Towards an Association of Product Configuration with Production Planning

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Work situation

- Many studies about aiding product design

  [Brown and Chandrasekaran 1985], [Coyne, and al. 1990], [Suh 1990]

  - Among them : constraint based approaches and configuration

    [Tsang 1993], [Mittal and Frayman 1989], [Sabin and Freuder, 1996]

- Many studies about aiding project planning

  - Among them : constraint based approaches

    [Dechter and al. 1991], [Laborie 2003], [Mouhoub and Sukpan 2005]

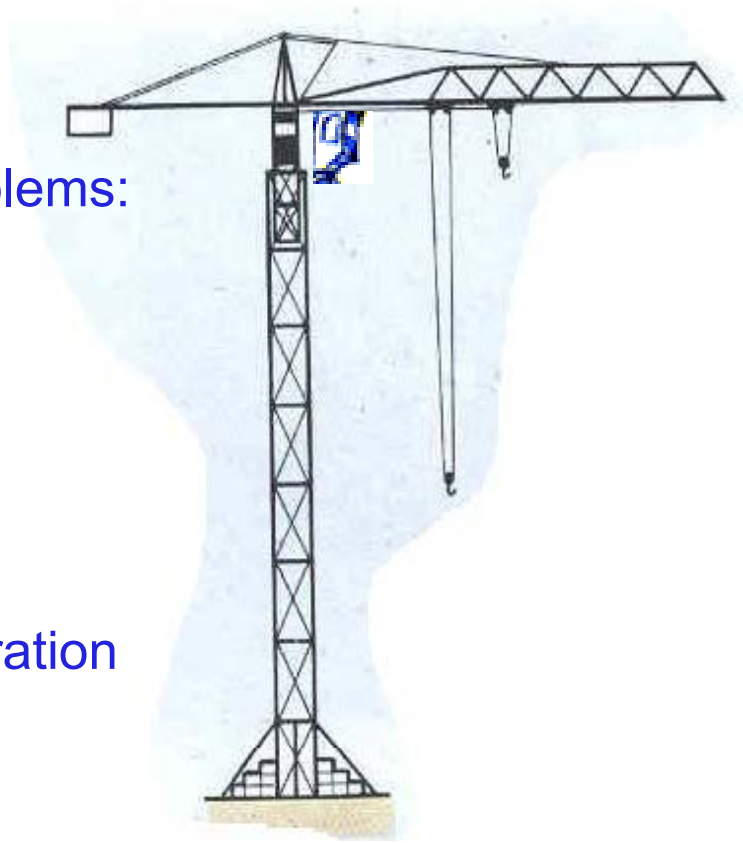
- Few studies mixing them : [Suh 90], [Steward 81], [Gero 90]….

  – Product configuration decisions ➔ Project planning decisions

  – Project planning decisions ➔ Product configuration decisions

Work situation

- Goal of our study…
  - Propose an approach that allows previous interactions
  - Constraint based approach to propagate decision consequences
  - ***In an interactive way***



- Constraints Satisfaction Approaches or Problems:
  - Triplet (X, D, C) where:
    - X = set of variables
    - D = set of domains, one for each variable
    - C = set of constraints

- Detailed example on paper: a crane configuration

Summary

- Product Configuration
  - Modelling need
  - Constraint model and algorithm
- Project Planning
  - Modelling need
  - Constraint model and algorithm
- Proposition for coupling
  - Model of cooperation
  - Illustrate examples

Product Configuration

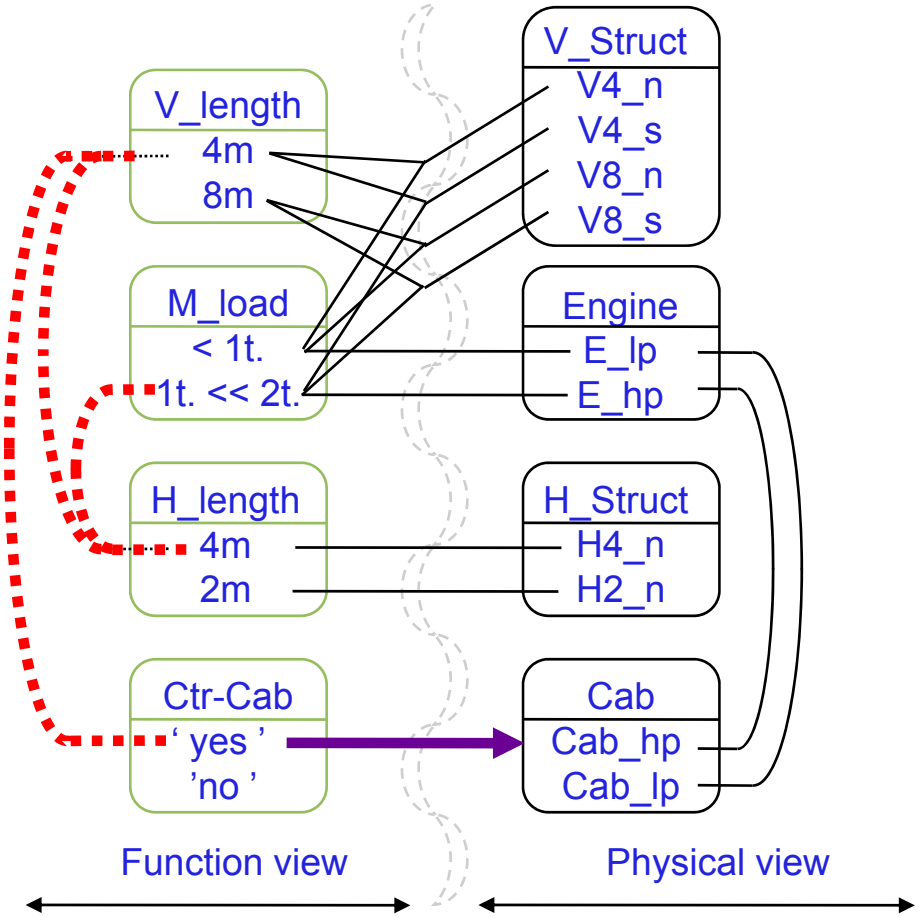
- Product configuration :
  - Generic model of a product family :
    - set of components + set of properties
    - relation between components and properties
  - Find combinations that fulfil the customer's requirements

