The GRAI Method
Part 1: global modelling

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- 1. Introduction
- 2. The GRAI model
- 3. The GRAI grid

First part

INTRO-DUCTION

Definition of the GRAI method

- The GRAI method owns to the enterprise modelling domain. The purpose is to design or reengineer production systems (manufacturing or service).
- The GRAI method focuses on the decisional aspect (control system).
- From a general point of view, the GRAI method applies to performance improvement.

Composition of the GRAI method

The GRAI Method:

- is built up starting from a **reference model**, the GRAI model, which is a consistent set of concepts that model any production system in a generic way and *a priori*,
- is based on **graphical modelling languages** which instantiate the concepts of the GRAI model to build the specific model of the studied case,
- follows a structured and participative **approach** within which actors and steps are defined, allowing effectiveness and time saving.

Composition of the GRAI method

Note:

The GRAI nets and the structured approach are not presented in this course and can be found in:

The GRAI method
Part 2: detailed modelling and methodological issues

Application domains of the GRAI method

- Production systems **engineering**,
- Choice and implementation of **software packages** for management: ERP (Enterprise Resources Planning), SCM (Supply Chain Management), CRM (Customer Relationship Management) or other computerized solutions (decisional...);
- Choice and implementation of **performance indicators** systems;
- Development and implementation of **industrial strategies**;
- Support to **quality** approaches;
- **Knowledge** Management.

Second part

THE GRAI MODEL

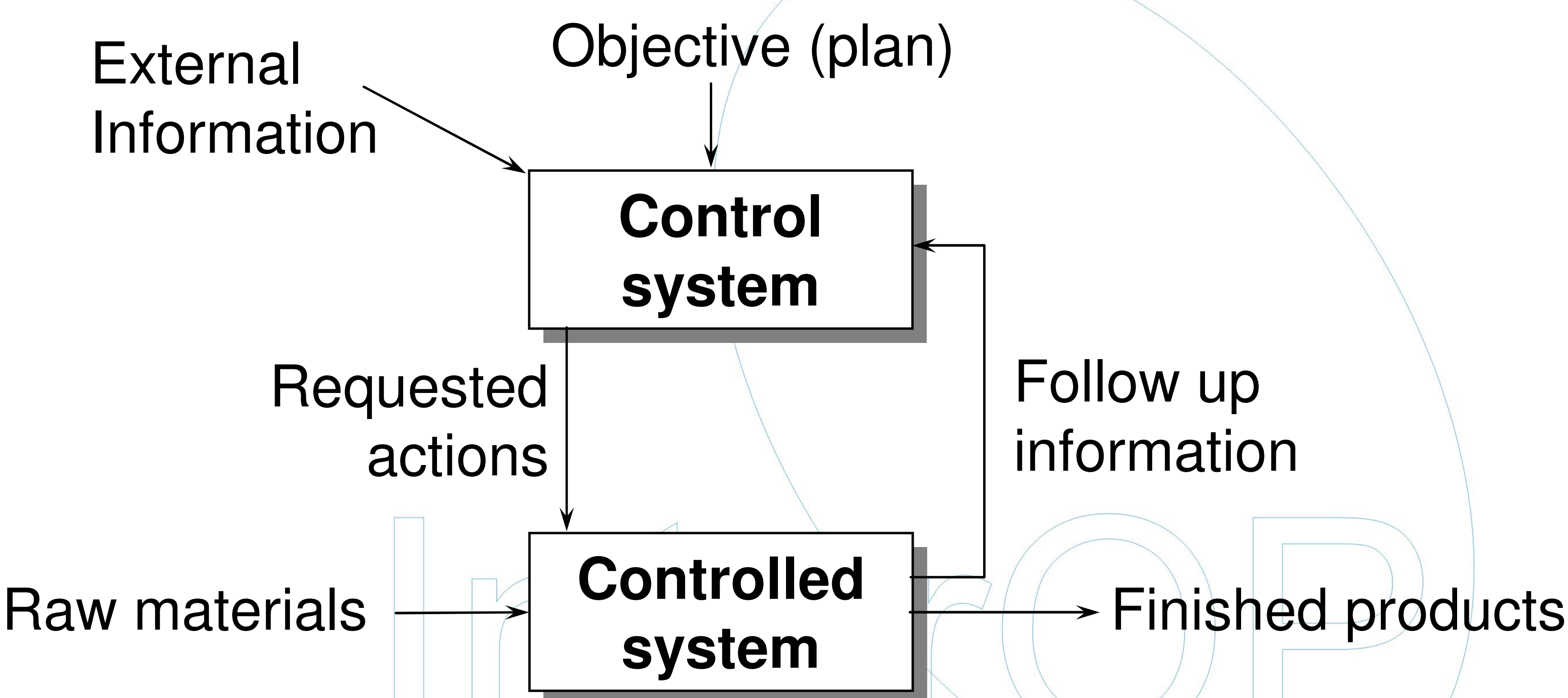
INTRODUCTION

Objectives of the GRAI model

The GRAI Model:

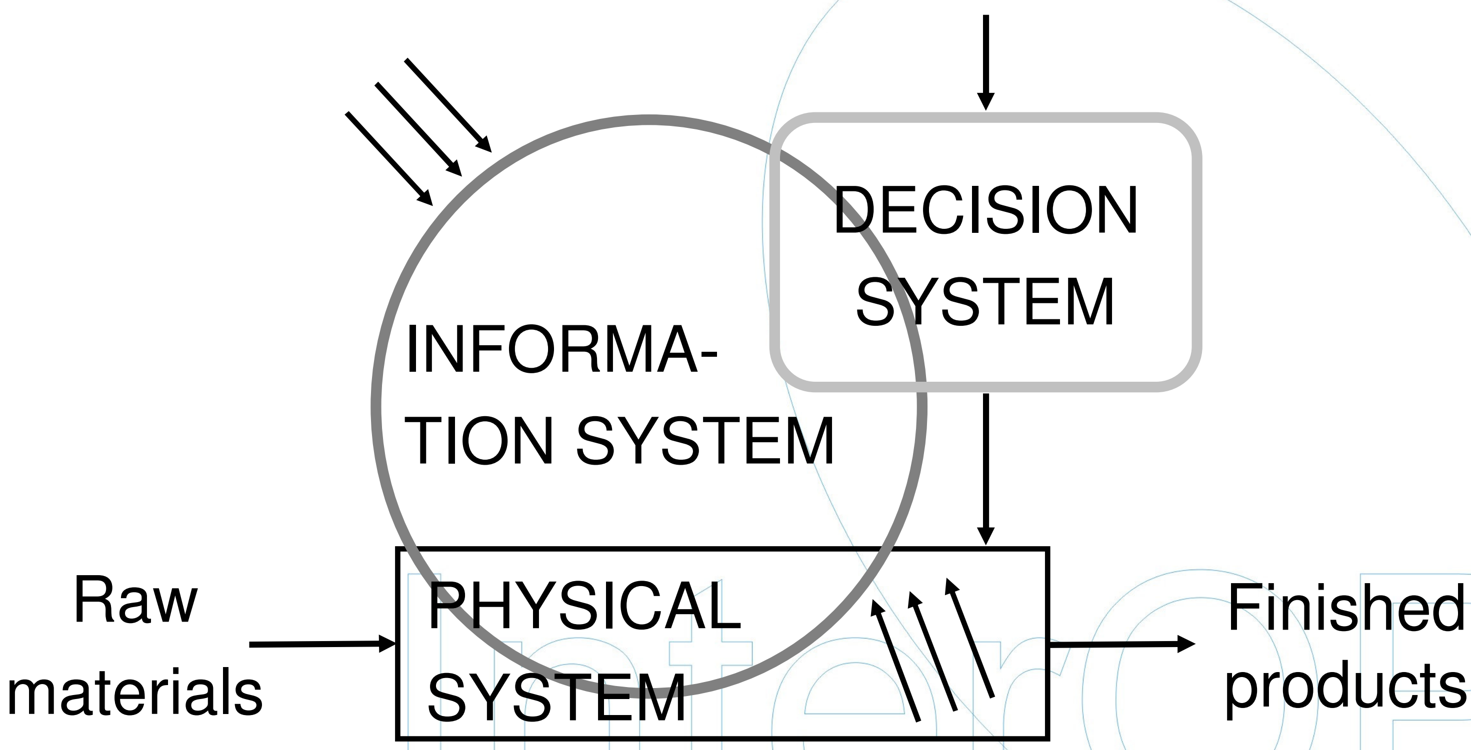
- defines the reference conceptual structure of the production system of any manufacturing or service firm or of any organization,
- defines the basic concepts and their interrelationships.

System control



(physical system or operating system)

Information system emergence



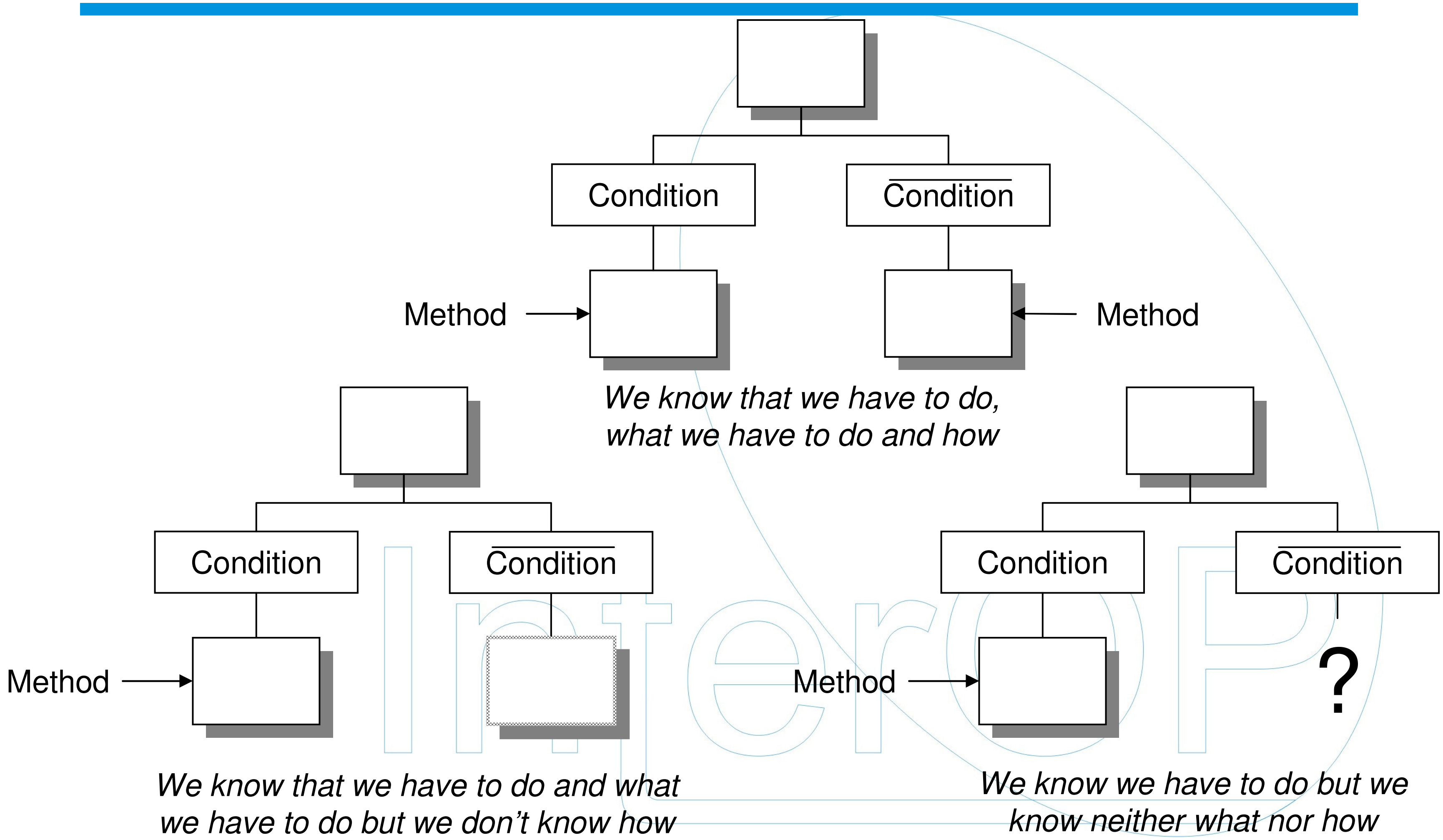
DECISION IN THE GRAI MODEL

Definition

DECISION: Activity of choice between several possibilities

"To decide, it is to identify and solve the problems that any organization encounters" (H.A. Simon)

Decision making: possible situations



Decision components

To **DECIDE**, it is necessary to know:

- expected performances of this decision (**OBJECTIVES**),
- elements on which one can play (**DECISION VARIABLES** or action variables),
- limits of the potentiality of the decision variables (**CONSTRAINTS**),
- the result of the previous decisions (**PERFORMANCE INDICATORS**),

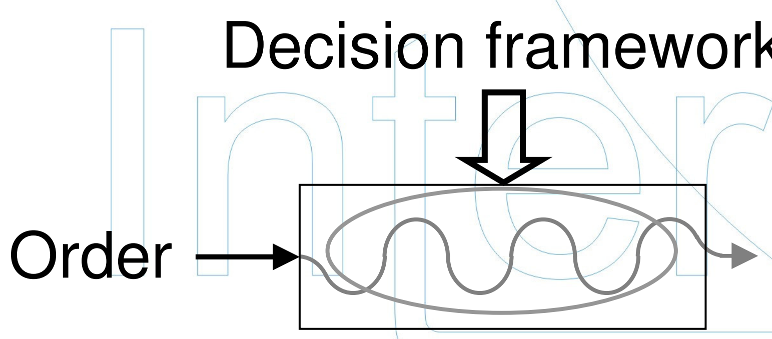
and to have:

- a support to choose among possible actions (**CRITERIA**).

Decision framework and order

All the elements which have been right described constitute the **DECISION FRAMEWORK.**

The decision framework is fundamentally different from the principal information to be processed qualified of **ORDER.**



Decision framework and order

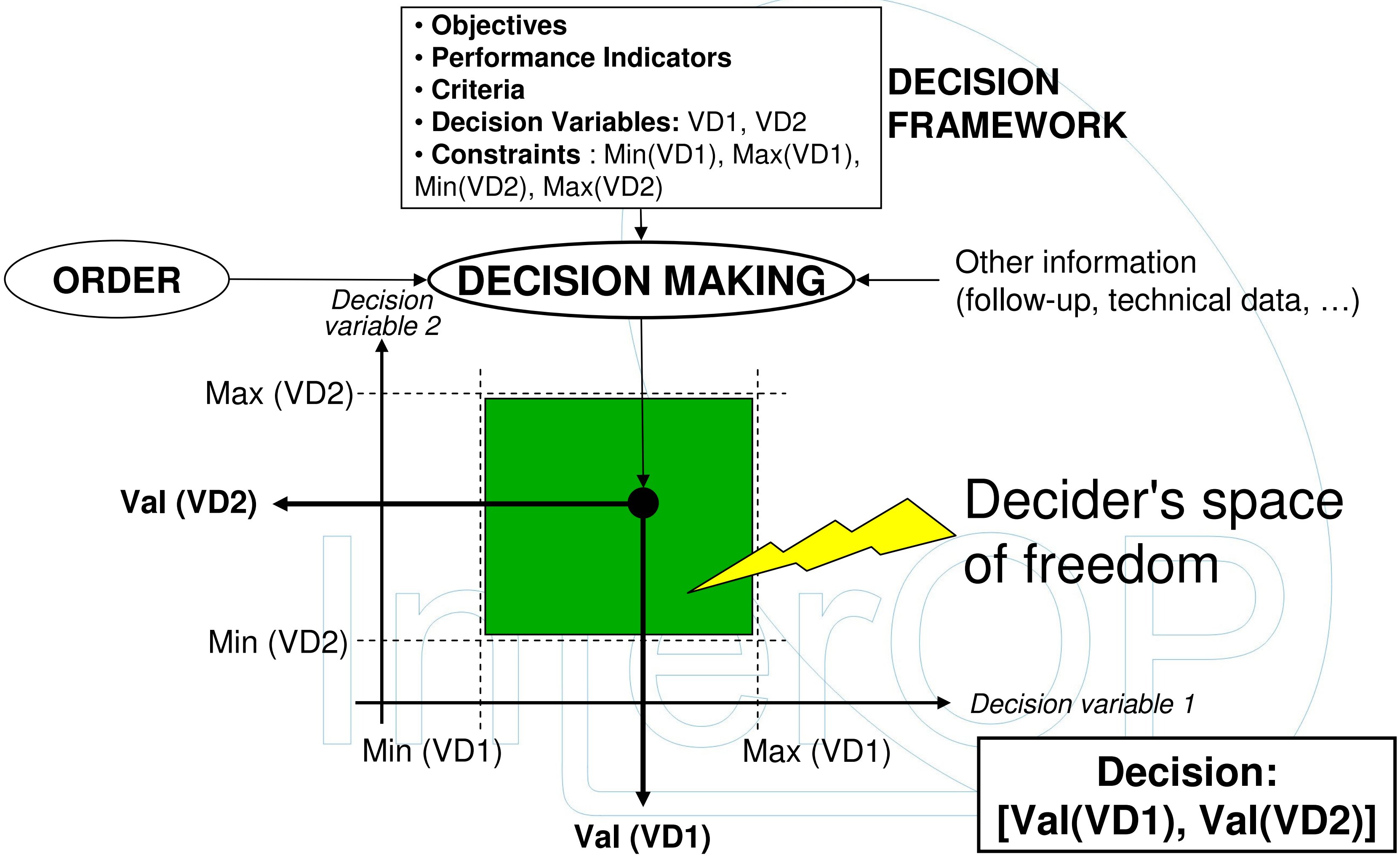
Example: Integration of the orders book in a production plan

