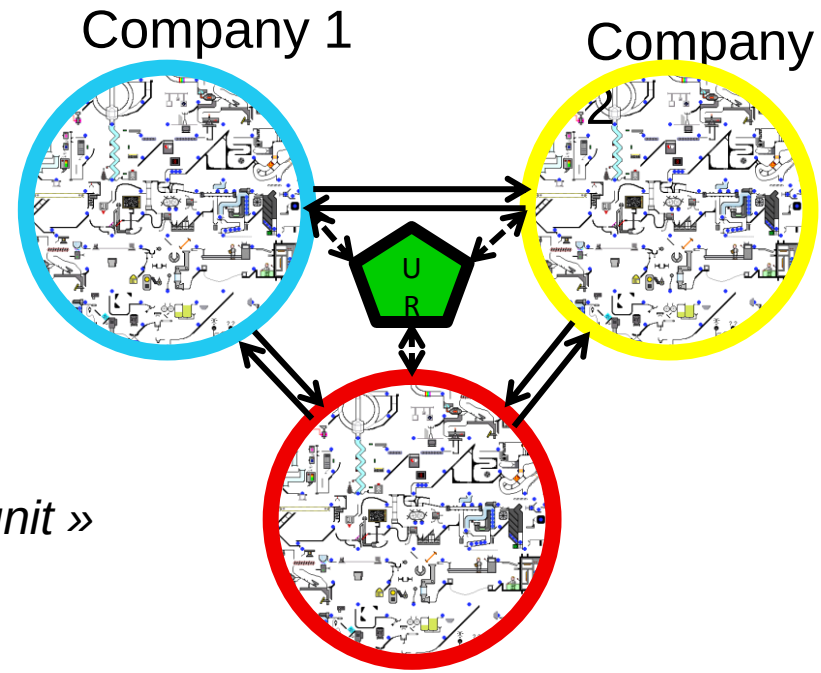
« Each plant owns its own regeneration unit »



Objective function (MMUSD/yr)	Min.	Max.	GP solution
Cost C1	1.514	6.964	**1.854**
Cost C2	1.144	7.046	**1.513**
Cost C3	2.813	14.134	**3.521**

Case 2

« The plants share a common regeneration unit »



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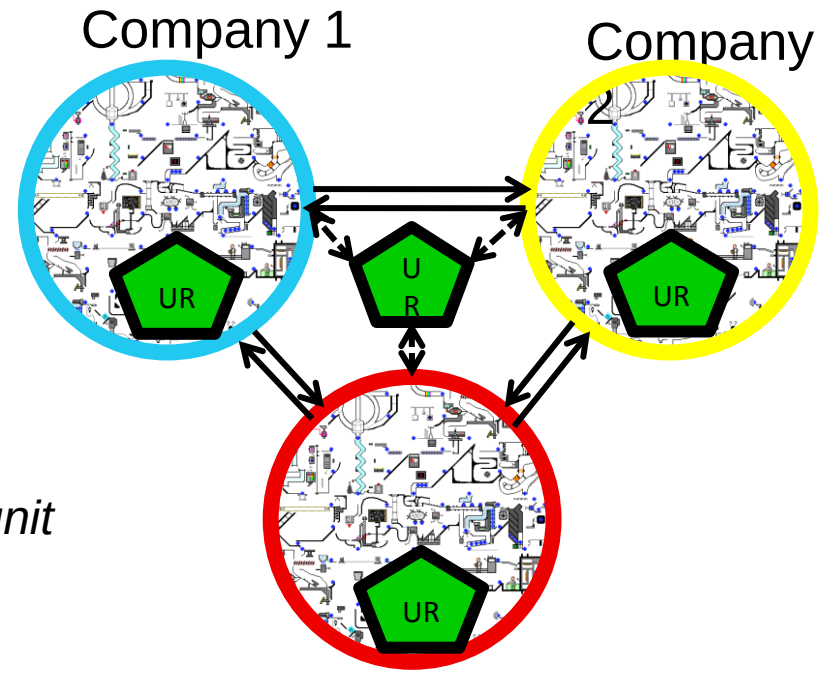
Cost C1	1.143	13.781	**1.976**
Cost C2	1.138	6.824	**1.316**
Cost C3	1.154	15.361	**2.981**

Case 3

« The plants share a common regeneration unit and can also own their unit »



RU are optimally chosen among 9 possible types

Objective function (MMUSD/yr)	Min.	Max.	GP solution
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Case 3

559 Industrial symbiosa in the world

Conclusions:
Recommandations for the plant of the future

- 1. No efficient exchanges without normalization or standard
- 2. No complex systems without virtualization
- 3. no guarantee for proper service without very high network rate
- 4. No confidence without cybersecurity
- 5. No industry 4.0 without new approaches and industrial organization
- 6. No industry 4.0 without changes in learning and education

  (A7 4.0: Nomadism, web laboratory, learning center, RFID applications, Photovoltaic plant on the parking(5000 M2))
- 7. No industry 4.0 without any reglementary evolution
- 8. No efficiency without resources optimization

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1780 - Révolution industrielle 1.0
Premières installations de fabrication mécanique.

1900 - Révolution industrielle 2.0
La production de masse fondée sur la division du travail.

1979 - Révolution industrielle 3.0
Un réseau intelligent, système de fabrication autonome.

2020 - Révolution industrielle 4.0
Réseau Intelligent, Systèmes de fabrication autonome.

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http://www.usine-digitale.fr/article/video-l-incroyable-usine-qu-airbus-prepare-pour-2025.N268567

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« For the first time in the history of human mankind, the economy is covering the entire planet,

For the first time, human people are mastering the exchanges of goods and the exchange of information in real time,

We are the actors and witnesses of an industrial revolution with major technological changes, with the unbelievable emergence of Asia and with the decline of ideologies coming from the 20th century….. »

Philippe Chalmin, Professeur d' Histoire économique à l' Université Paris Dauphine