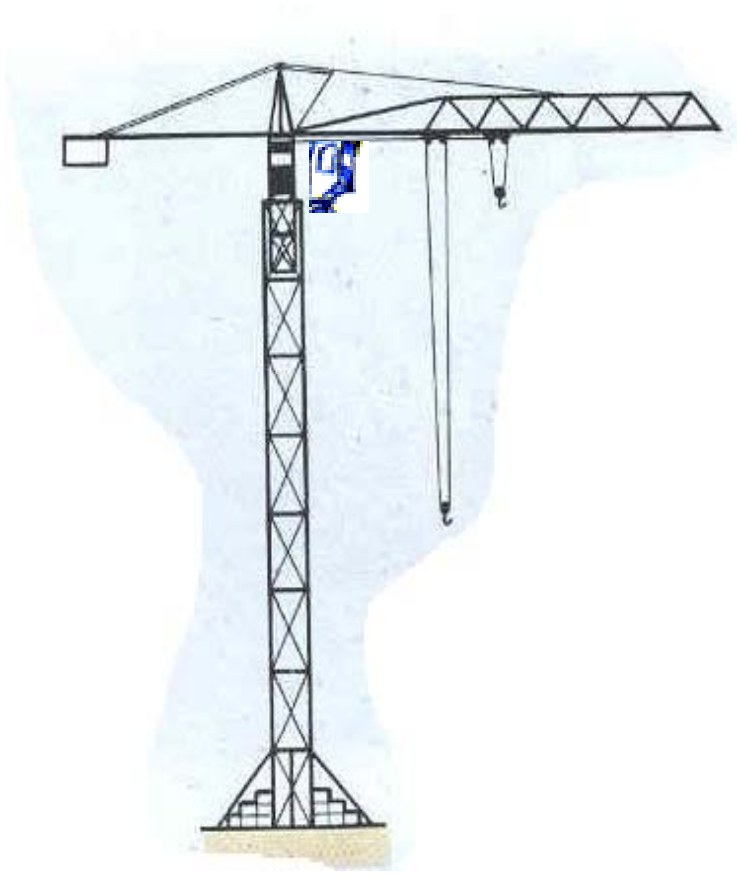
- Configuration model :
  - Set of variables
    - - mainly symbolic and discrete
  - Constraints between components and properties
    - - compatibility constraints + activity constraints

- Interactive processing :
  - Constraint filtering
  - Arc consistency

- Classical, well known and robust approaches…

Product Example





Project planning

- Project planning :
  - Generic model of a family of realization plans:
    - set of operations (or tasks) + resource + operation existence control
    - precedence constraints + AND nodes + XOR nodes
  - Find combinations that support realization of the configured product

- Project Planning model :
  - Resources are considered unlimited in this communication
  - Operation or task ={duration, start and finish time} with intervals
  - As far as we know:
    - no existence condition on task / no XOR nodes for task
    - no interval or multi-interval for : duration, start and finish time

  - Classical constraint approaches and tools (as ECLiPse) work fine.