Order: order books

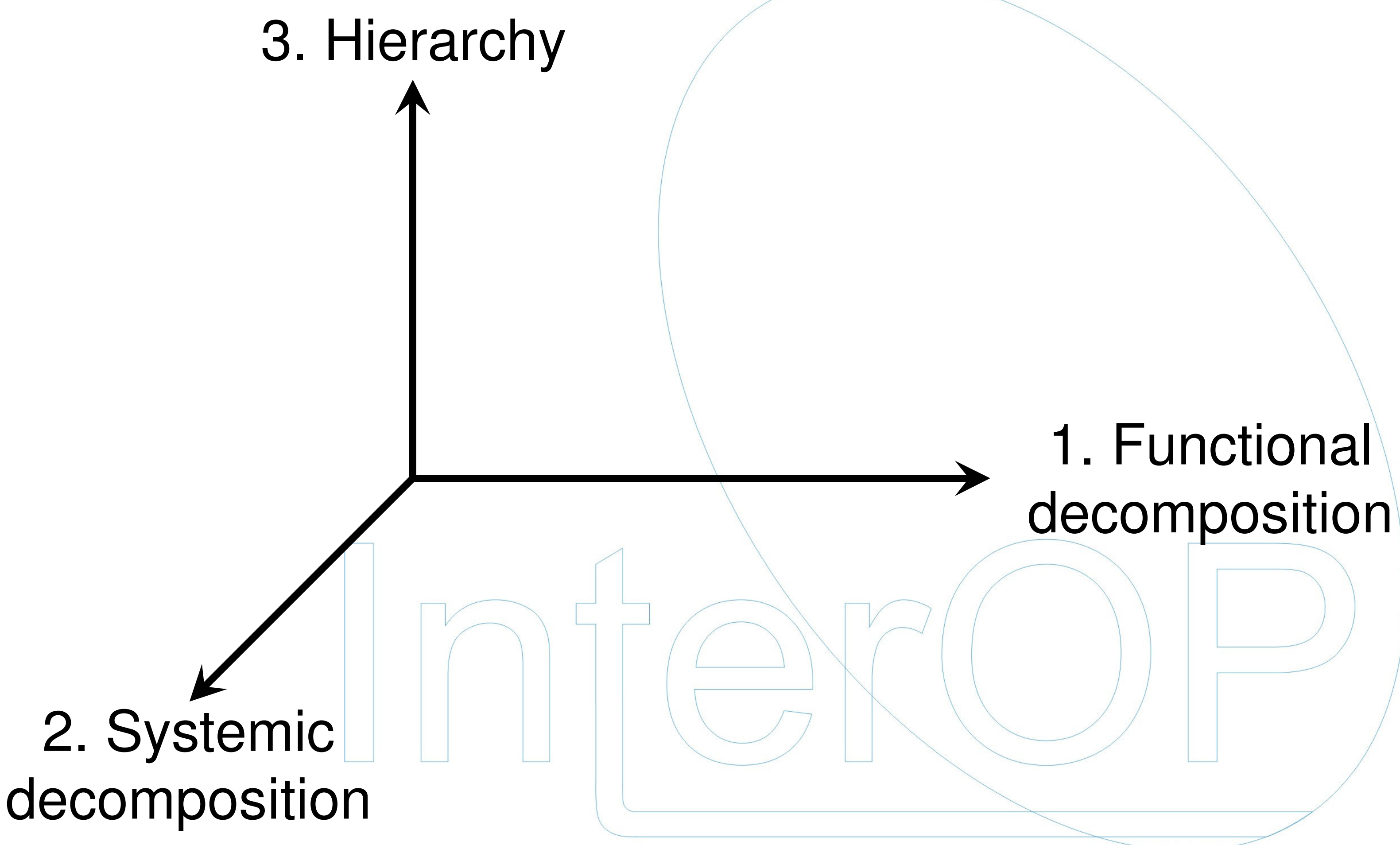
Decision framework:

- Objective: respect of deadlines, costs, etc.
- Decision variables: resource allocation, etc.
- Etc.

Conceptual view of decision making



Three decomposition axes



FUNCTIONAL DECOMPOSITION

Decomposition according to functions identified in the enterprise

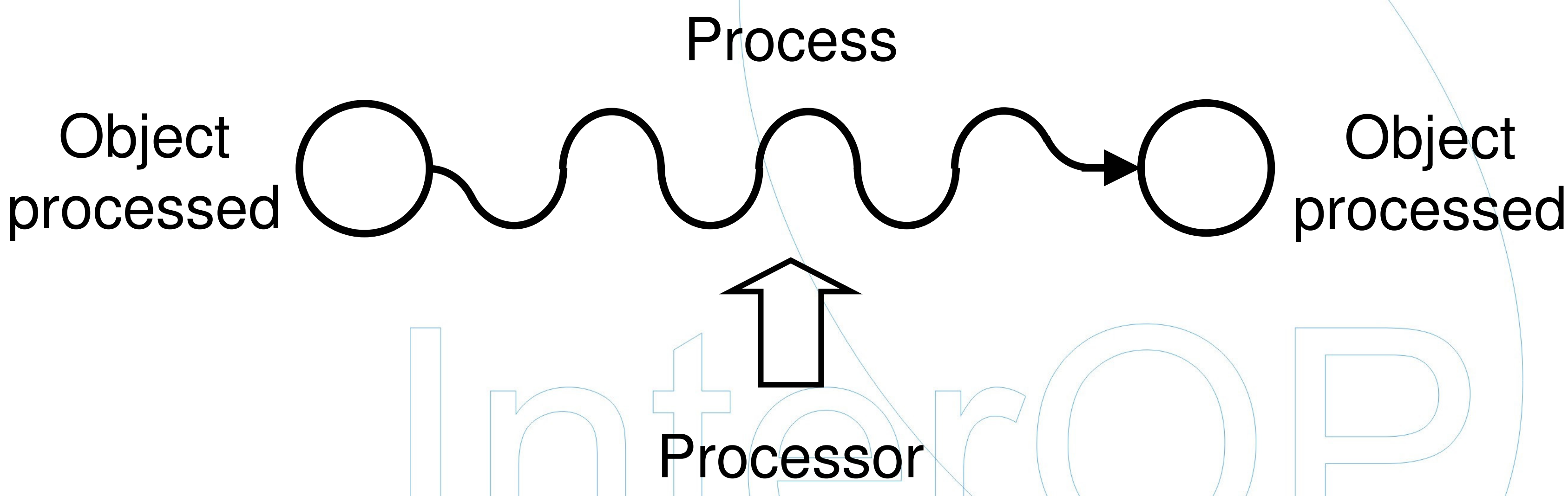
Structure of the control system starting from a free division of the company:

- Traditional functions (commercial, design, industrialization, manufacturing, delivery...)
- Big process (purchasing, manufacturing, assembly, completion, delivery...)

SYSTEMIC DECOMPOSITION

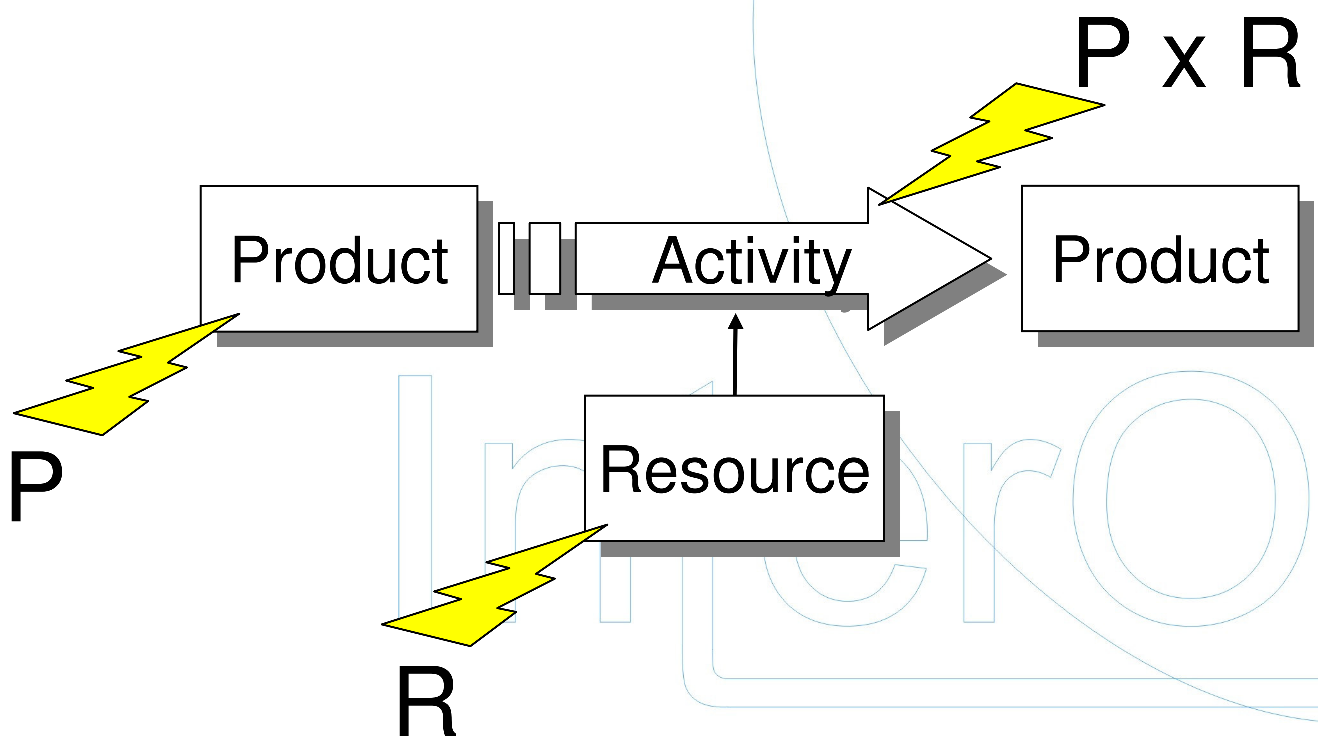
Activity control

From a typology coming from systems theory…



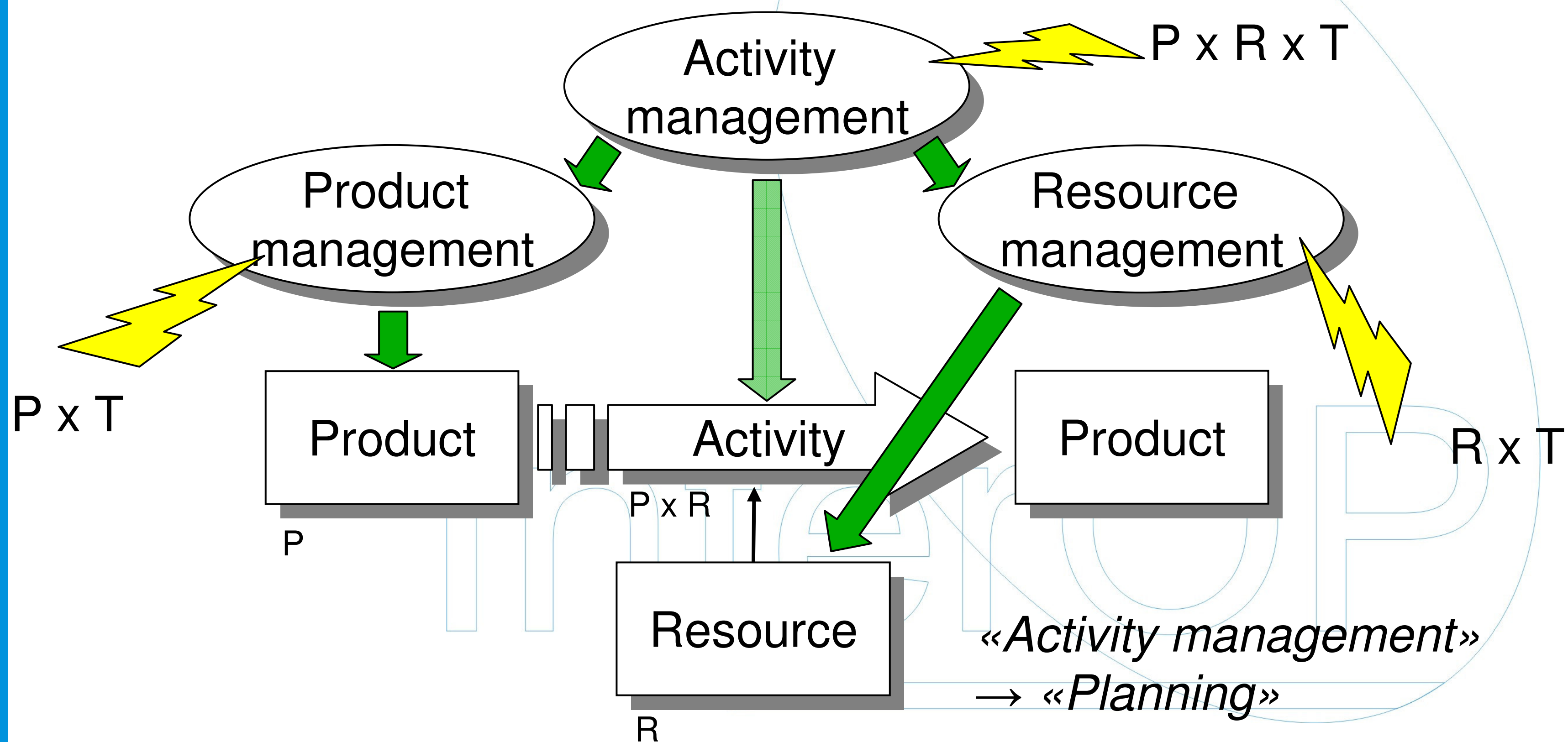
Activity control

… to the elementary concepts of a production activity:
(minimal model of a production activity)



Activity control

Production activity control: basic concepts



«Activity management»
→ *«Planning»*

The three elementary control functions

Products management	Planning	Resources management
Flows management decisions	Decisions of synchronisation and co-ordination between products flows and resources capacities	Capacities management decisions
P x T	P x R x T	R x T

The three elementary control functions

Decisions of products management:
- Purchase management
- Supplying and inventories management

Example of decisions for purchase management:
- Types of products to supply (related to selected technologies)
- Research of potential suppliers
- Definition of provisioning modes (on purchase order, by KANBAN, by split batches...)

The three elementary control functions

Example of decisions for resources management:

- Definition of the types of production means (choice of technologies) and of the personnel profiles
- Investments in production means and personnel (purchase of means correspondent to selected technologies and recruitment of personnel with good profiles)
- Decision of capacity (number of teams...)
- Assignment of the personnel

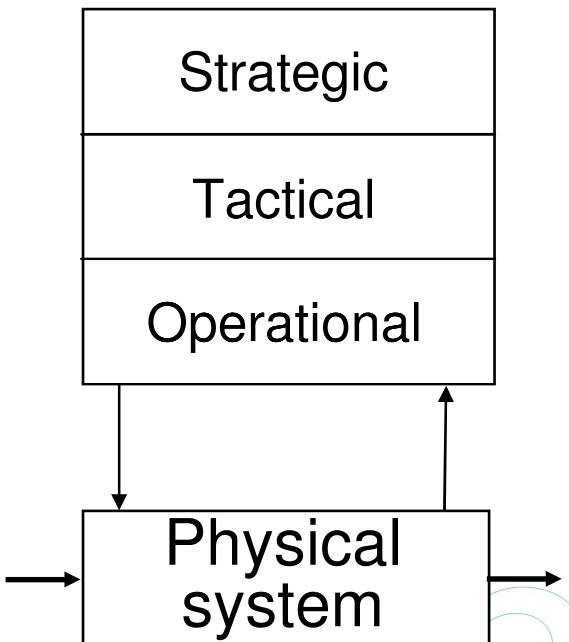
HIERARCHY

First concept: typology of decisions

Three categories of decisions exist:

- **Strategic**: decisions which define the global objectives of the system (company strategy),
- **Tactical**: decisions which define the means to achieve the goals defined at the upper level,
- **Operational**: decisions which allow to act by implementing the means defined at the upper level.

First concept: typology of decisions

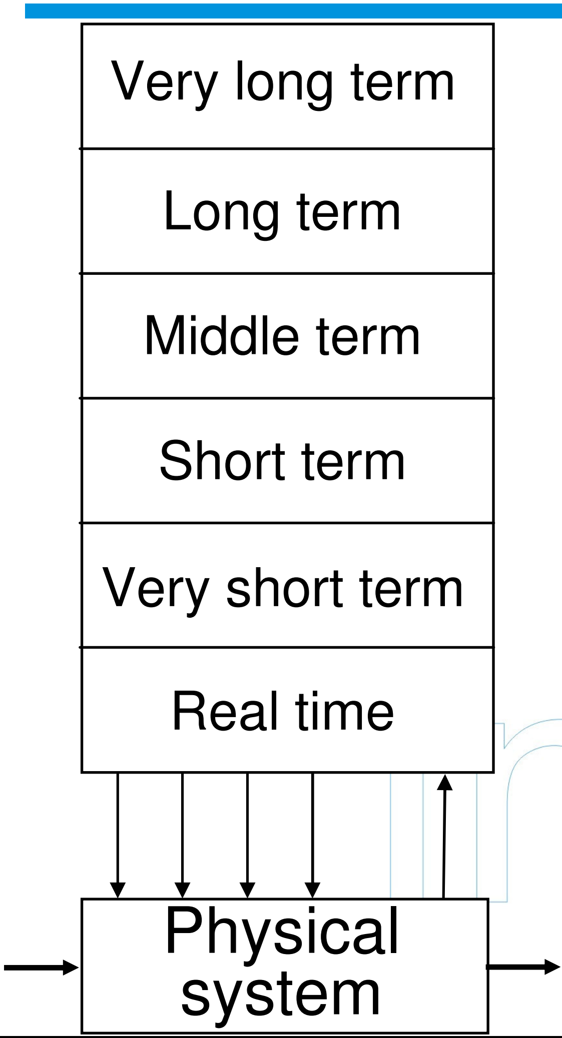


Some comments

- In practice, there is no hierarchical level specific to these three types, the three categories of decision are interlaced: majority of strategic decisions at the higher level and majority of operational decisions at the lower level,

- Practically speaking, the distinction is not obvious,
- The concept is not structuring.

Second concept: terms



Some comments:

- The length of the term depends on:

  - the dynamics of the environment (upper levels),

  - the dynamics of the physical system controlled (bottom levels);
- This concept is not structuring.

Finally, this concept is only used to order the levels but not to quantify the terms.

Why a hierarchy?