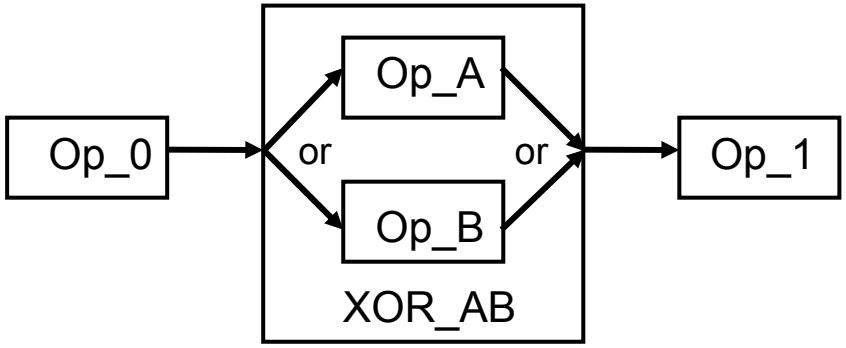
  - In other cases, not obvious at all :
    - very few studies [Mouhoub Sukpan 2005] temporal/activity constraints

=> we propose a XOR node based on bound consistency

Project planning

- XOR node based on bound consistency
  - Two (or more) tasks connected with a XOR node are in a XOR node

  - A task T is defined at intervals with :
    - possible length of time : T.pdt
    - possible start time : T.pst
    - possible finish time : T.pft
    - and Tpft = Tpst + Tpdt

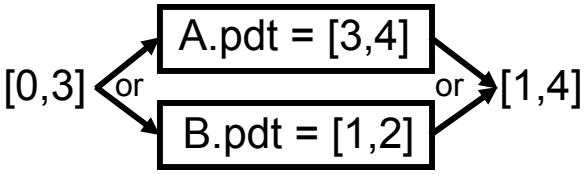


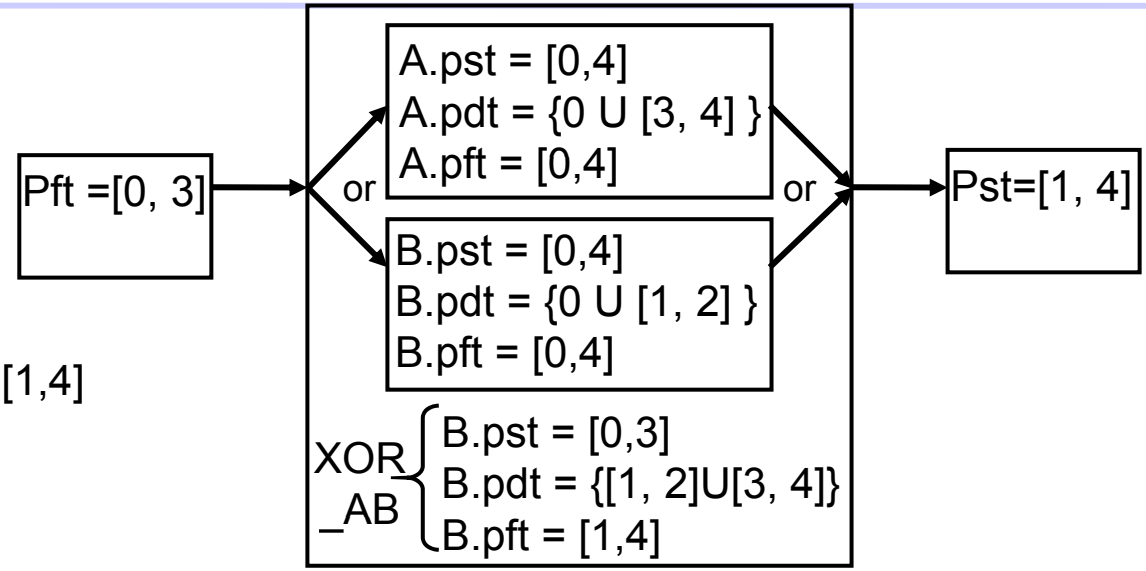
  - Arrows correspond with constraint TX → TY : Y.pst >= X.pft

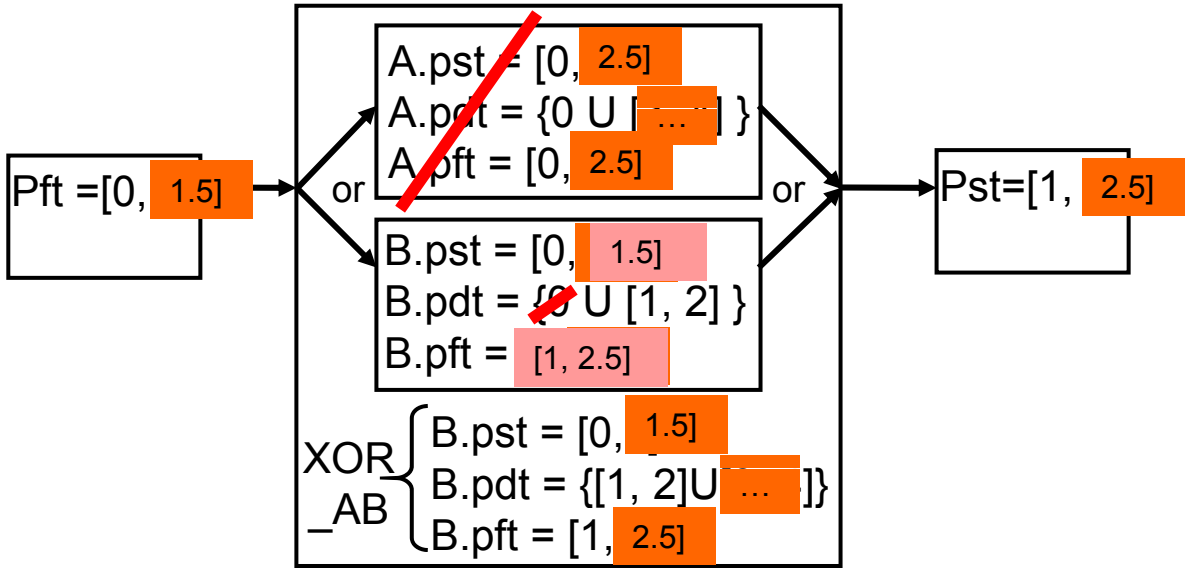
  - Duration of all the tasks of the XOR node (A and B) :
    - zero value (0) is included in the duration of task A and B,
    - 0 for a task duration means that the task is not considered anymore
    - a constraint implies that the duration of all tasks except one = 0
  - Duration of the XOR node :
    - XOR_AB.pdt = A.pdt U B.pdt (union of task durations)
    - XOR_AB.pdt > 0 (one of the tasks must be selected)