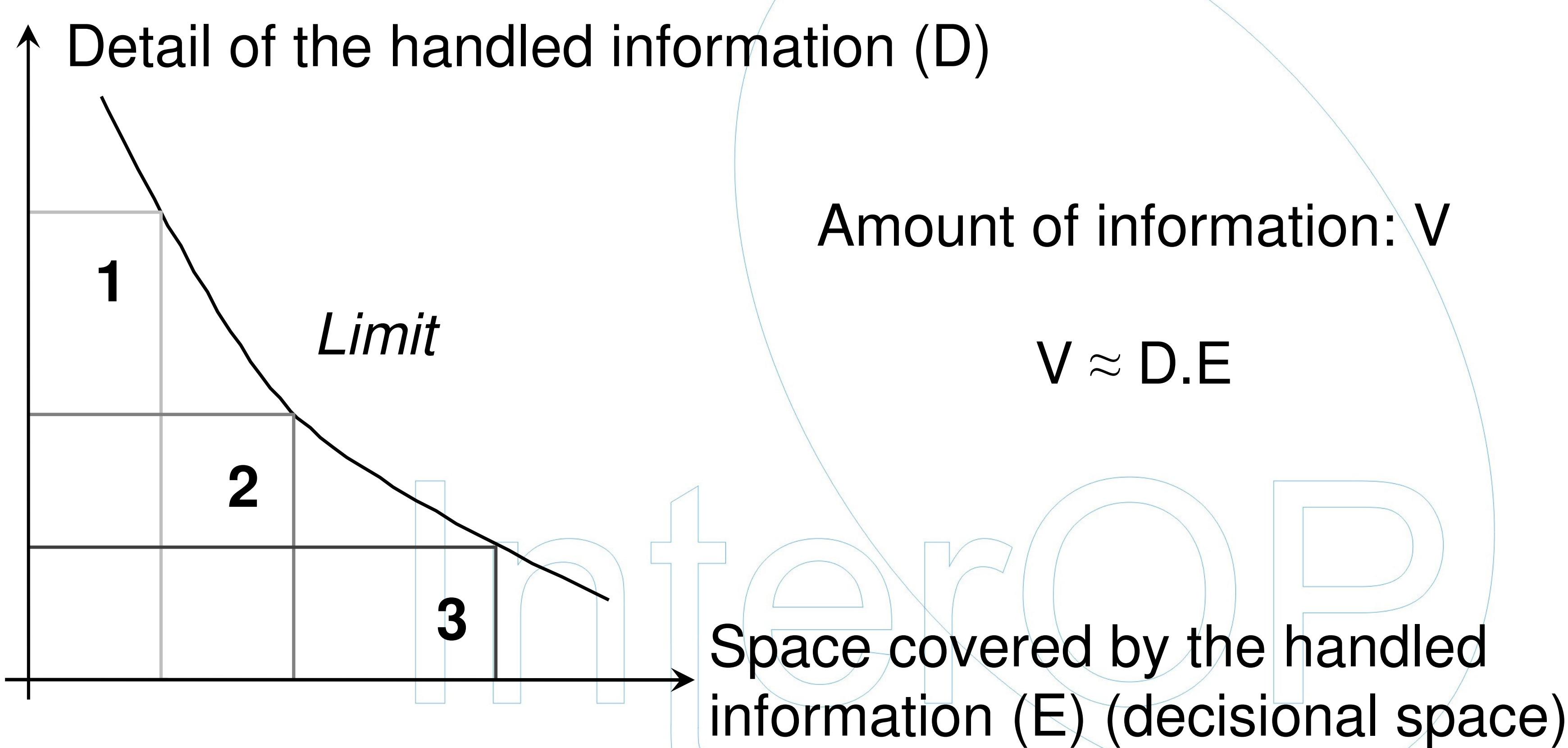
Complex systems imply a huge amount of information to handle to model and control them,

Necessity to understand the system:

- in detail so that it can be operational,
- as a whole to ensure that it realizes what it was designed and built for (artificial system)

Need for intermediate levels to ensure consistence between the two extreme sights.

A way to limit the amount of information

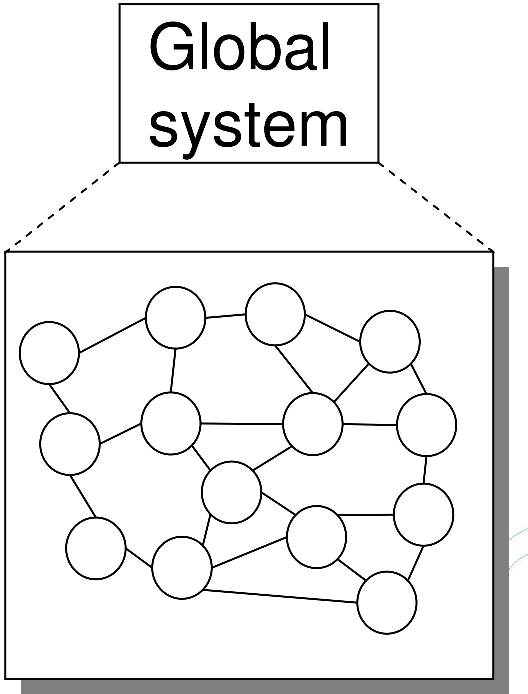


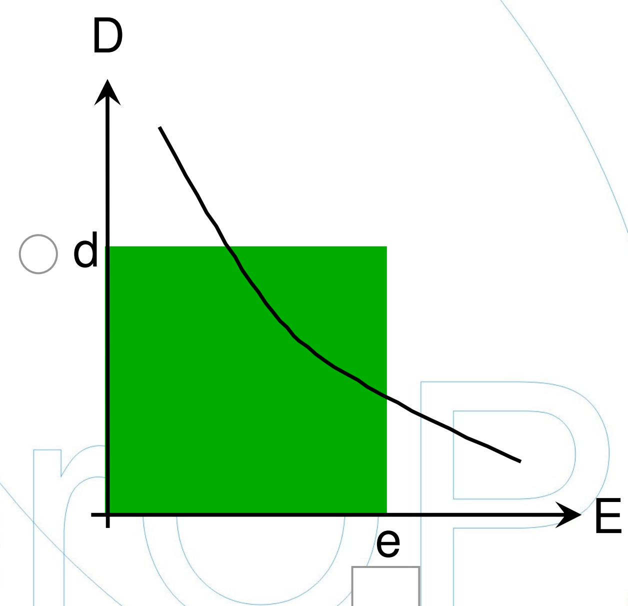
Amount of information: V

$$V \approx D.E$$

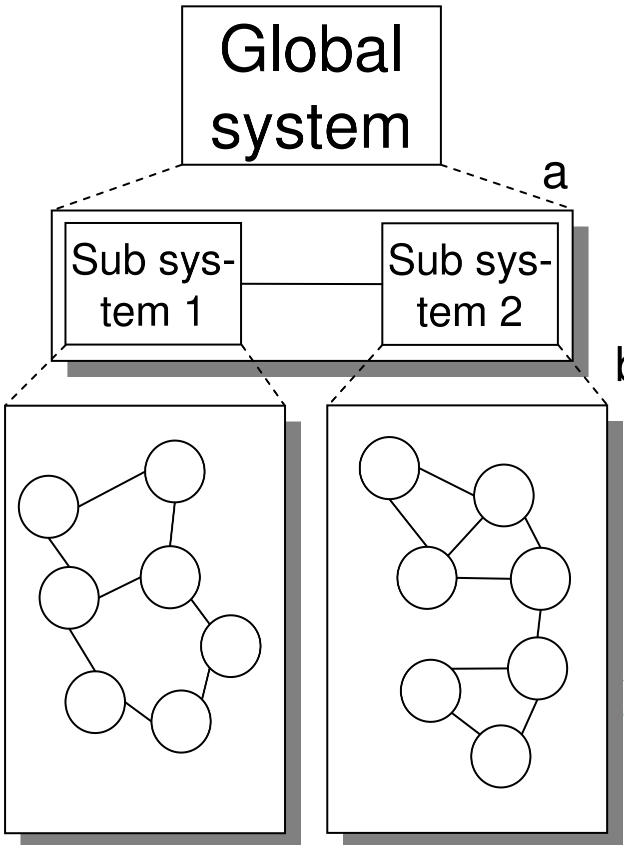
A way to limit the amount of information

Example

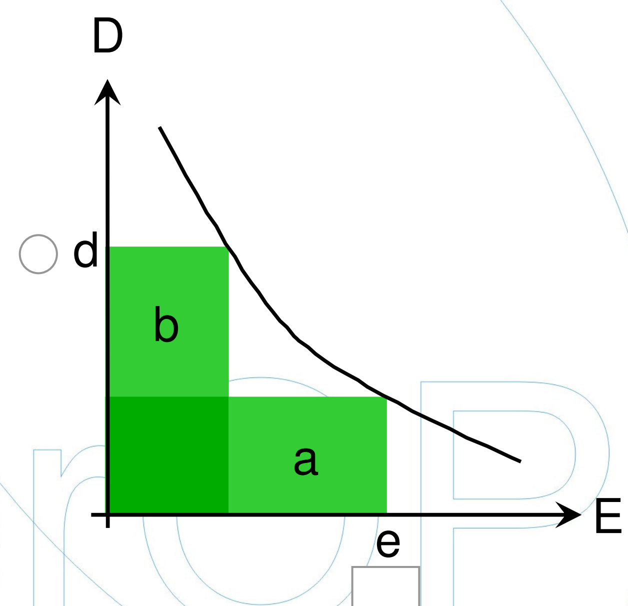




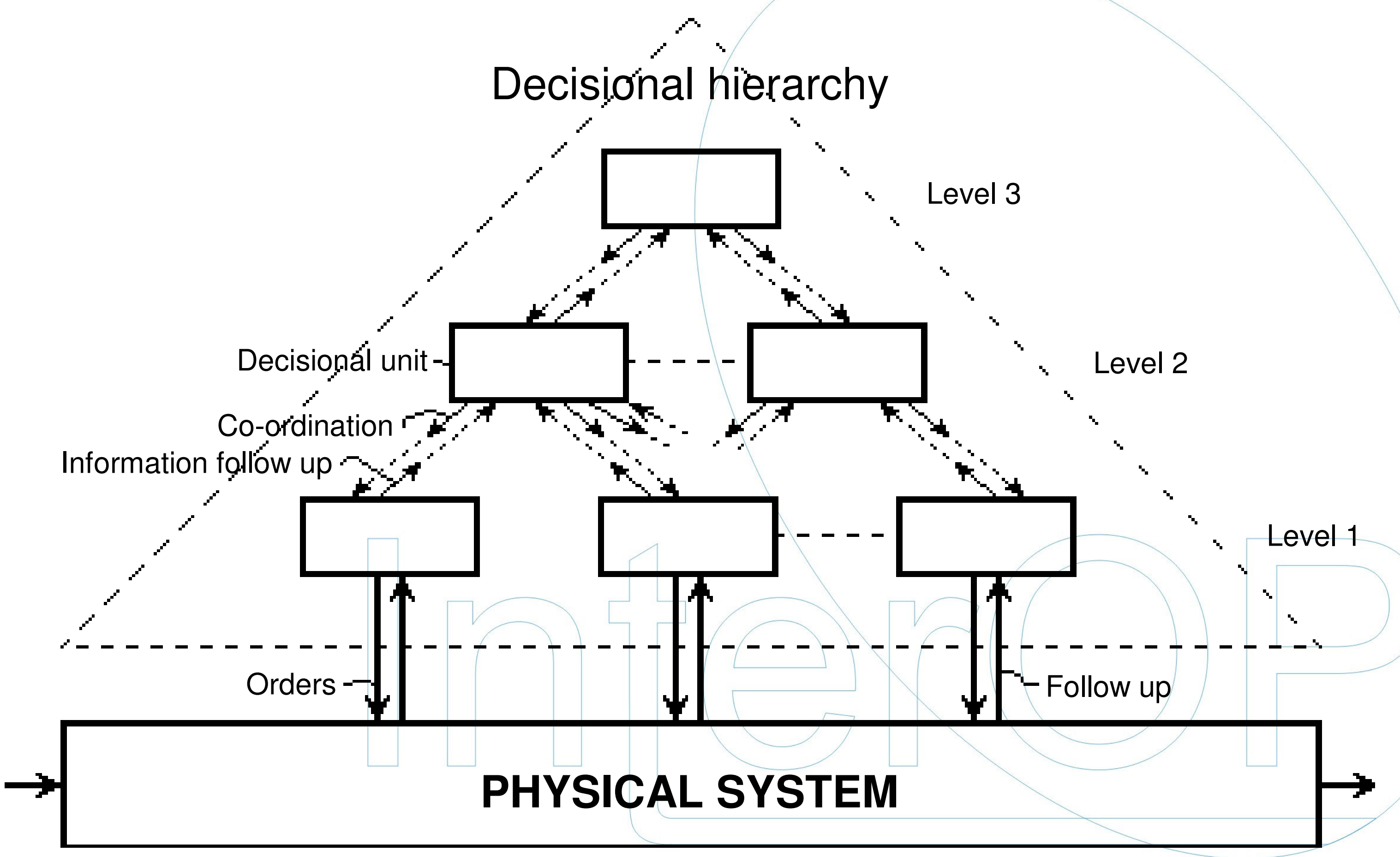
A way to limit the amount of information



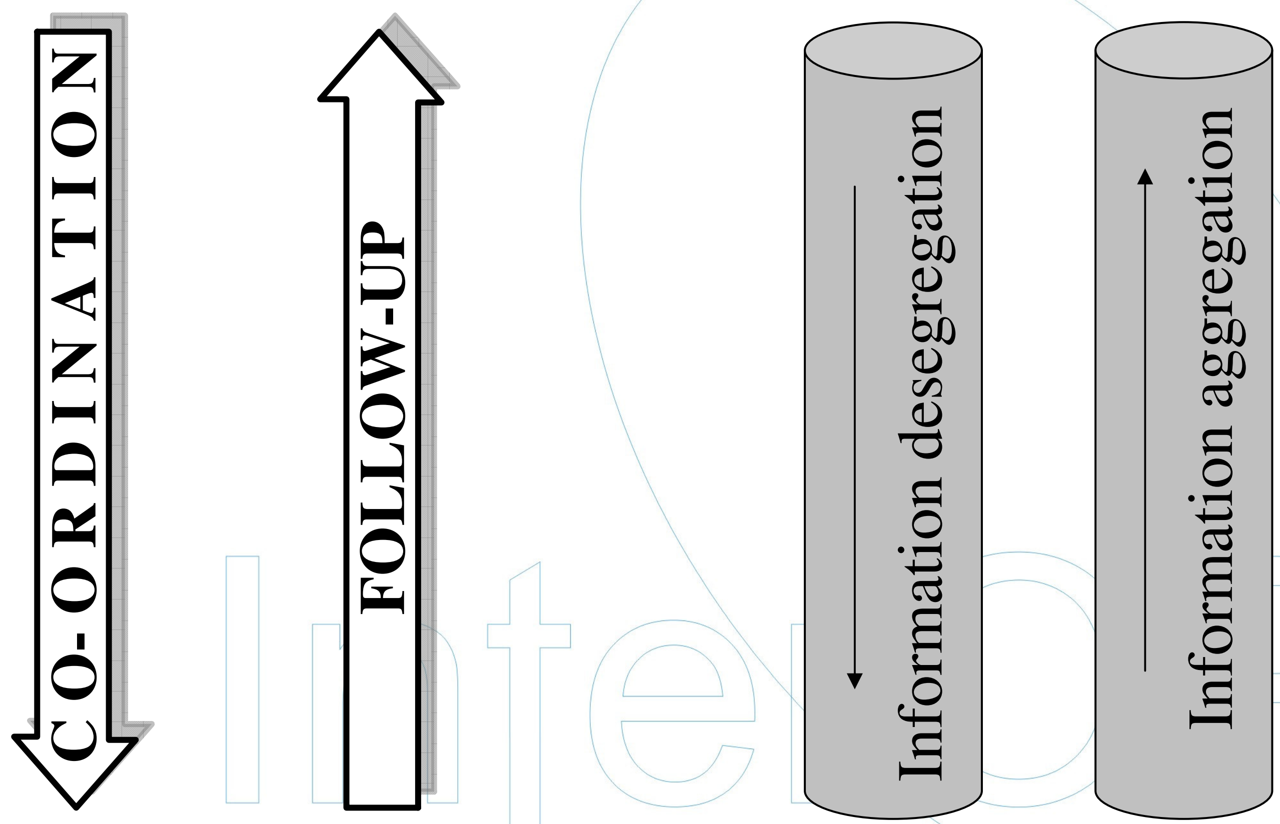
Example



The co-ordination point of view



The co-ordination point of view



The co-ordination point of view

Co-ordination allows:

- each decisional unit to work with a quantity of information that it can handle,
- each decisional unit to deal with its local problems (decentralization),
- the local processing to be carried out in consistence with the global objectives.

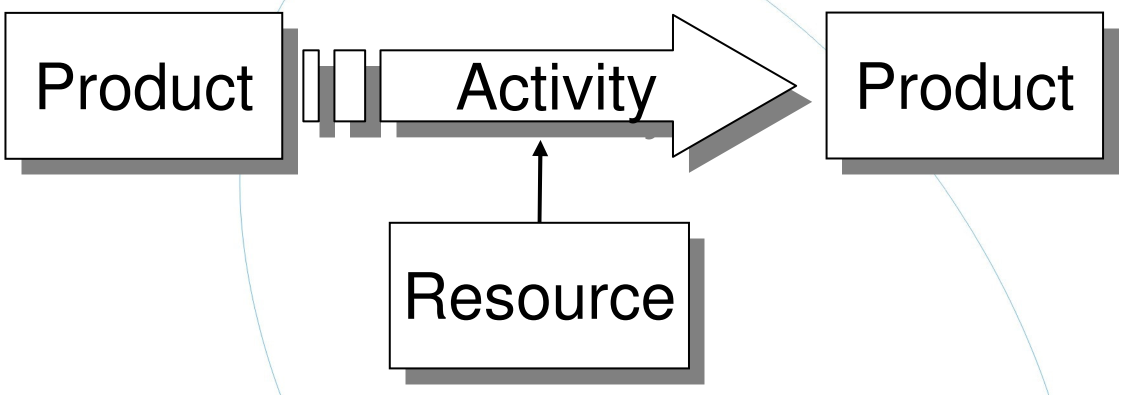
The co-ordination point of view

Co-ordination supposes that:

- each decisional unit has its own model,
- each model is reduced to the field of the decisional unit with the necessary level of detail,
- the whole set of models is consistent.

Levels characterisation

Minimal model of a production activity



The decision space can be described according to:

- products,
- resources,
- activities,
- time.

Levels characterisation

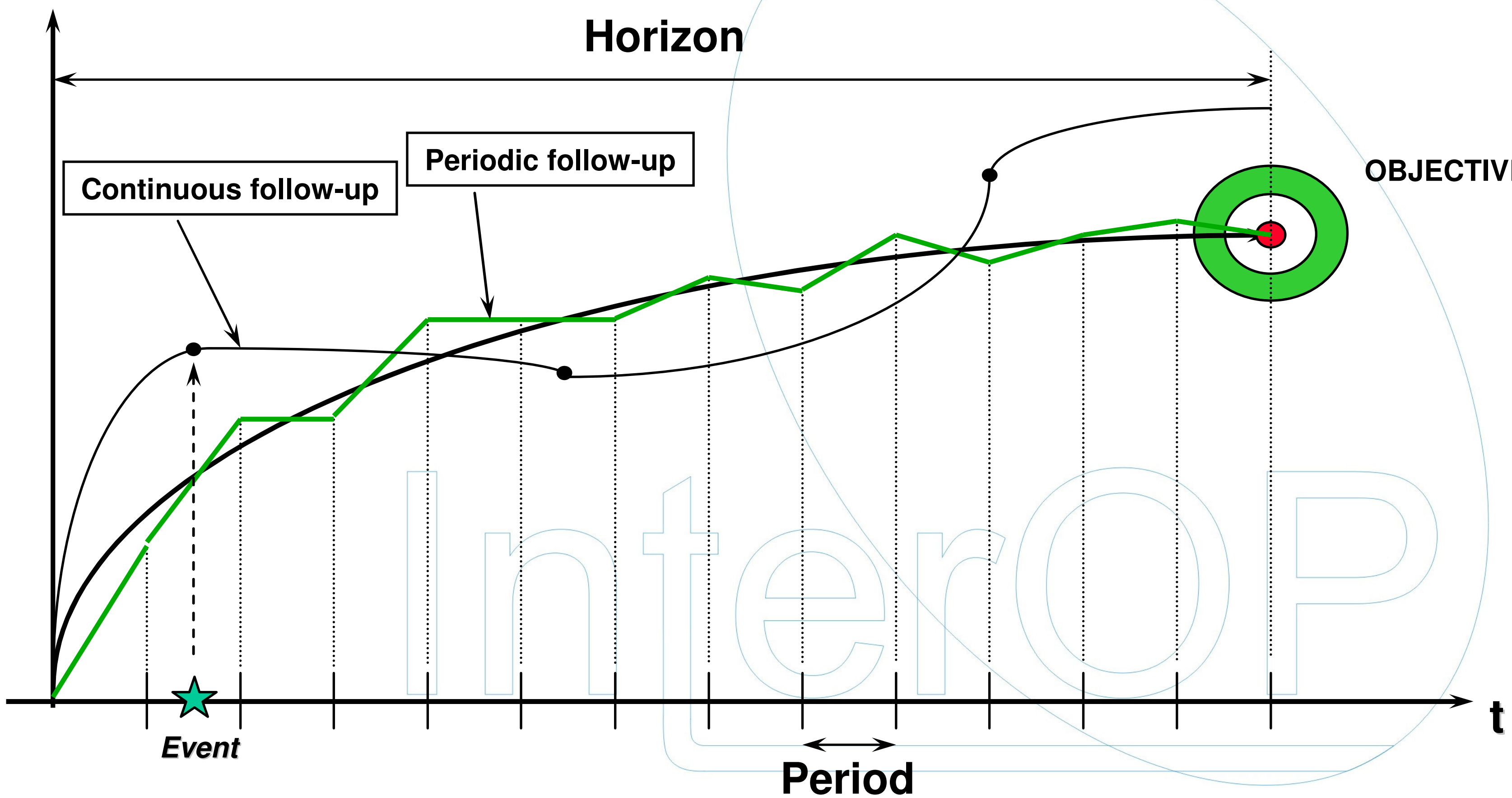
- A level is characterized by the degree of detail of each of these elements.
- The decomposition is consistent if there is consistence between the levels of detail of the four elements.

TIME	Product	Resource	Activity
Long term	Product family	Production unit	Activity
Middle term	Finished product	Load centre	Phase
Short term	Article	Load shop	Sub phase
Very short term	Allocated article	Detailed load shop	Operation
Real time	Material	Work shop	Action

(Gallois, 89)

Temporal characterisation of levels

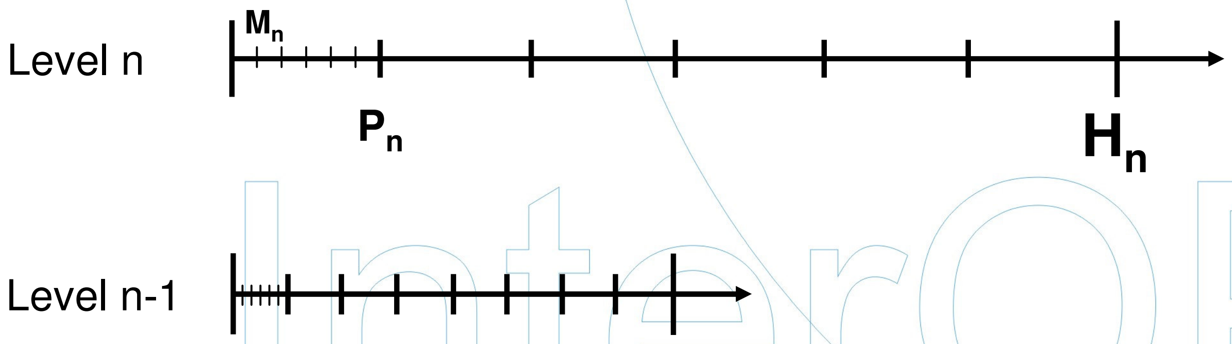
Horizon and period concepts



Temporal characterisation of levels

Characteristic concepts related to time:

- Horizon,
- Period,
- Processing unit (elementary and non divisible period of time).



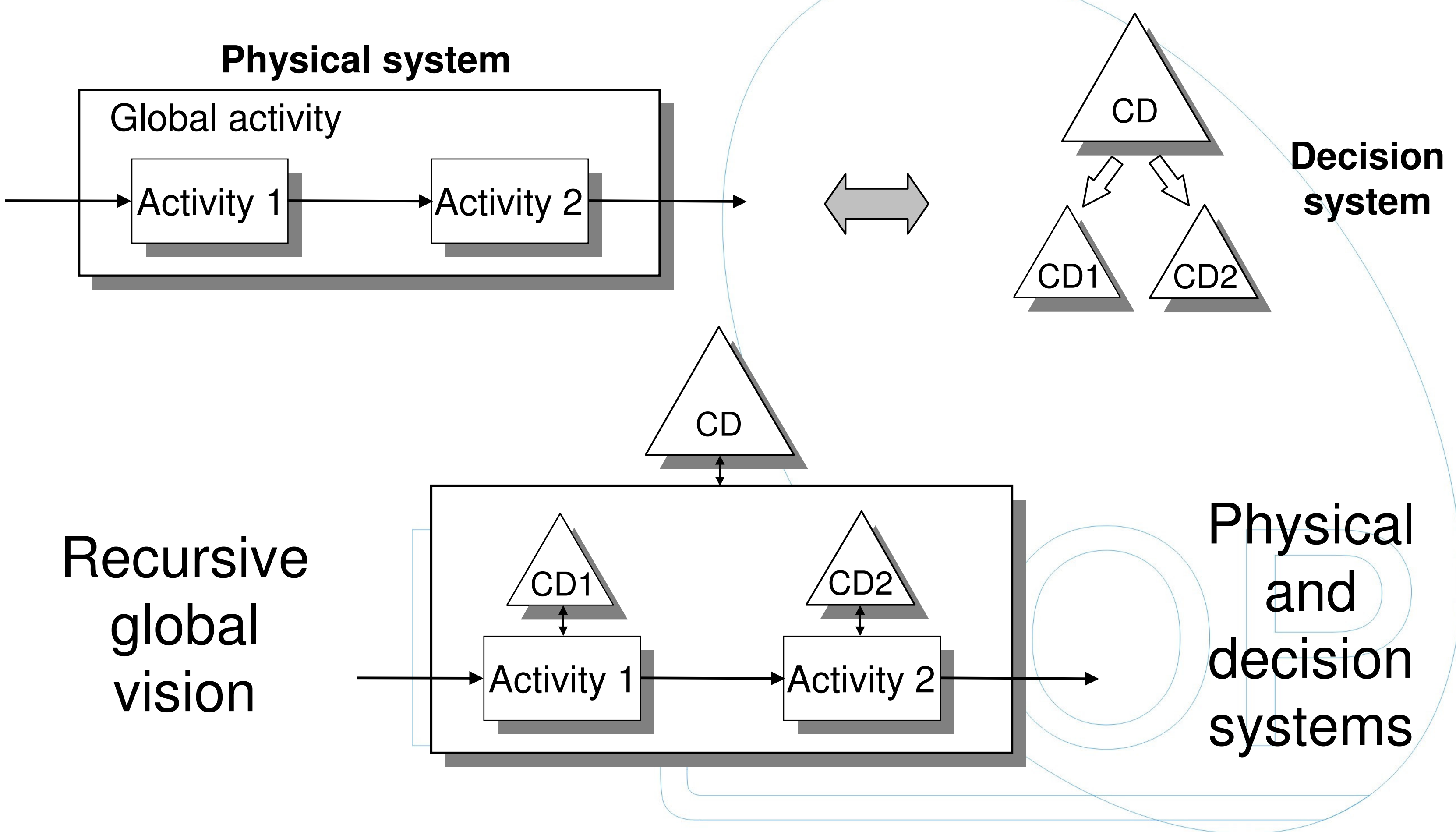
Note: the horizon is related to the space of decision-making, the processing unit is related to the detail.

Temporal characterisation of a level

Some comments:

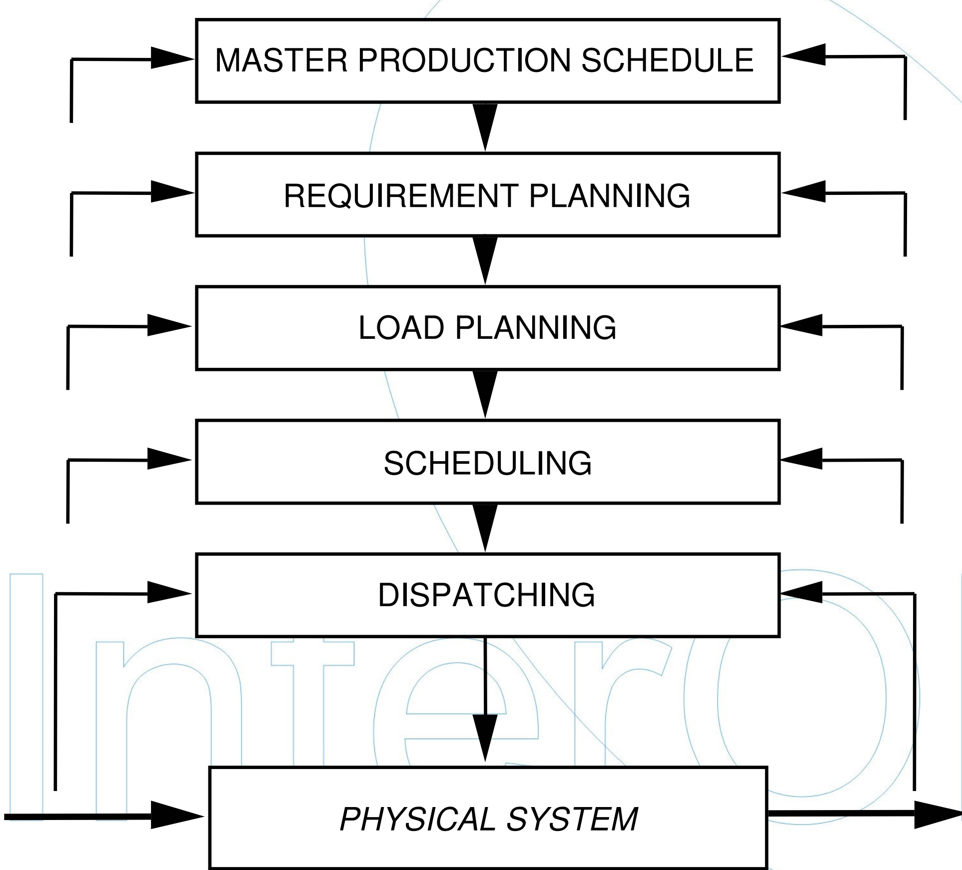
- The GRAI model considers that the nominal decision-making is periodic and that non-nominal decisions (adjustment) are made on events (between periods);
- As the decision-making on event cannot be characterized by one period, it is necessary to associate it to the level of detail that corresponds to its influence domain;
- A good definition of the period value allows to decrease the quantity of decisions on events;
- The notions of horizon and period favourably replace the notion of term (long term, etc.).

Recursiveness



The processing sequence point of view

Example in production management:



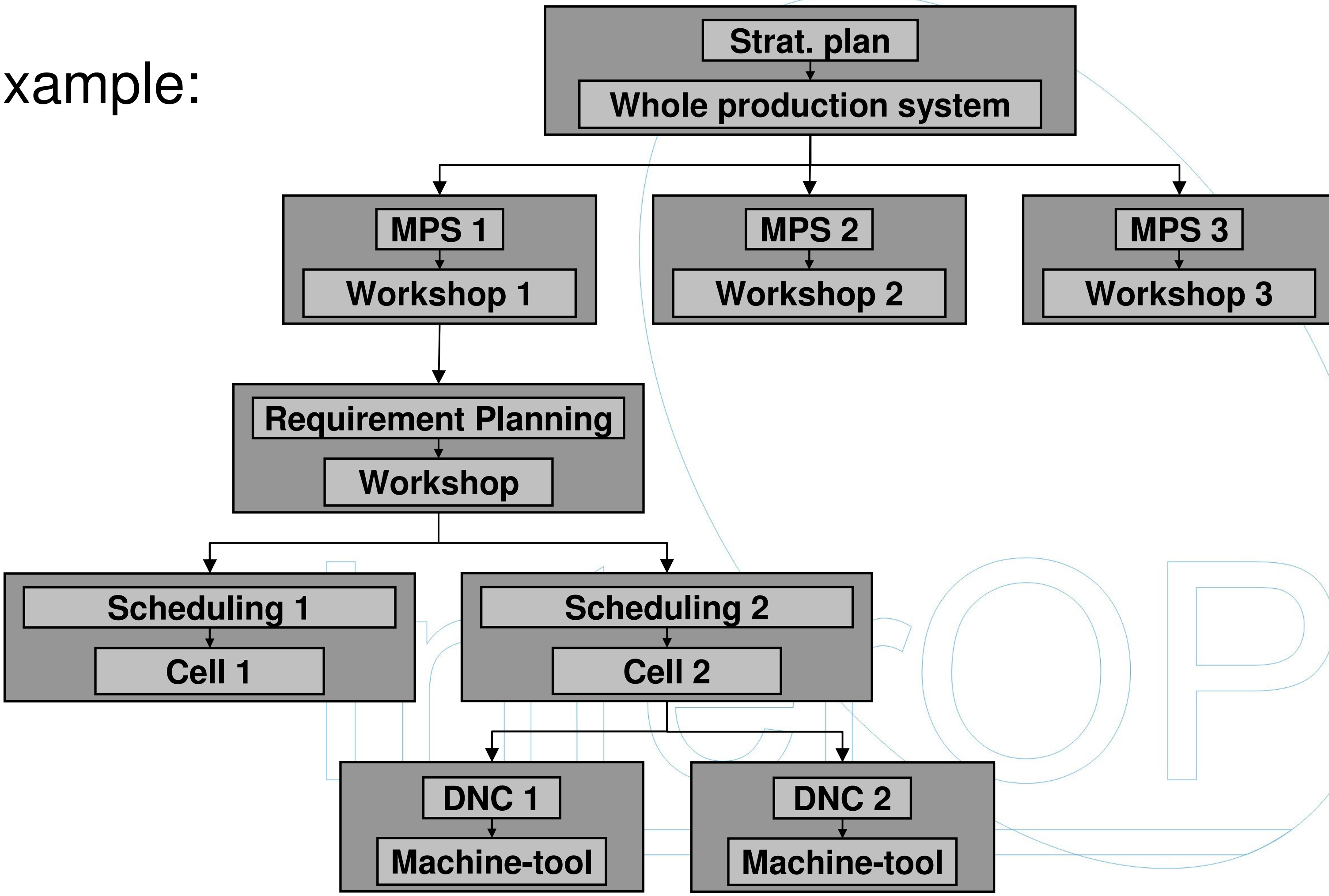
Combination of the two types of hierarchies

Production management combines the two types of hierarchies:

- one co-ordination hierarchy to control from a global level towards detailed levels,
- one processing sequence hierarchy consistent with the implemented model of production management