Project planning

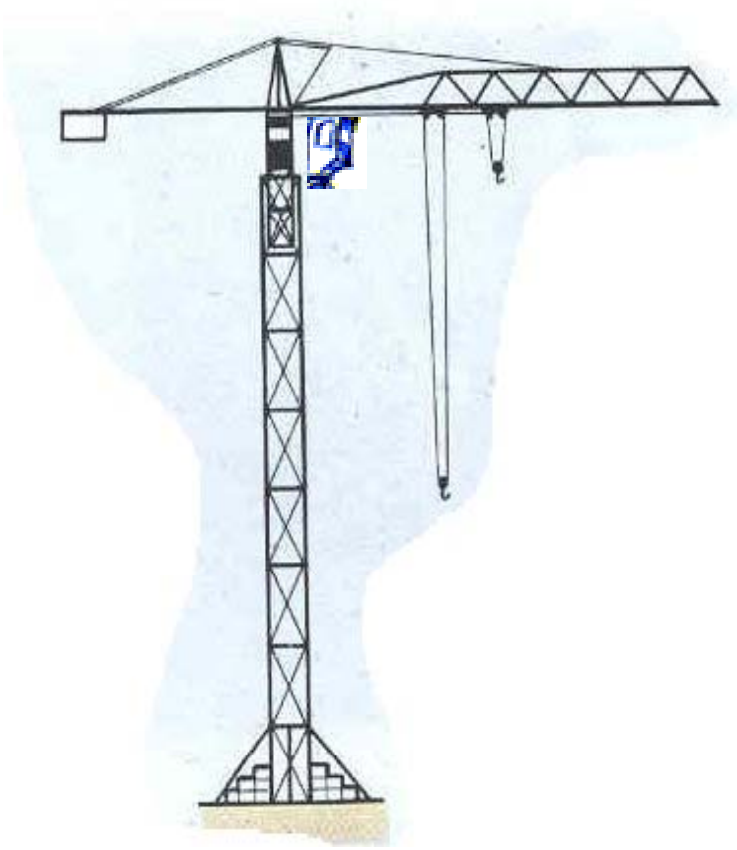
XOR behaviour

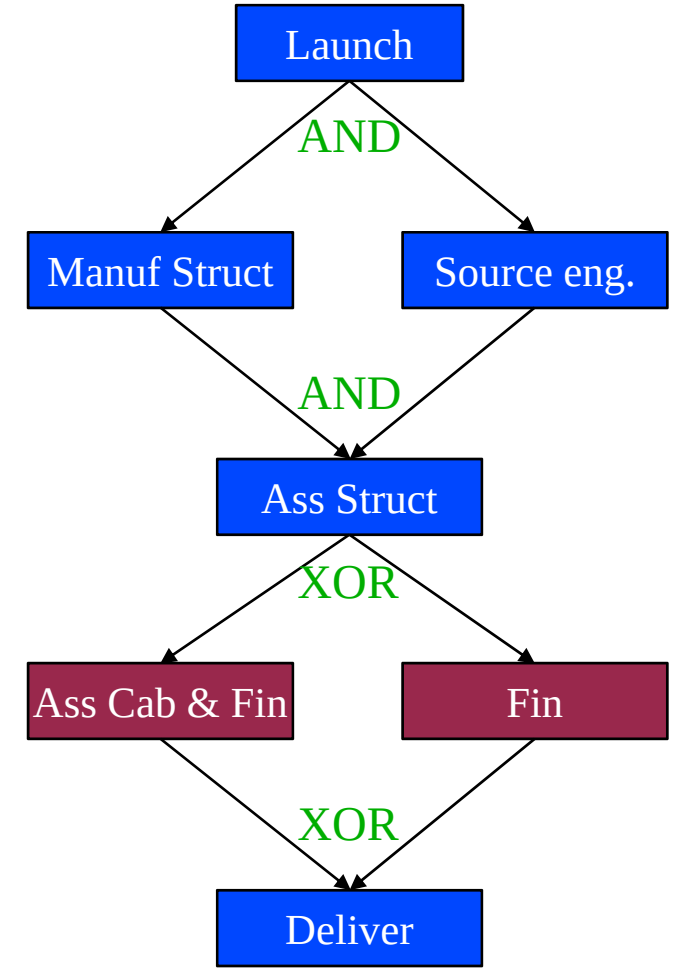






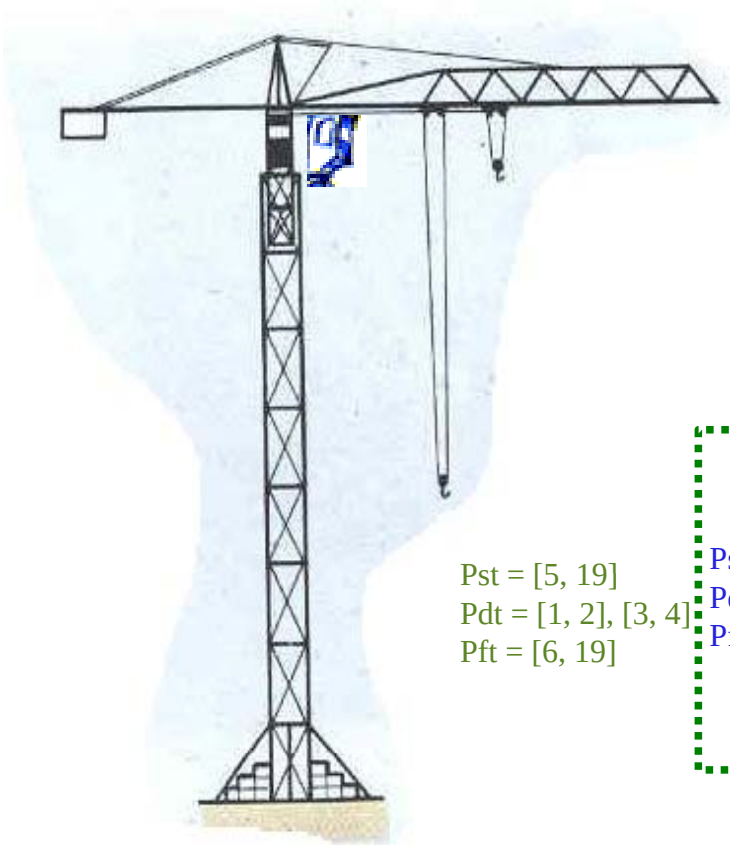
Planning example



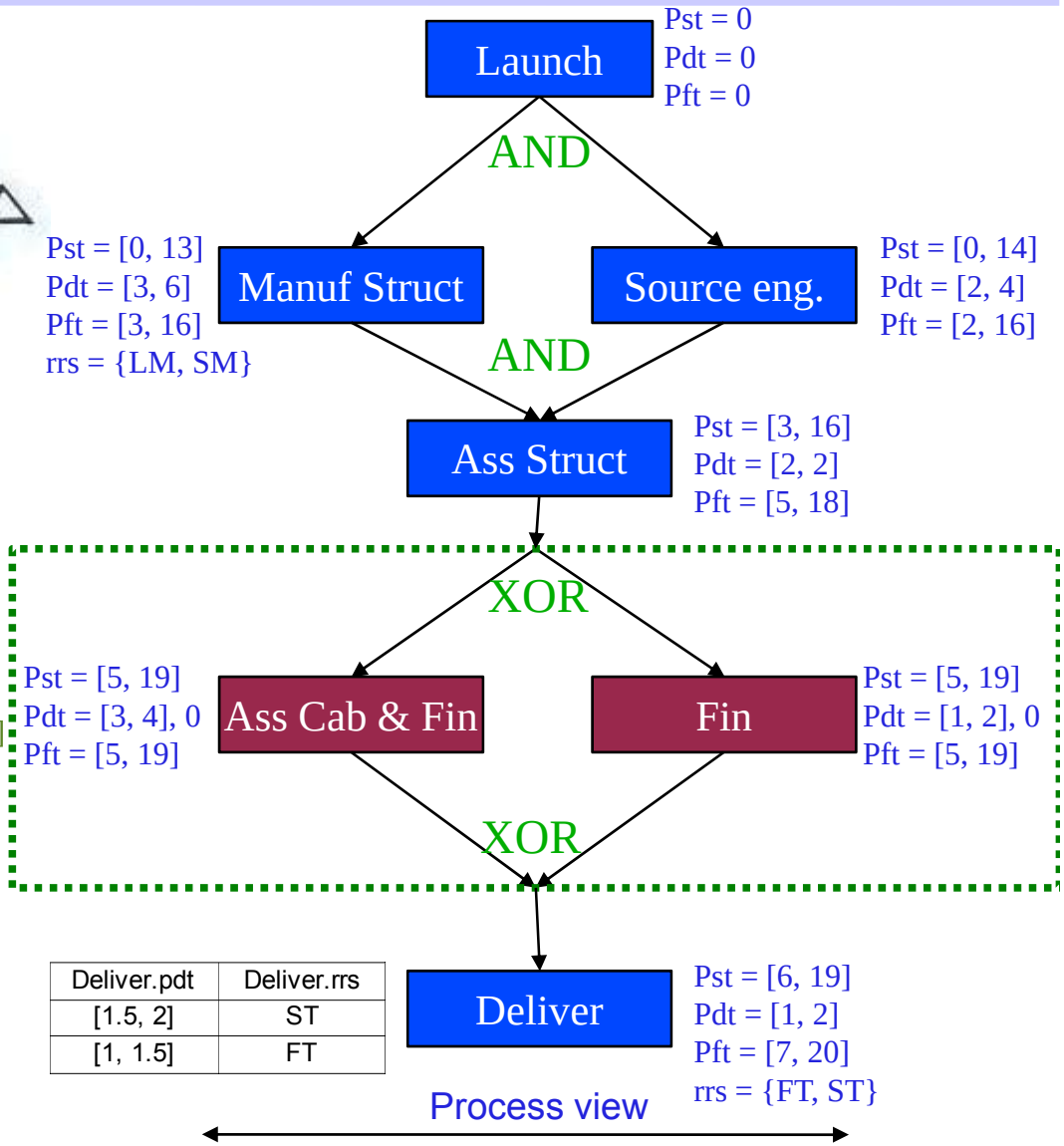


Process view

Planning example



Pst = [5, 19]
Pdt = [1, 2], [3, 4]
Pft = [6, 19]



Deliver.pdt	Deliver.rrs
[1.5, 2]	ST
[1, 1.5]	FT

Process view

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Proposition for coupling