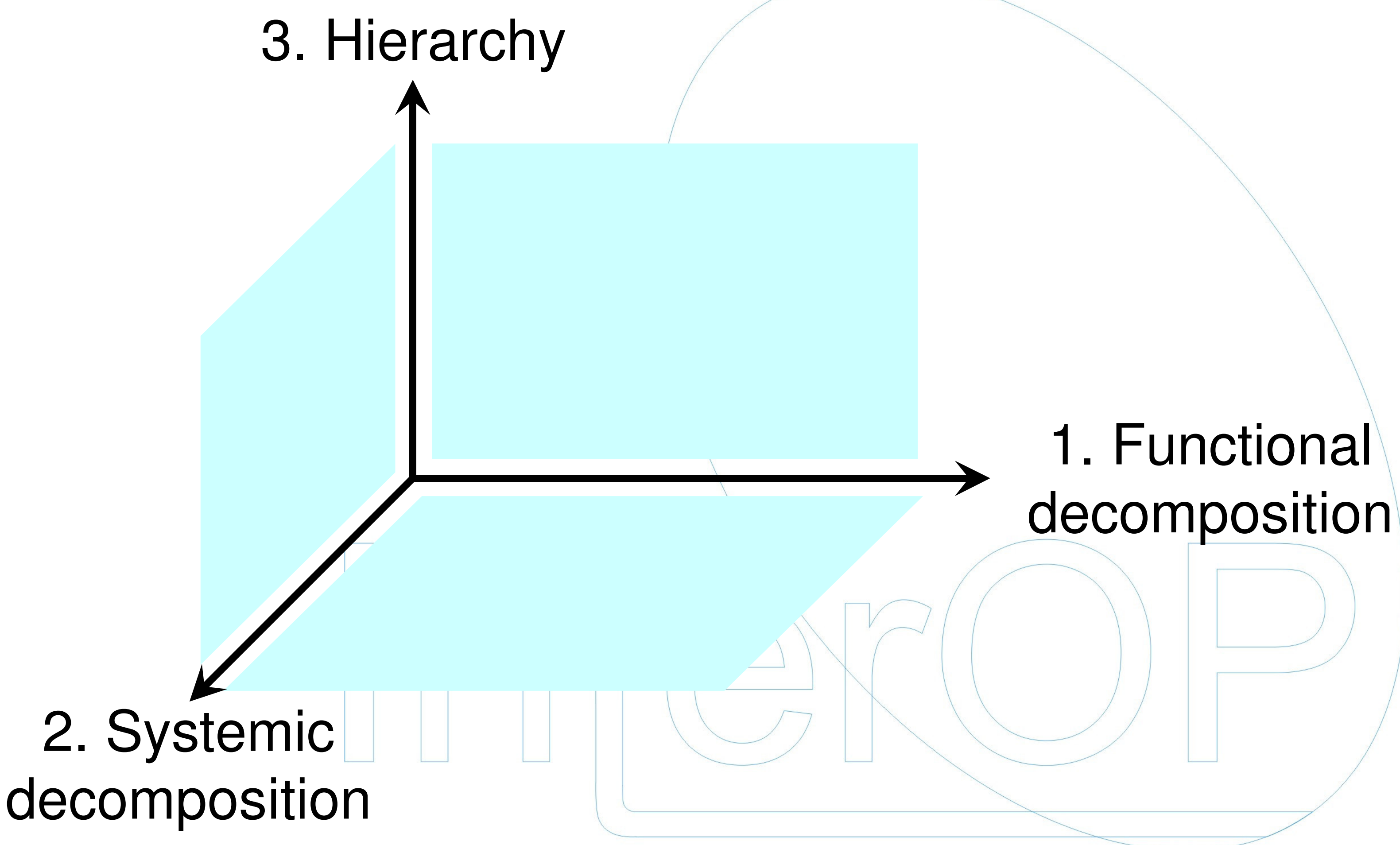
Combination of the two types of hierarchies

Example:



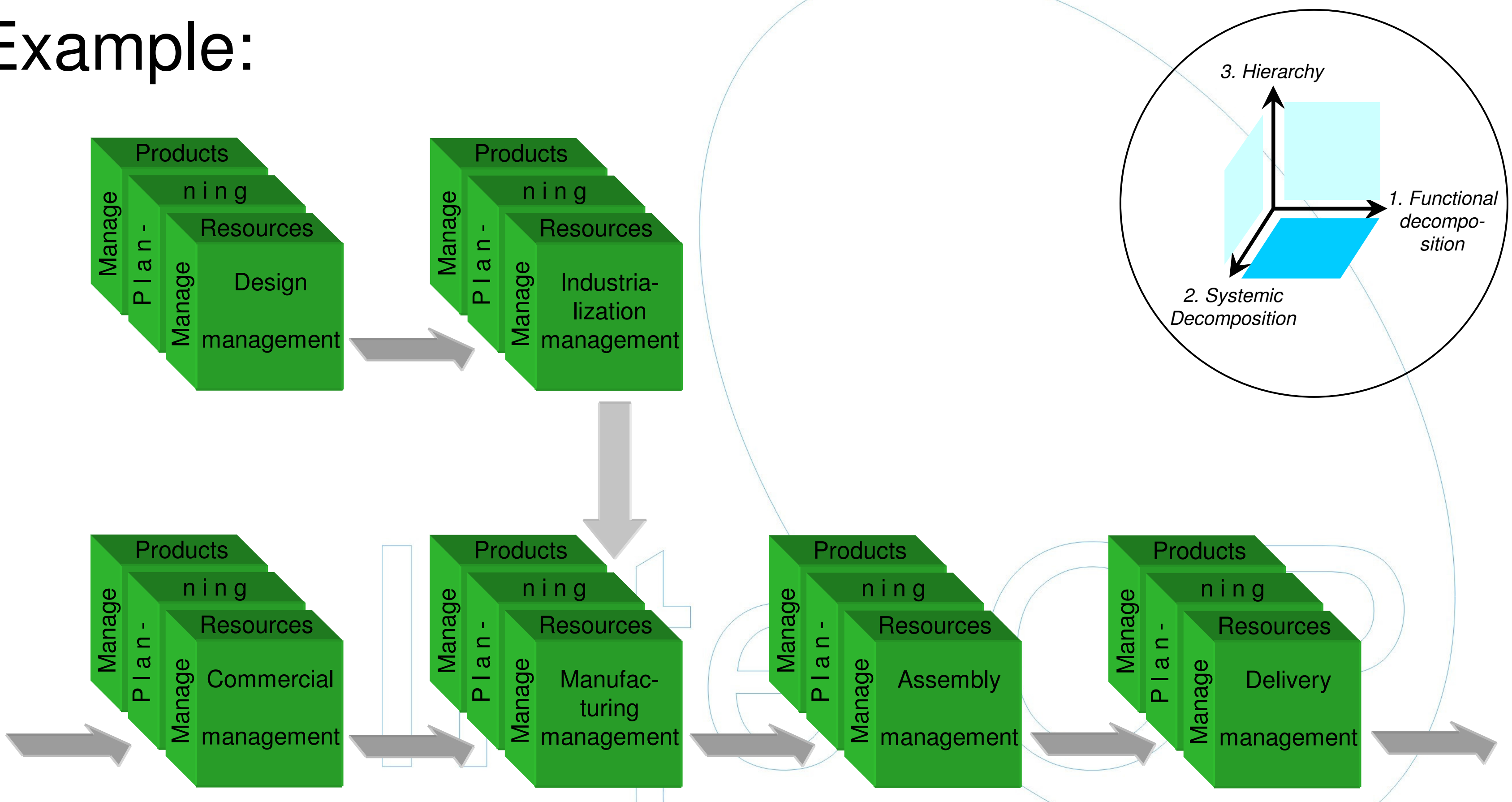
THE THREE MODELLING DOMAINS

Three axes of decomposition: three faces of modelling

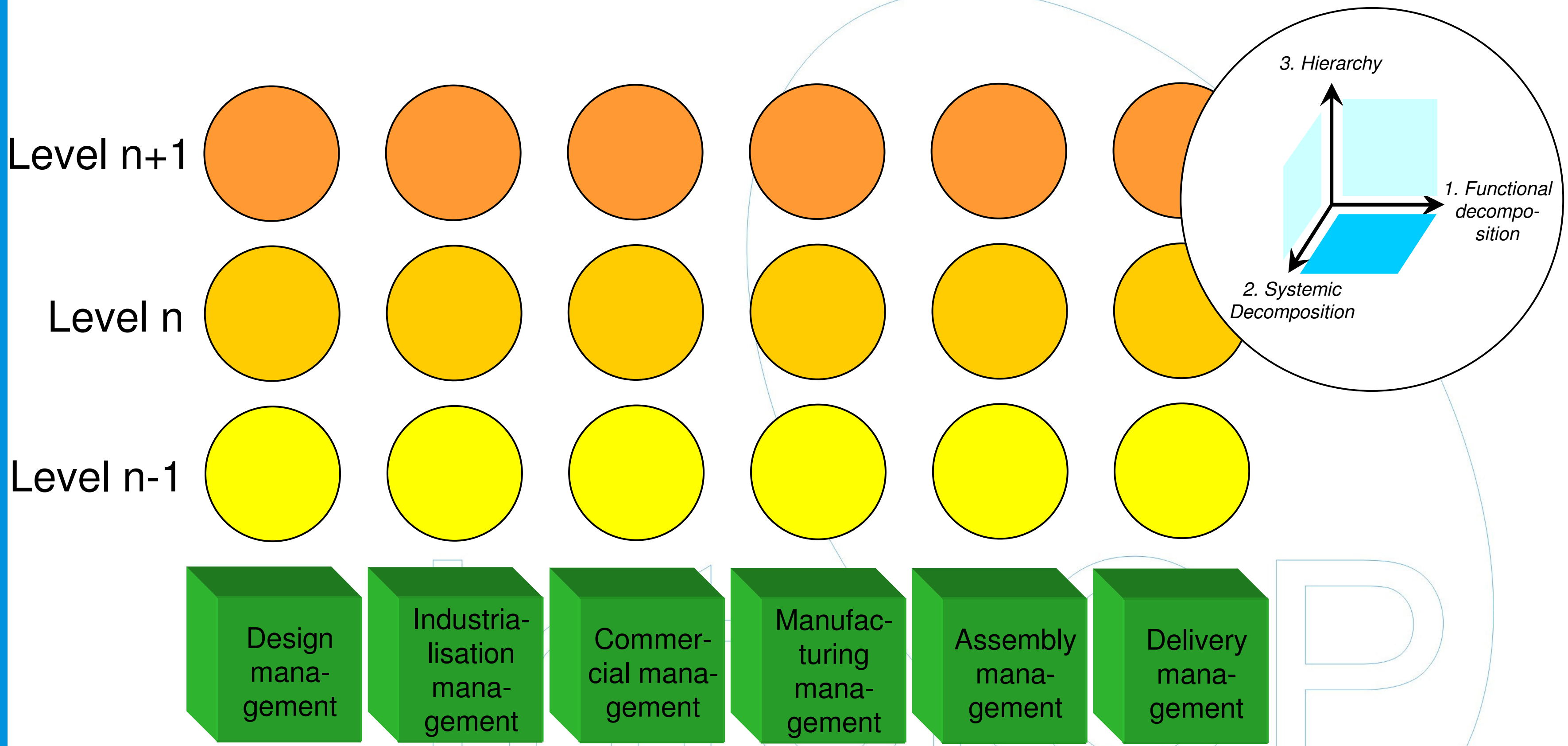


Application of systemic decomposition to functional decomposition

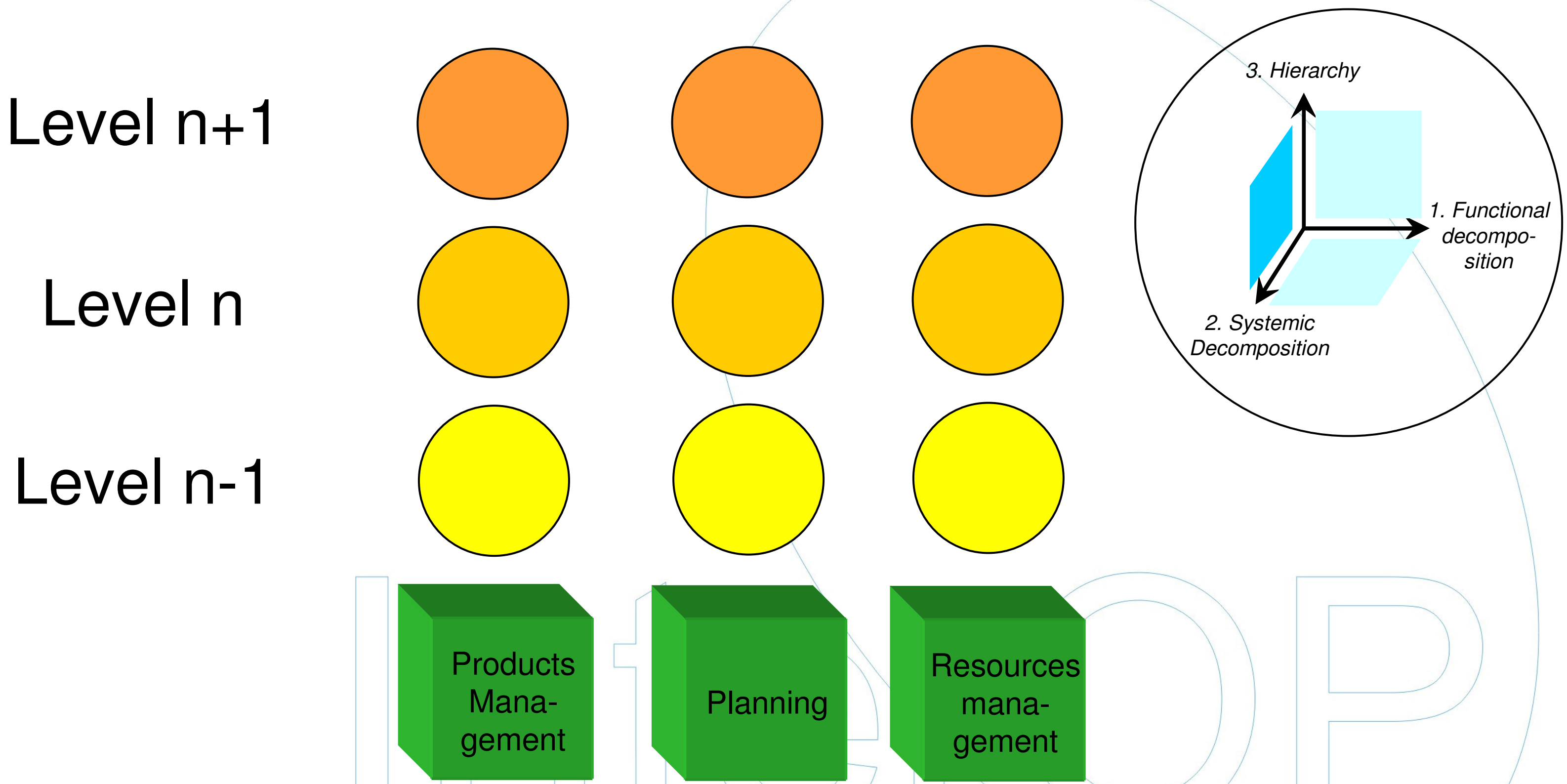
Example:



Application of hierarchy to functional decomposition



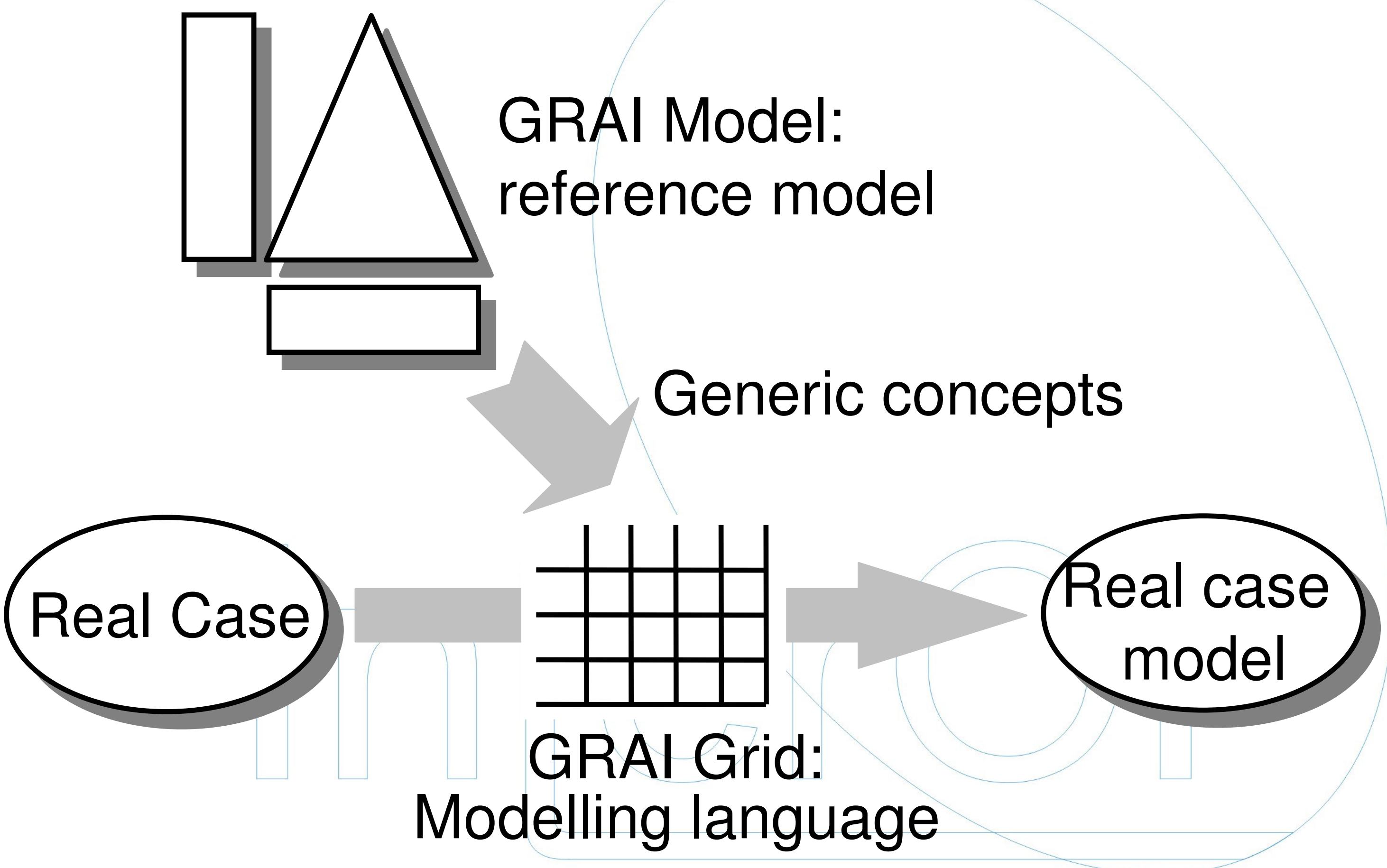
Application of hierarchy to systemic decomposition



Third part

THE GRAI GRID

From GRAI Model to GRAI Grid



CONCEPTS OF THE GRAI GRID

Functions and levels

Coming from the GRAI model

Columns = functions

Lines = levels (defined by couples horizons / periods)

	F_1	F_2	F_3	...	F_n
H1 P1					
H2 P2					
H3 P3					

The grid is used to represent the periodic part of the control system (periodic nominal running)

Decision centres

All control decisions that belong to **one** function and to **one** level constitute **one** decision centre

	F_1	F_2	F_3	...	F_n
H1 P1					
H2 P2			Decision centre		
H3 P3					

External information / Internal information

Two columns are added, one on each extremity:

- External information (exchanges with the environment of the production system, primarily commercial information),
- Internal information (exchanges with the physical system, primarily information of follow up),

… used by decision centres.

External information / Internal information

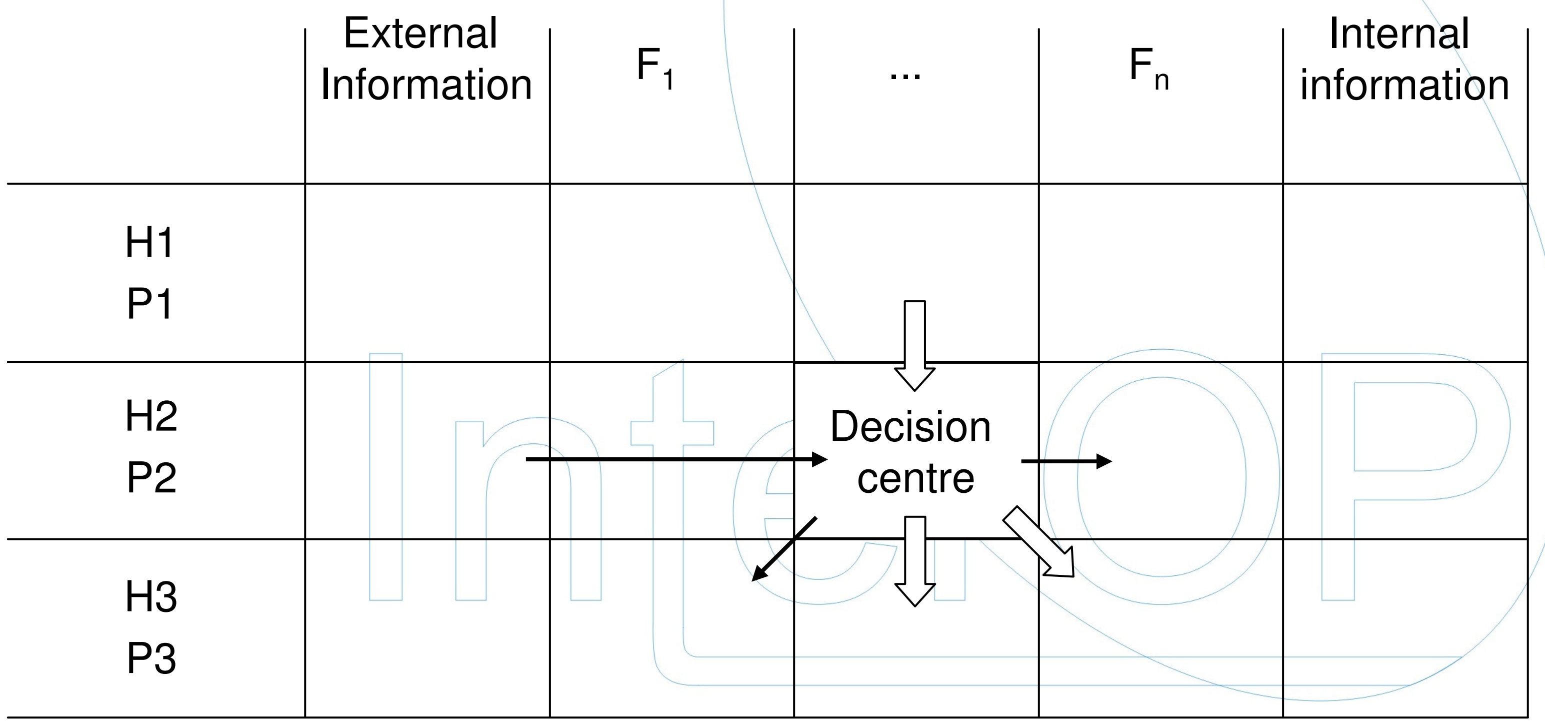
	External Information	F_1	...	F_n	Internal Information
H1 P1					
H2 P2			Decision centre		
H3 P3					

Decision framework and information flow

⇨ Decision framework

→ Information flow

Note: only the information flows that are necessary for understanding are mentioned.



Decision framework content

Consistently with what has been seen before, a decision framework corresponds to:

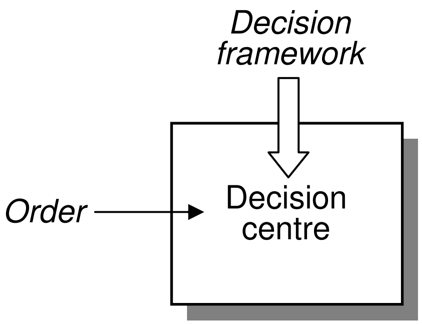
- objectives (nature + value),
- decision variables (nature),
- constraints (value),
- and eventually criteria (nature);

and also

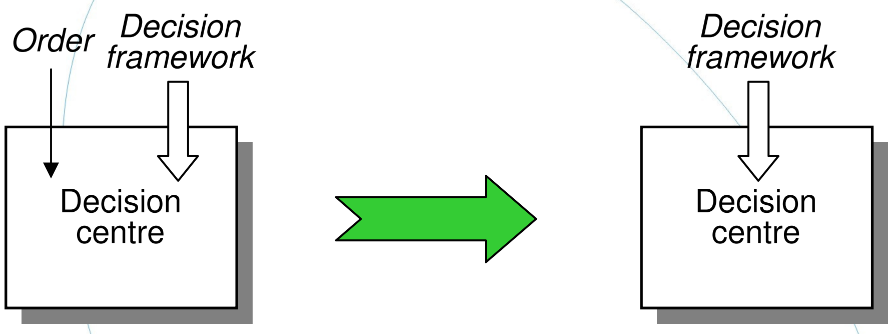
- an order (information flow) if the way is the same than the decision framework (nature + value),
- a follow up information (nature + value).

Decision framework content

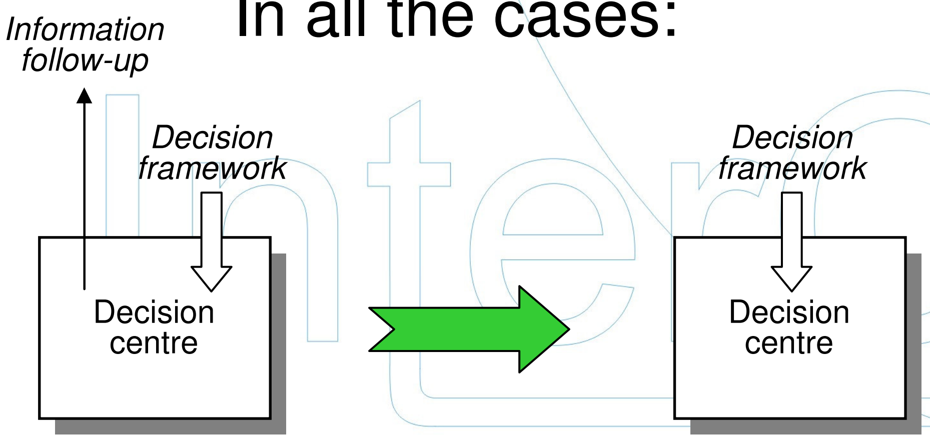
Usual case:



Particular case:



In all the cases:



Decision framework content

Operationally, what is exchanged by a decision framework depends on the model of control.

Extremes:

- everything changes each time (extremely dynamic structure and slightly structured),
- nothing changes (completely static structure).

Example of average situation:

- the value of objectives (fixed nature of objectives),
- the value of constraints (fixed nature of decision variables),
- the value of possible criteria.

Syntax rules

Levels

- The horizon/period couples must be single i.e. there cannot be two levels identified by the same horizon/period couple.
- The levels are ordered top down by decreasing periods and by decreasing horizons in the case of equal periods.

Decision framework

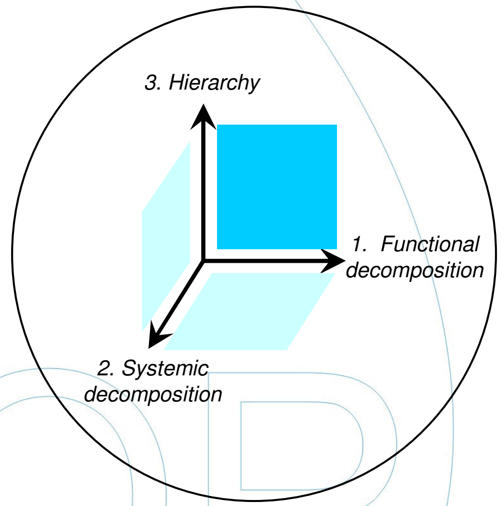
There cannot be two decision frameworks with the same emitting decision centre and the same receiving decision centre.

GRID FUNCTIONS

Type of grids

First case:

The functions indicated in the grid represent the functions of the company ("to manage commercial", "to manage manufacturing", "to manage deliveries", etc. – functional decomposition):

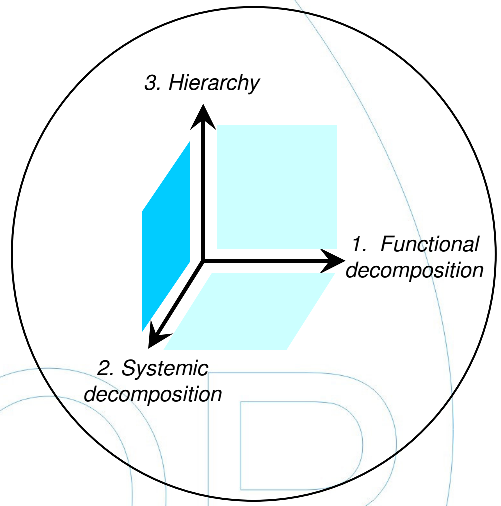


this is a **Functional grid**

Type of grids

Second case:

The functions indicated in the grid represent the elementary control functions (“to manage products”, “to plan”, “to manage resources” – systemic decomposition):



this is a **Control grid**

Example of a functional grid

	External Information	To manage commercial	To manage design	To manage industrial-isation	To manage manufact-uring	To manage assembly	To manage deliveries	Internal information
Horizon = 5 years Period = 1 year								
Horizon = 2 years Period = 1 month								
Horizon = 2 months Period = 1 week								
Horizon = 2 weeks Period = 1 day								

Example of a control grid

	External information	To manage products	To plan	To manage resources	Internal information
Horizon = 5 years Period = 1 year					
Horizon = 2 years Period = 1 month					
Horizon = 2 months Period = 1 week					
Horizon = 2 weeks Period = 1 day					

Shortened identification of levels, functions and decision centres

- **Levels**

  Levels are enumerated bottom up (classically 10, 20, 30, etc.).

- **Functions**

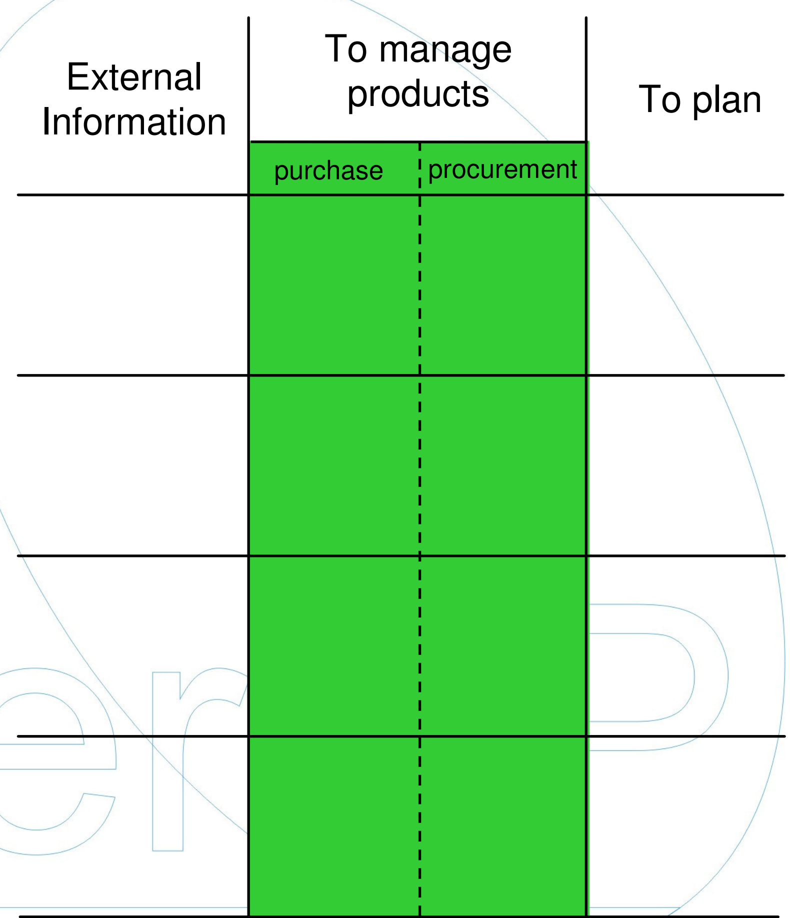
  Functions are usually named with 2 letters. Example: MR for “to manage resources”.

- **Decision centres**

  Decision centres are named by concatenating the number of the level and the acronym of the function. Example : MR/30 for the decision centre that belongs to the function MR and to the level 30.

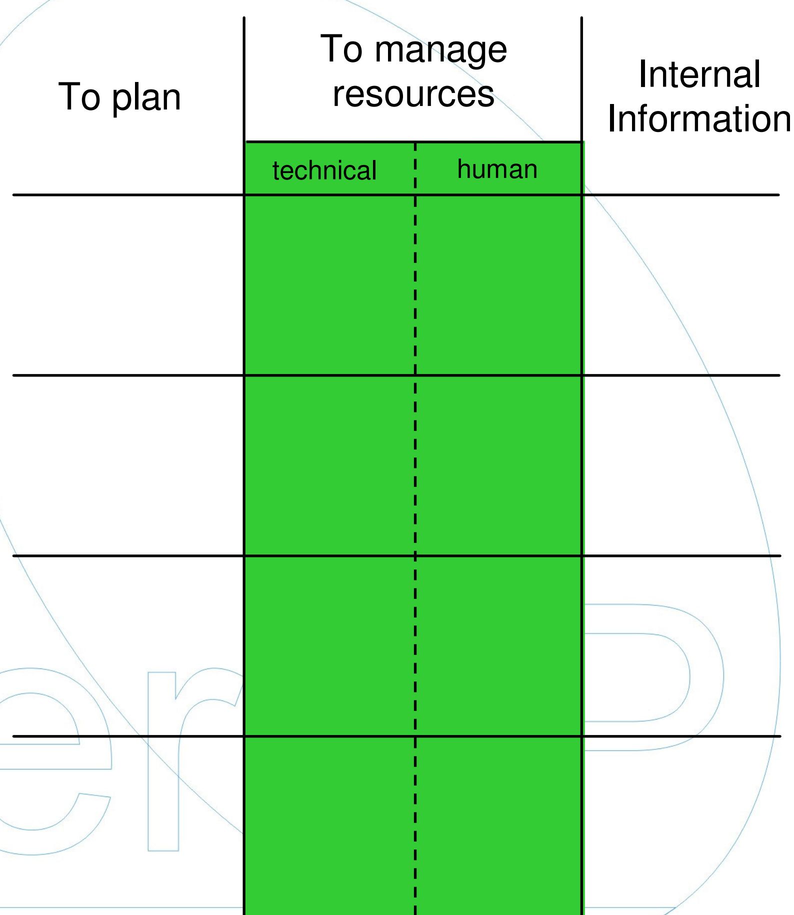
Control grid: decomposition of the function «to manage products»

If the function "purchasing" belongs to the study domain, its management is considered to belong to the function "to manage products" that can be decomposed in "to manage procurement" and "to manage purchasing".



Control grid: decomposition of the function «to manage resources»

If the human resource and technical resource are managed separately, the function “to manage resources” can be decomposed in “to manage technical resources” and “to manage human resources”.



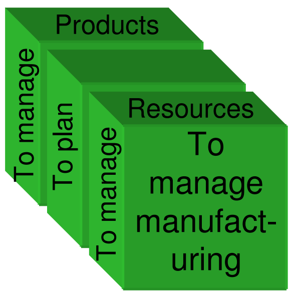
Example of a control grid

		External information	To manage products: To man. purchase	To manage products: To man. procurem.	To plan	To manage resources	Internal information
50	2 years 1 month	Forecasts of sales per families	• To look for suppliers • To negotiate markets	• To define proc. strategy • To define critical proc.	To make Long Term plan	• To define engagement strategy • To define structural S/C	
40	8 months 1 month	Consolidated orders Orders book		To define proc. parameters	MSP MRP	To define conjectural S/C	
30	6 month 1 week		To send orders to suppliers	To make proc. plan	To plan workload + MT schedule	To define conjectural S/C	Inventories level
20	3 months 1 day		To recall suppliers		To plan workload + ST schedule	To assign the personnel	
10	1 day RT	Urgent orders To record orders			To dispatch		To record I/O raw materials, materials and FP

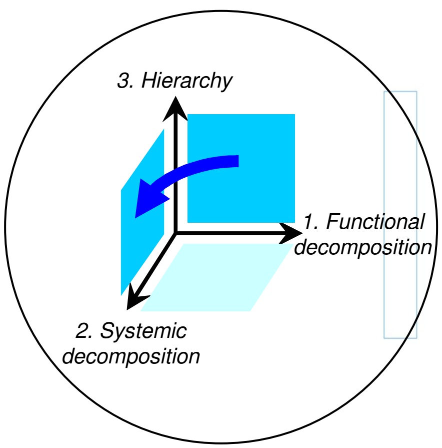
LINKS BETWEEN FUNCTIONAL AND CONTROL GRIDS

Deployment of a functional grid into a control grid

Reminder:



	External inform-ation	To manage com-mercial	To manage design	To manage industrial-isation	To manage manufact-uring	To manage assembly	To manage deliveries	Internal inform-ation
H1 P1								
H2 P2								



	External Inform-ation	To manage products	To plan	To manage resources	Internal inform-ation
H1 P1					
H2 P2					

Deployment of a functional grid into a control grid

- All functions of the functional grid can be deployed, and that on every levels.
- Are deployed only the functions for which detail is necessary.
- The names of the decision centres in the functional grid are generally the name of the decision centre of the function “to plan” of the same level in the control grid.