- Product configuration :
  - Classical CSP mainly discrete
  - Interactive configuration thanks to arc consistency

- Project planning :
  - Numerical CSP relying on interval analysis
  - Interactive planning thanks to bound consistency and XOR nodes

- Coupling product configuration and project planning
  - Identification of constraints involving variables belonging to the two problems :
    - any variable of the product model
    - temporal variables (duration, starting date, finishing date, ressources)
    - specific interpretation : duration restricted to {0}
      => task is not considered anymore

Coupling example

Coupling product configuration and project planning

- Product variable and ressources in planning

Manuf Struct . Rrs	V_length
SM	4m
LM	8m

- Product variable and length of time in planning

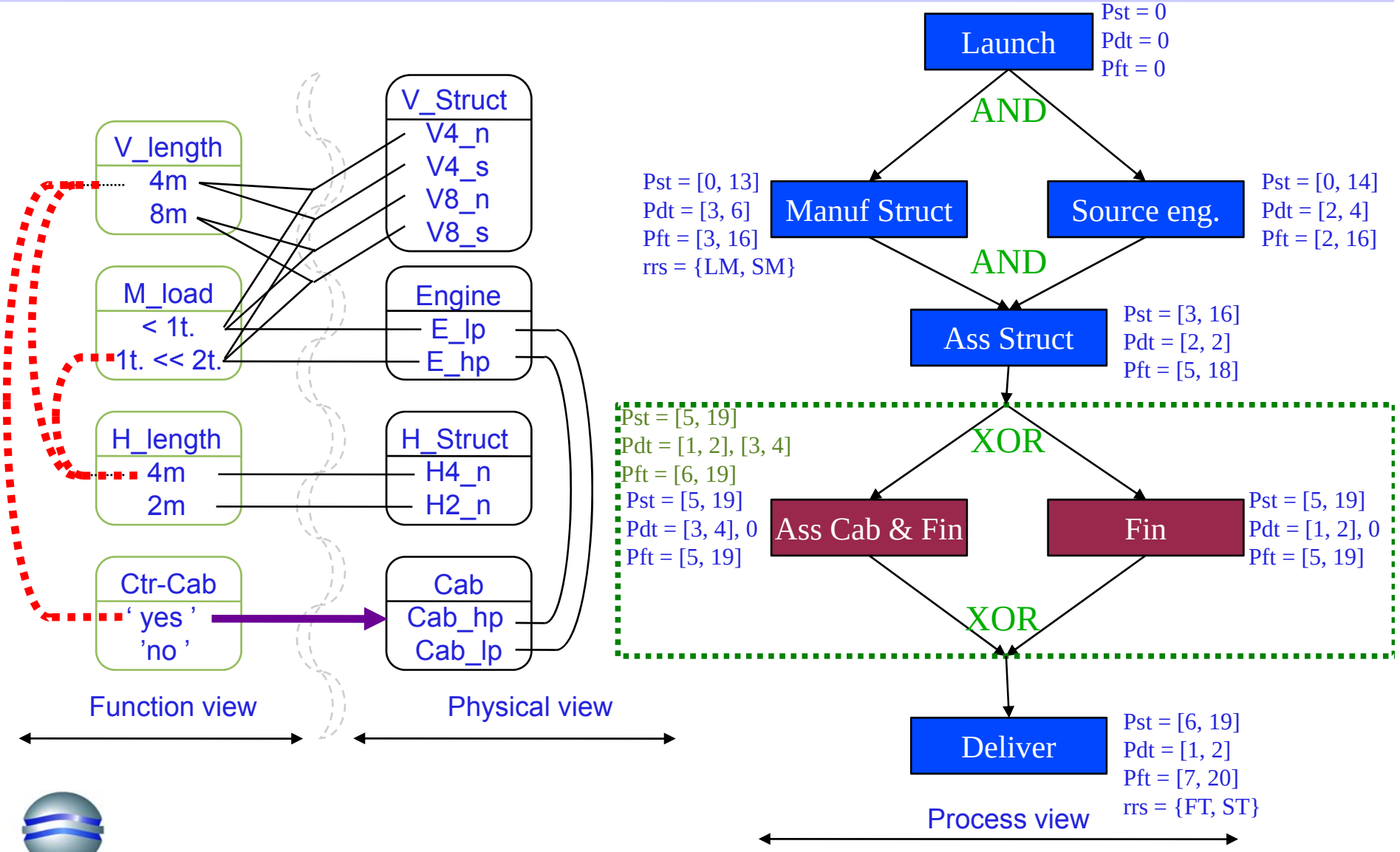
Manuf Struct . Pdt	M_load
[3, 4.5]	< 1t
[4.5, 6]	1t<<2t