Particular case: partial deployment

The needs for details can exist only for some levels (usually for the low levels): partial deployment.

	External Information	To manage the commercial	To manage design	To manage industrialis-ation	To manage Manufactur-ing	To manage assembly	To manage deliveries	Internal information
Horizon = 5 years Period = 1 year								
Horizon = 2 years Period = 1 year								

	External information	To manage products	To plan	To manage resource	Internal information
Horizon = 2 months Period = 1 week					
Horizon = 2 weeks Period = 1 day					

Particular case of a deployment in a functional grid: heterogeneous gird

					To manage manufacturing					
	External information	To manage commercial	To manage design	To manage industrial-isation	To manage products	To plan	To manage resources	To manage assembly	To manage deliveries	Internal information
Horizon = 5 years Period = 1 year										
Horizon = 2 years Period = 1 month										
Horizon = 2 months Period = 1 week										
Horizon = 2 weeks Period = 1 day										

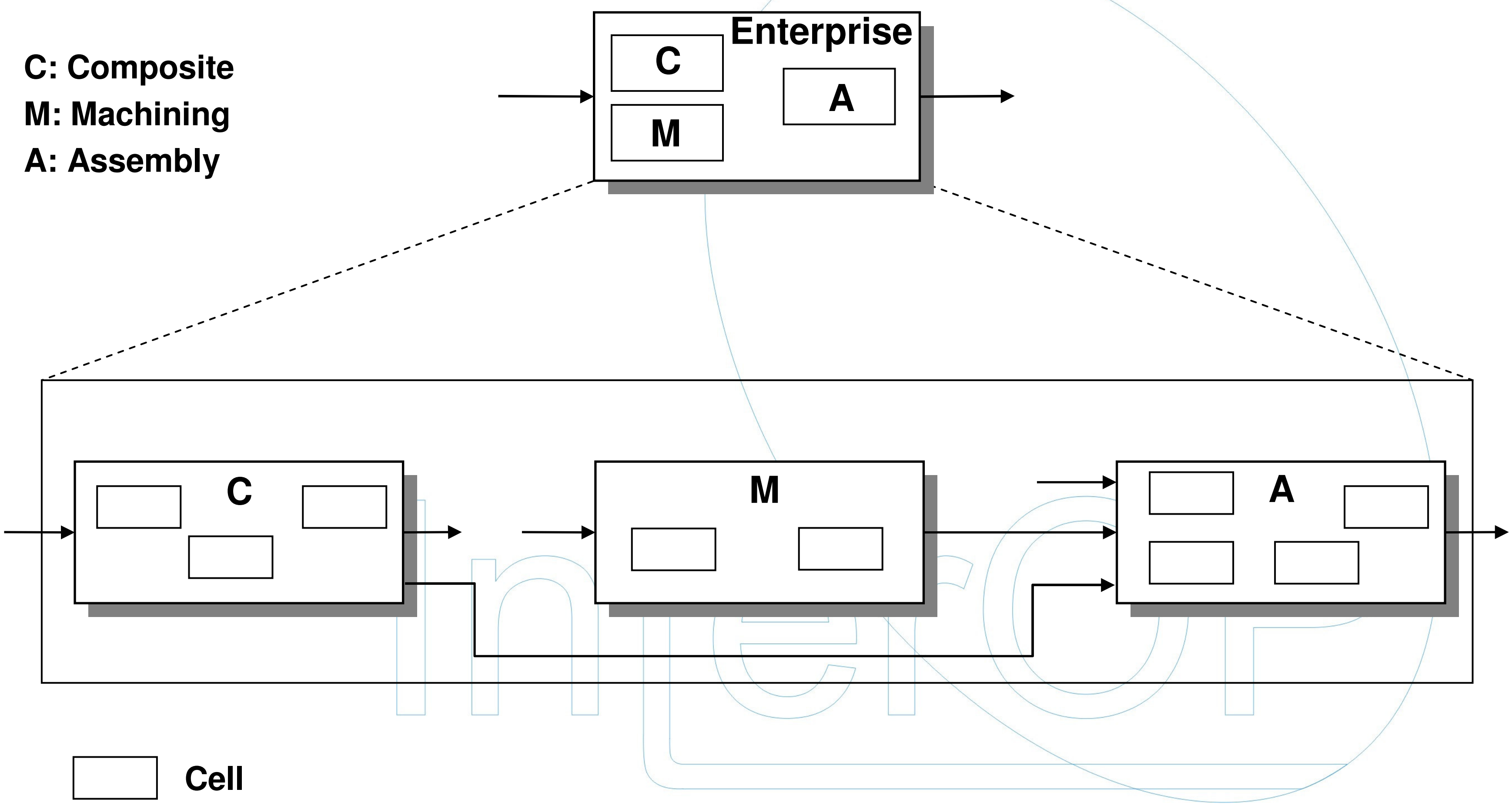
MULTI-GRIDS MODELLING (CO-ORDINATION GRID)

Example of multi-grid modelling on the production function

Example: a firm that produces materials in the domain of aerospace, composed of three production shops:

- Assembly,
- Composite,
- Machining.

Physical system decomposition

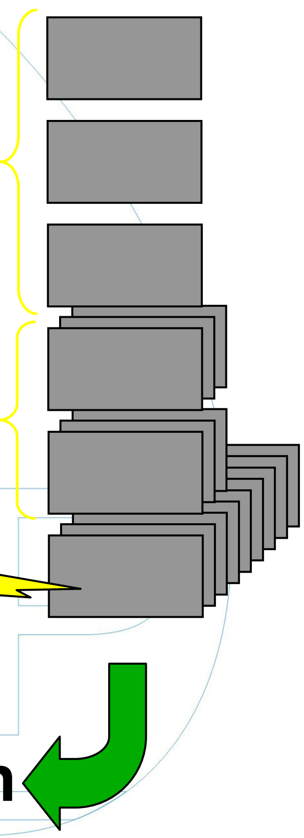


Planning level and corresponding resources

Planning level	Corresponding resource
• Industrial Strategic Plan (ISP)	Factory
• Global Master Production Schedule (MPSg)	Factory
• Global Material Requirement Planning (MRPg)	Factory
• Detailed Master Production Schedule (MPSd)	Shop
• Detailed Material Requirement Planning (MRPd)	Shop
• Scheduling (Sched)	Cell

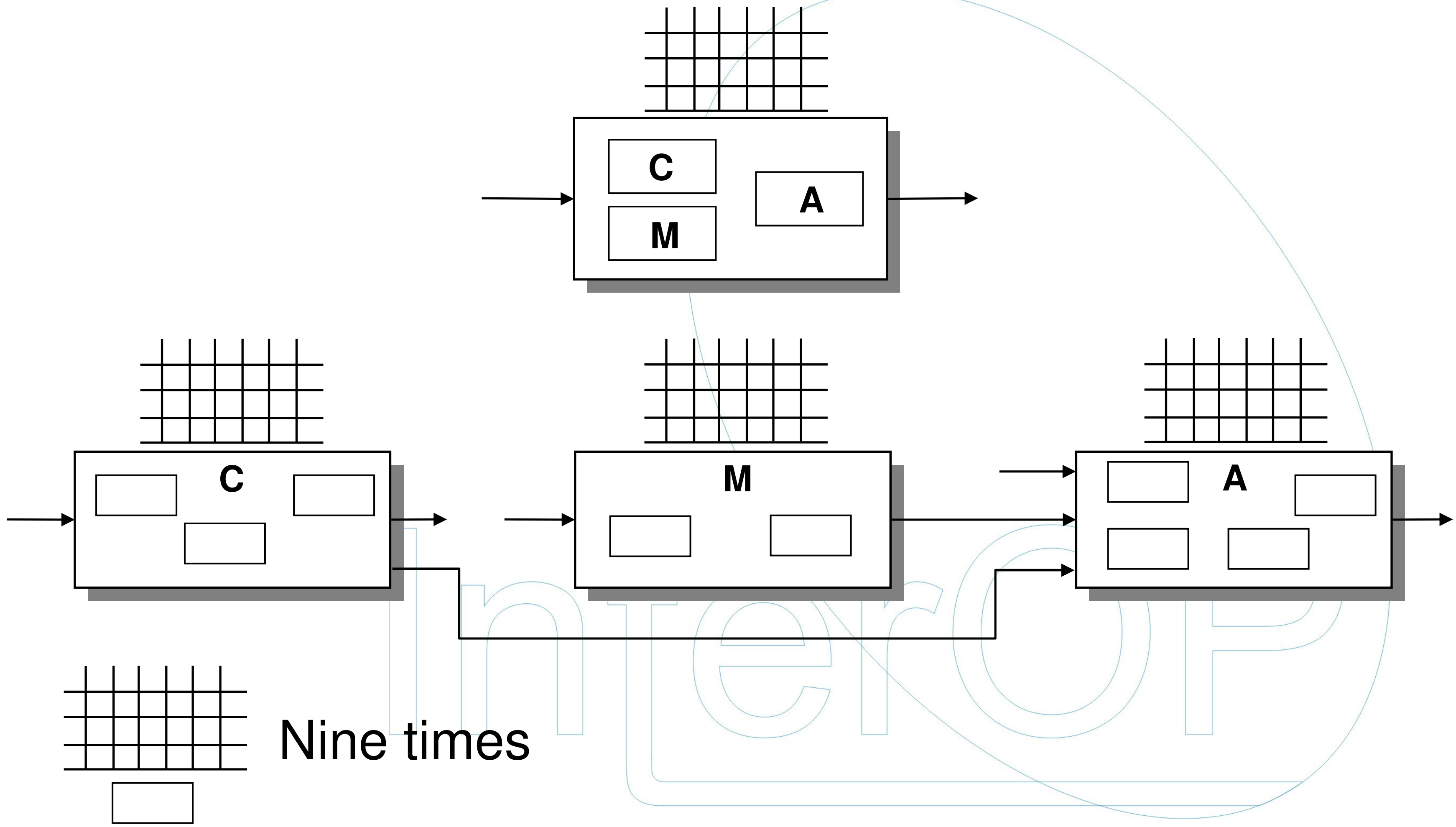
First solution: one grid

	MP	PI	MR	
Factory level		ISP		One instance
		MPSg		
		MRPg		
Shop level		MPSd		Three instances (one / shop)
		MRPd		
Cell level		Sched		Nine instances (one / cell)



Standardisation

Second solution: several grids



Second solution: several grids

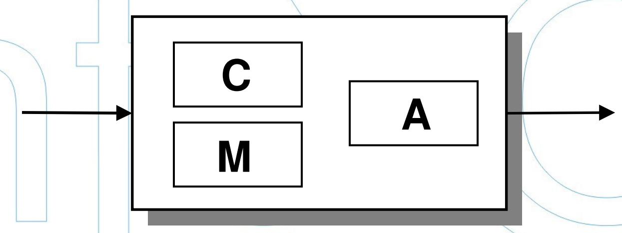
First level: factory

Control system

MP	PI	MR
	ISP	
	MPSg	
	MRPg	

Grid

Physical system



Second solution: several grids

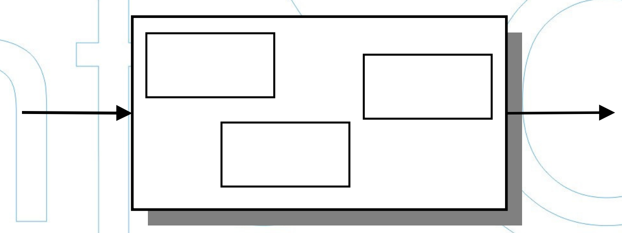
Second level: shop

Control system

MP	PI	MR
	MPSd	
	MRPd	

Grid

Physical system



Everything 3 times

Second solution: several grids

Third level: cell

Control system

MP	PI	MR
	Sched	

Grid

Physical system

Everything 9 times

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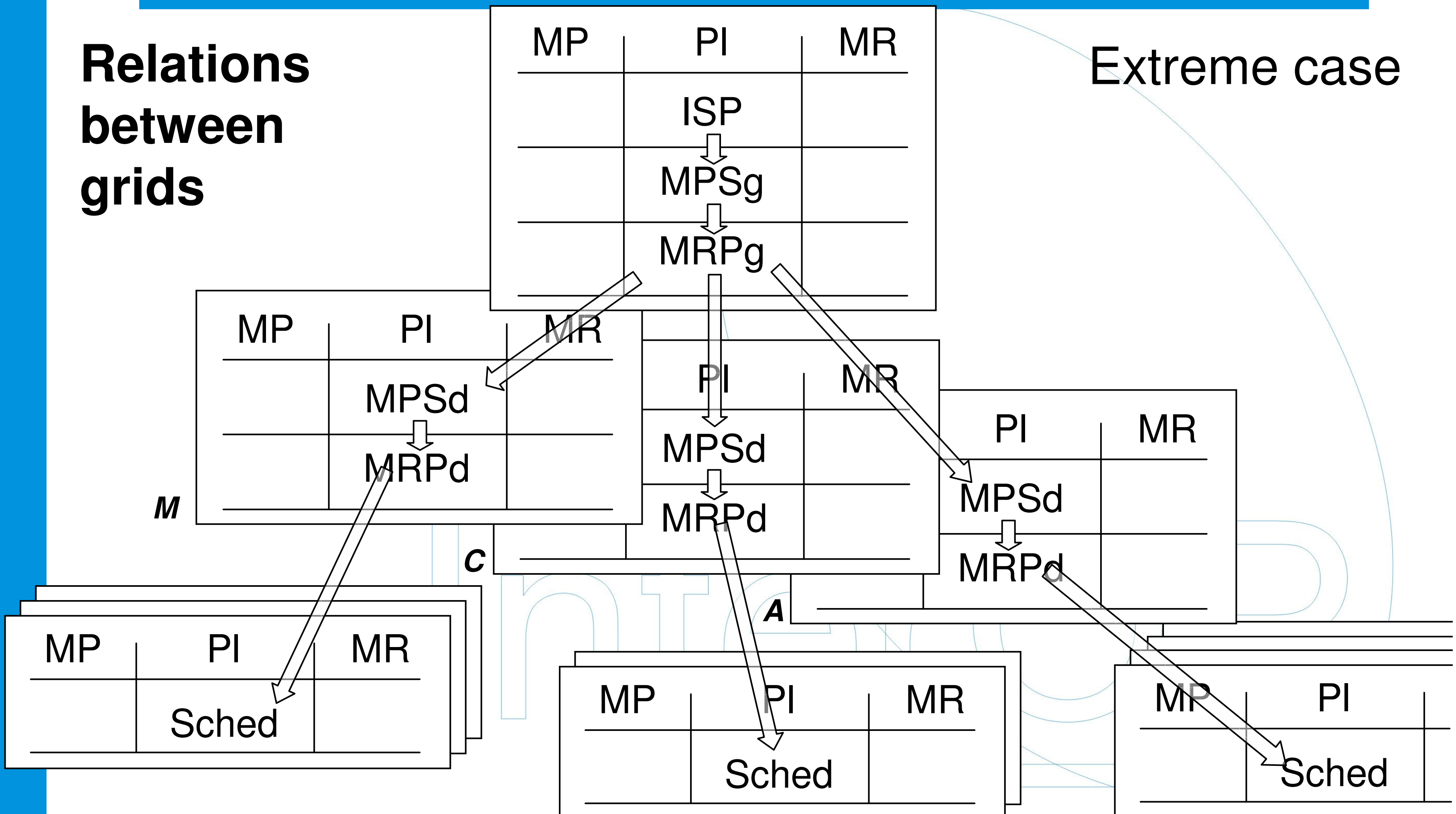
Second solution: several grids