Source Eng. Pdt	Engine
[2, 3]	E_lp
[3, 4]	E_hp

- Product variable and selection of a path

Ass Cab.pdt	Ctr-Cab
0	no
[3, 4]	yes

Coupling example



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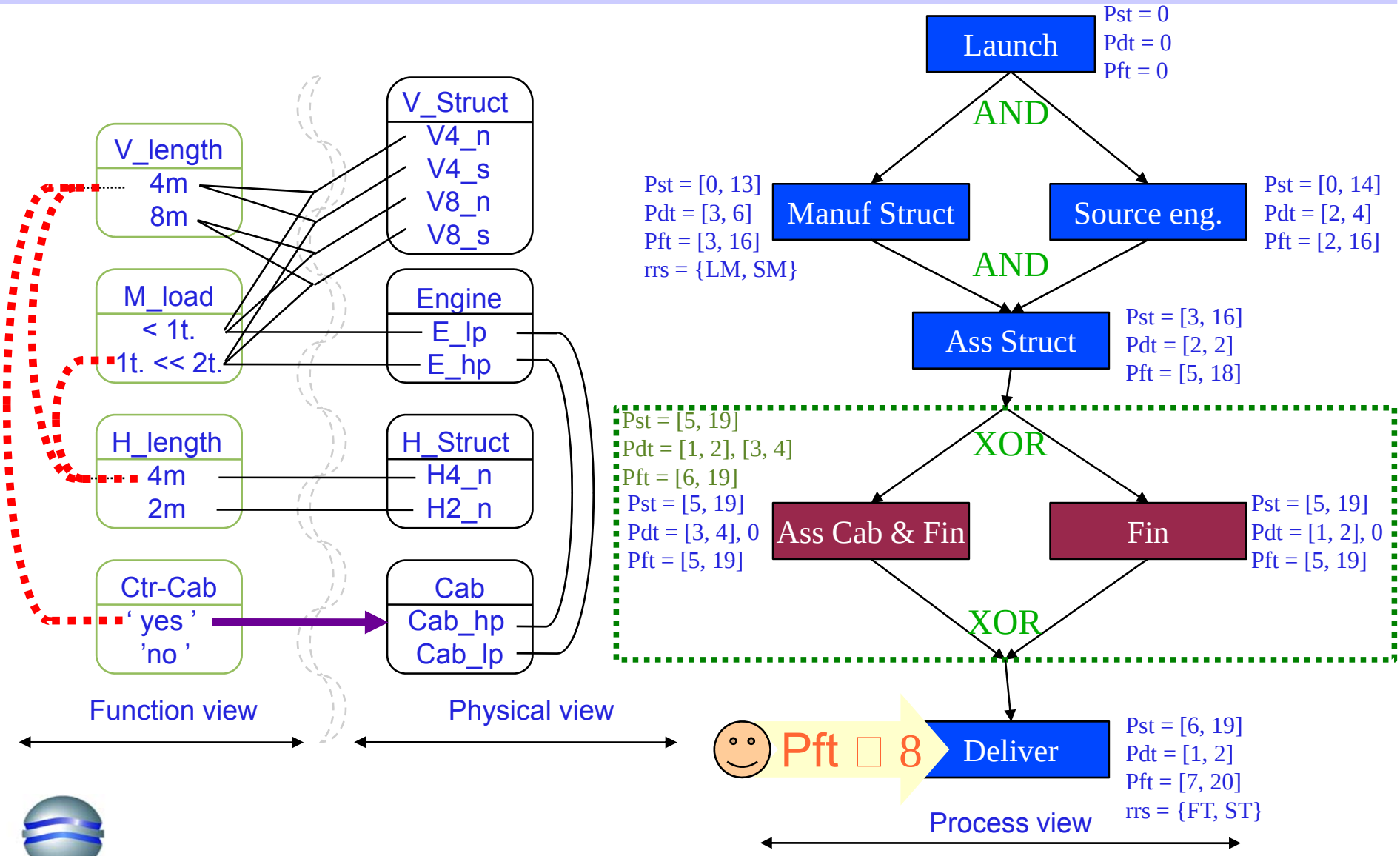