Relations between grids

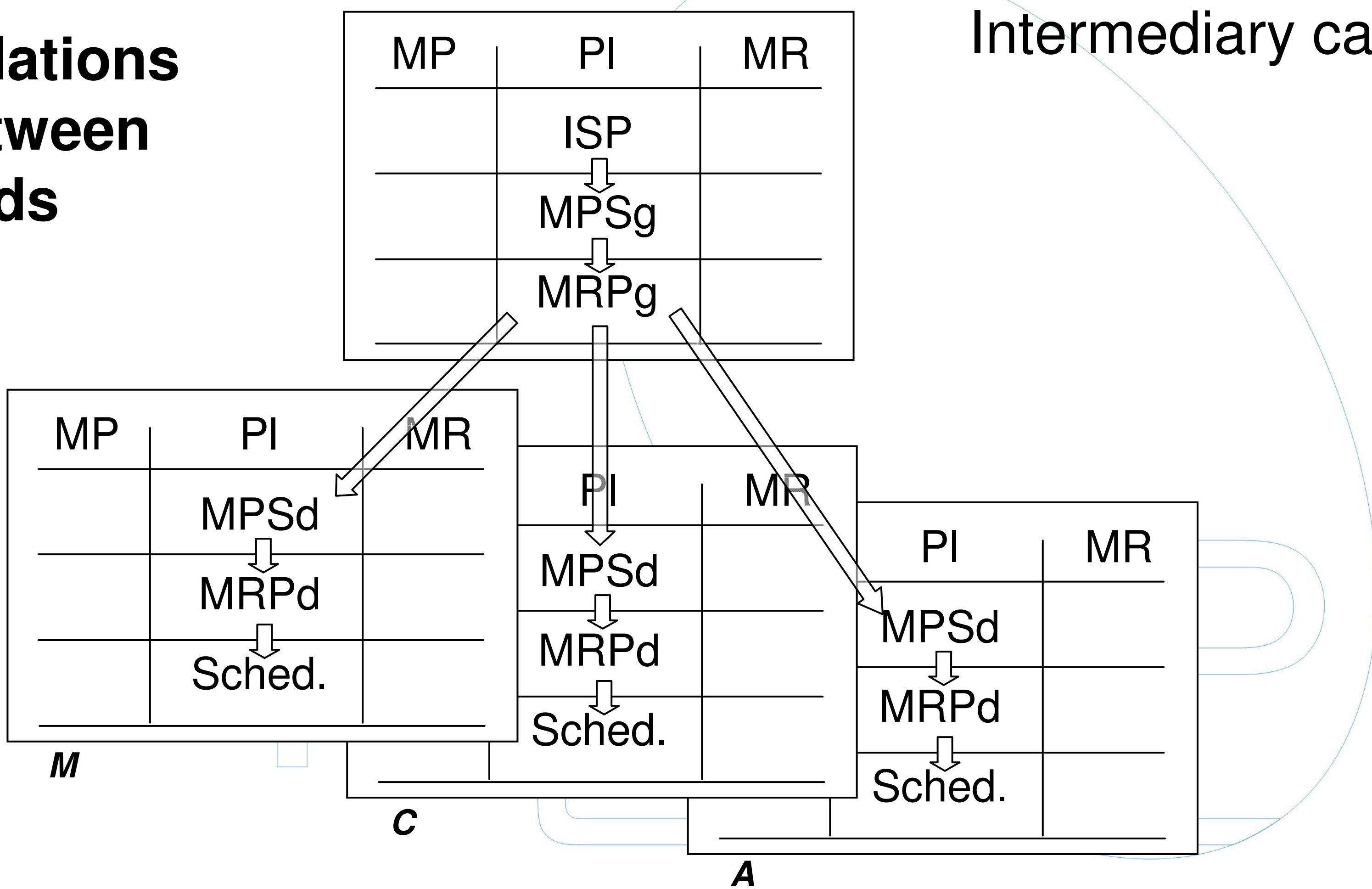
Extreme case



Second solution: several grids

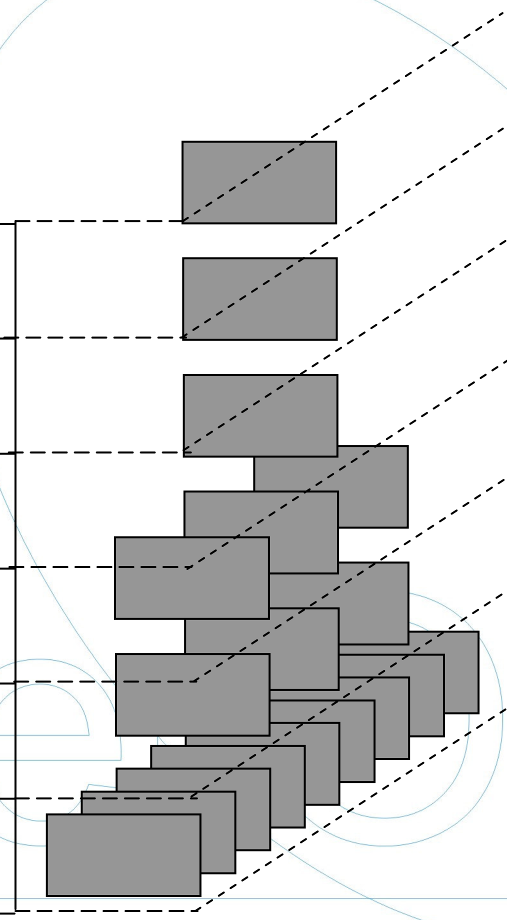
Relations between grids

Intermediary case

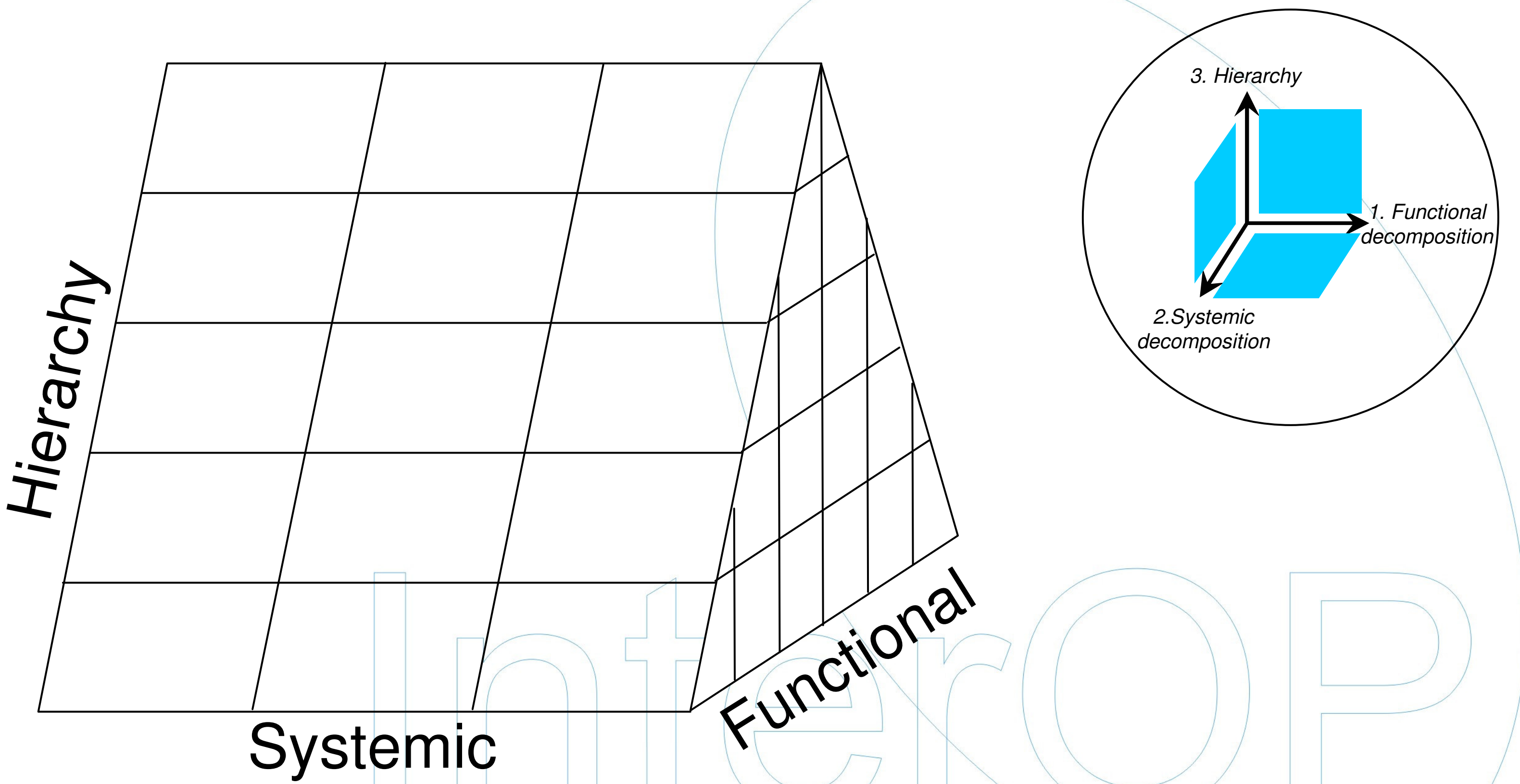


Conclusion

MP	PI	MR
	ISP	
	MPSg	
	MRPg	
	MPSd	
	MRPd	
	Sched	

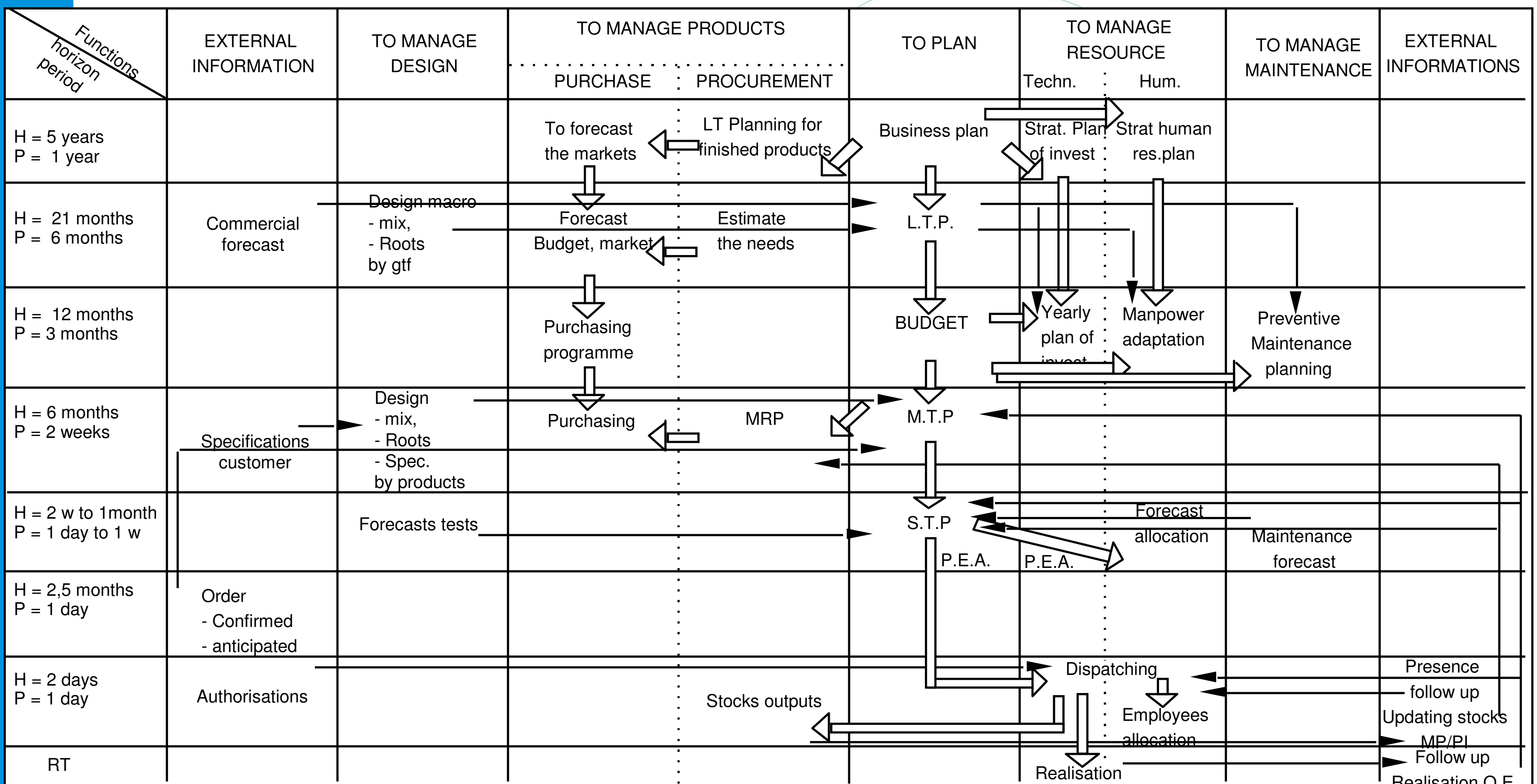


Conclusion: the prism

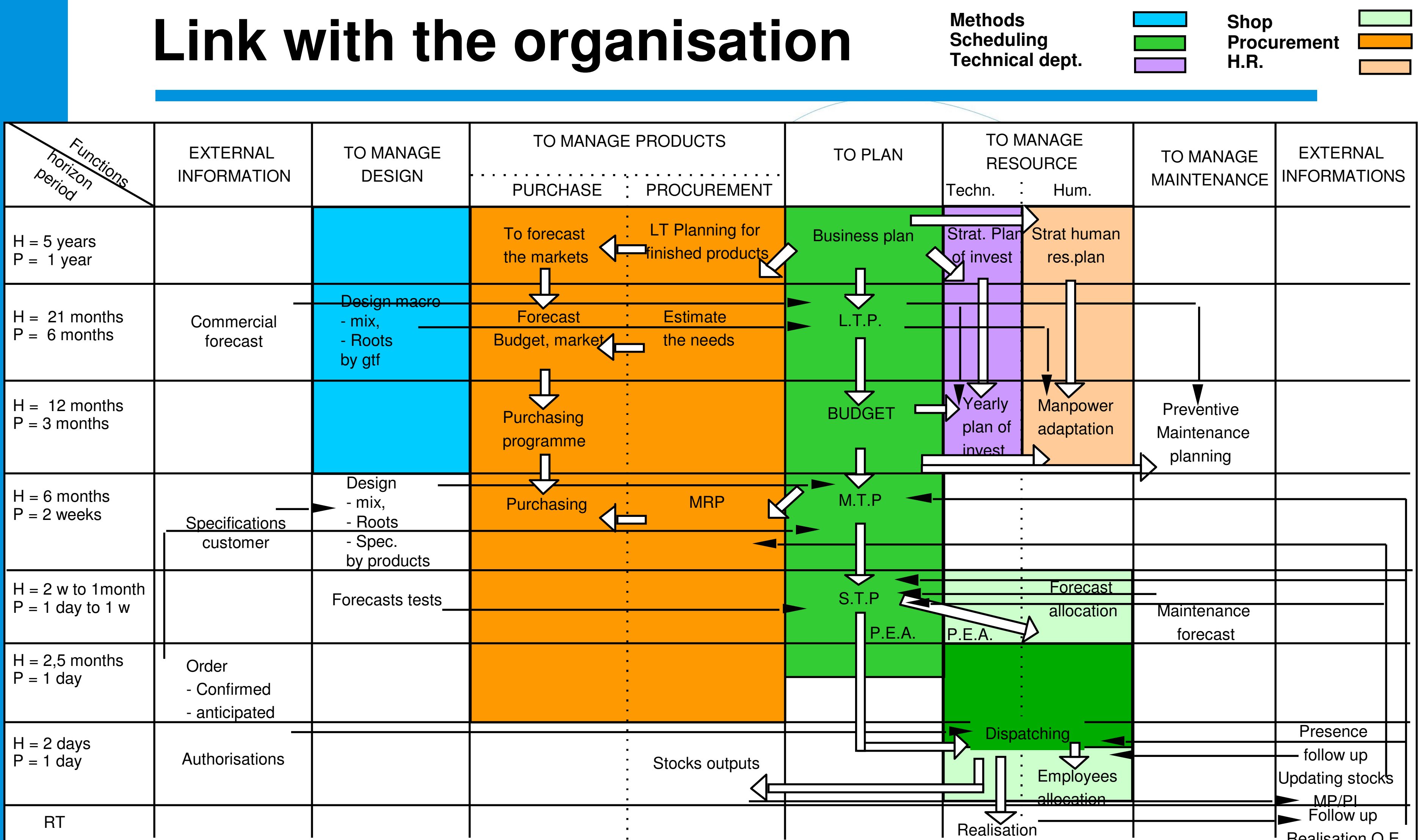


POSSIBLE EXTENSIONS OF THE GRID

Example of a GRAI grid

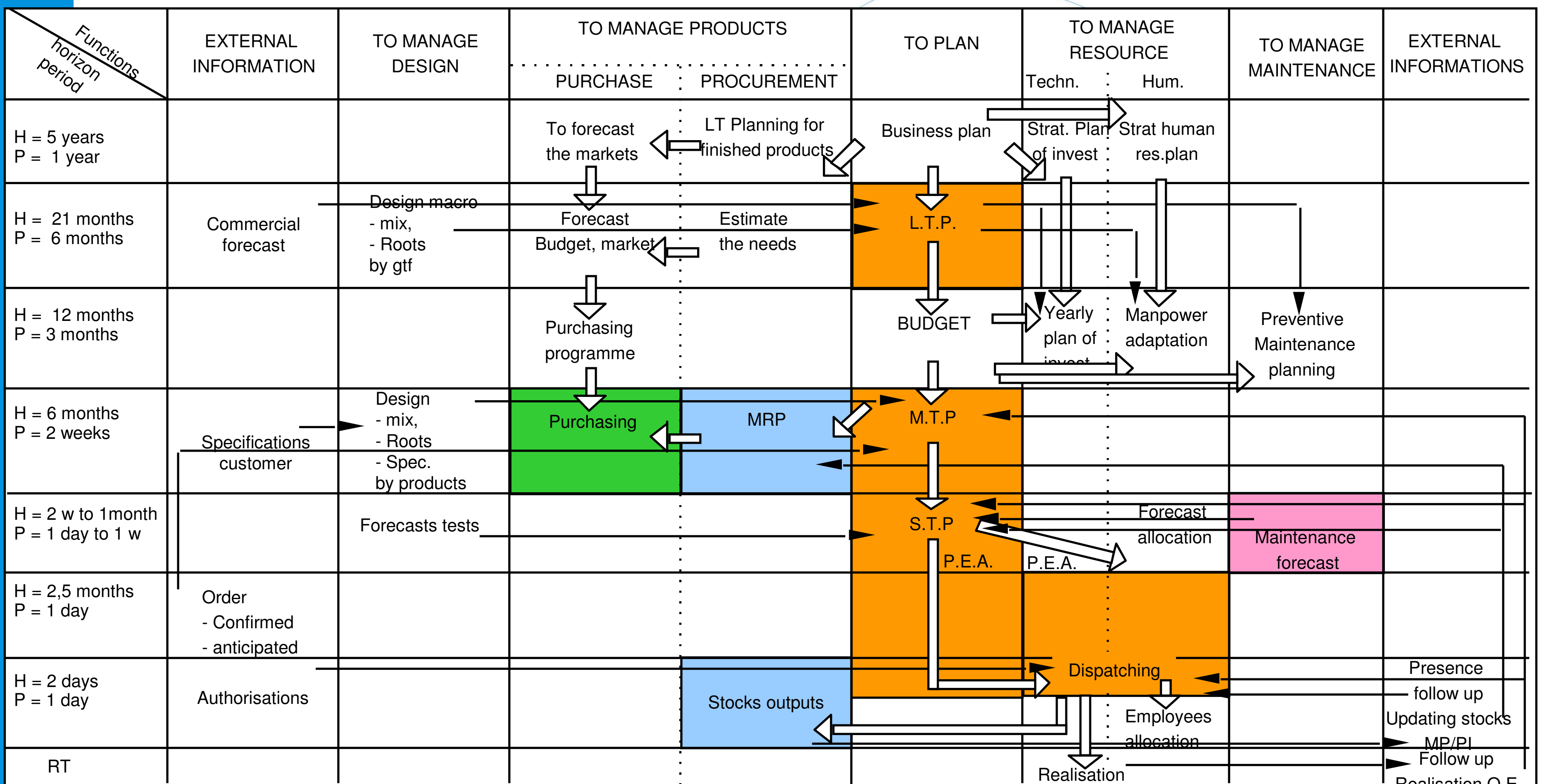


Link with the organisation



Link with software

CAPM
Inventories control SW
Procurement SW
Maintenance SW



Thank you for your attention