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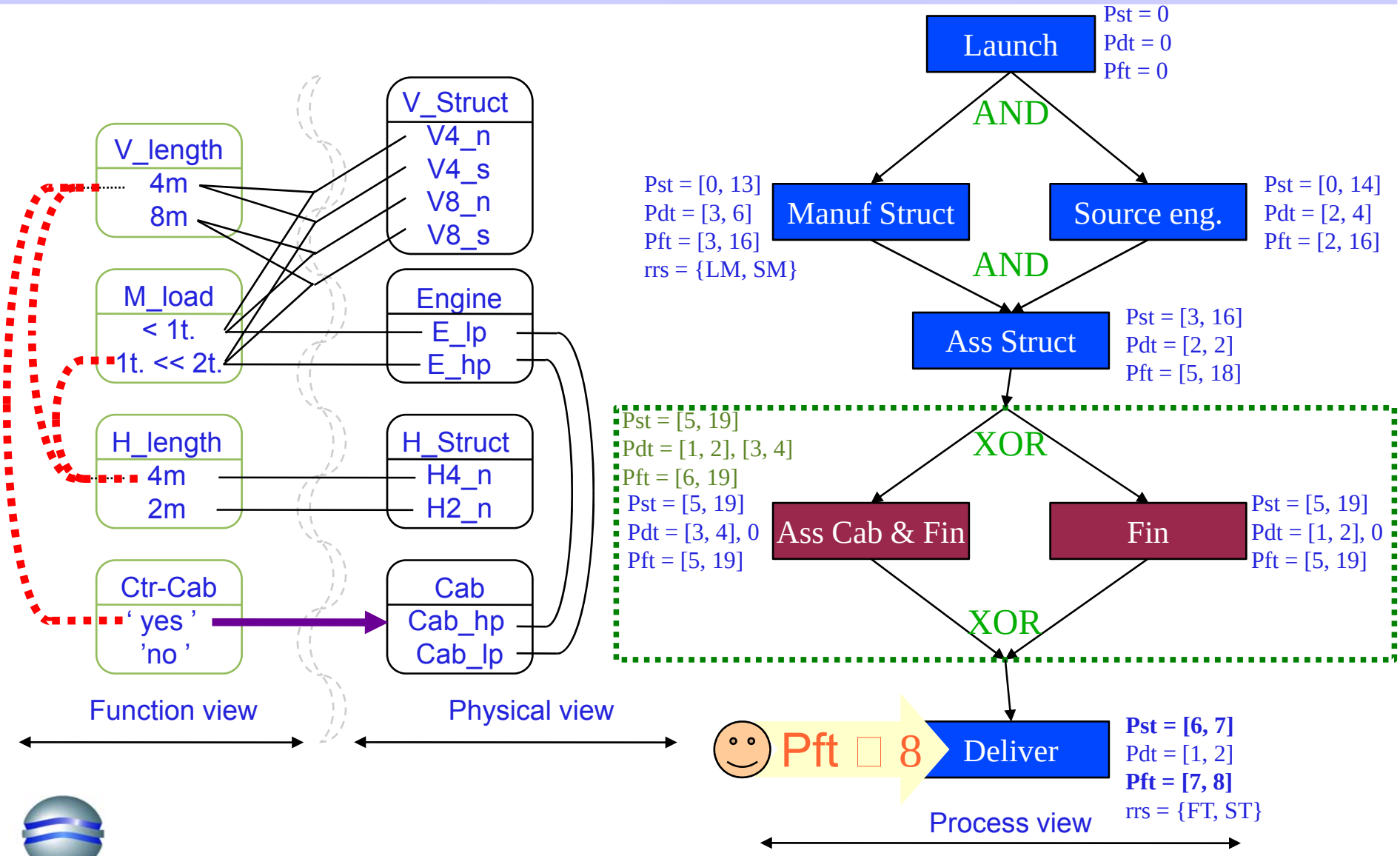
Coupling example



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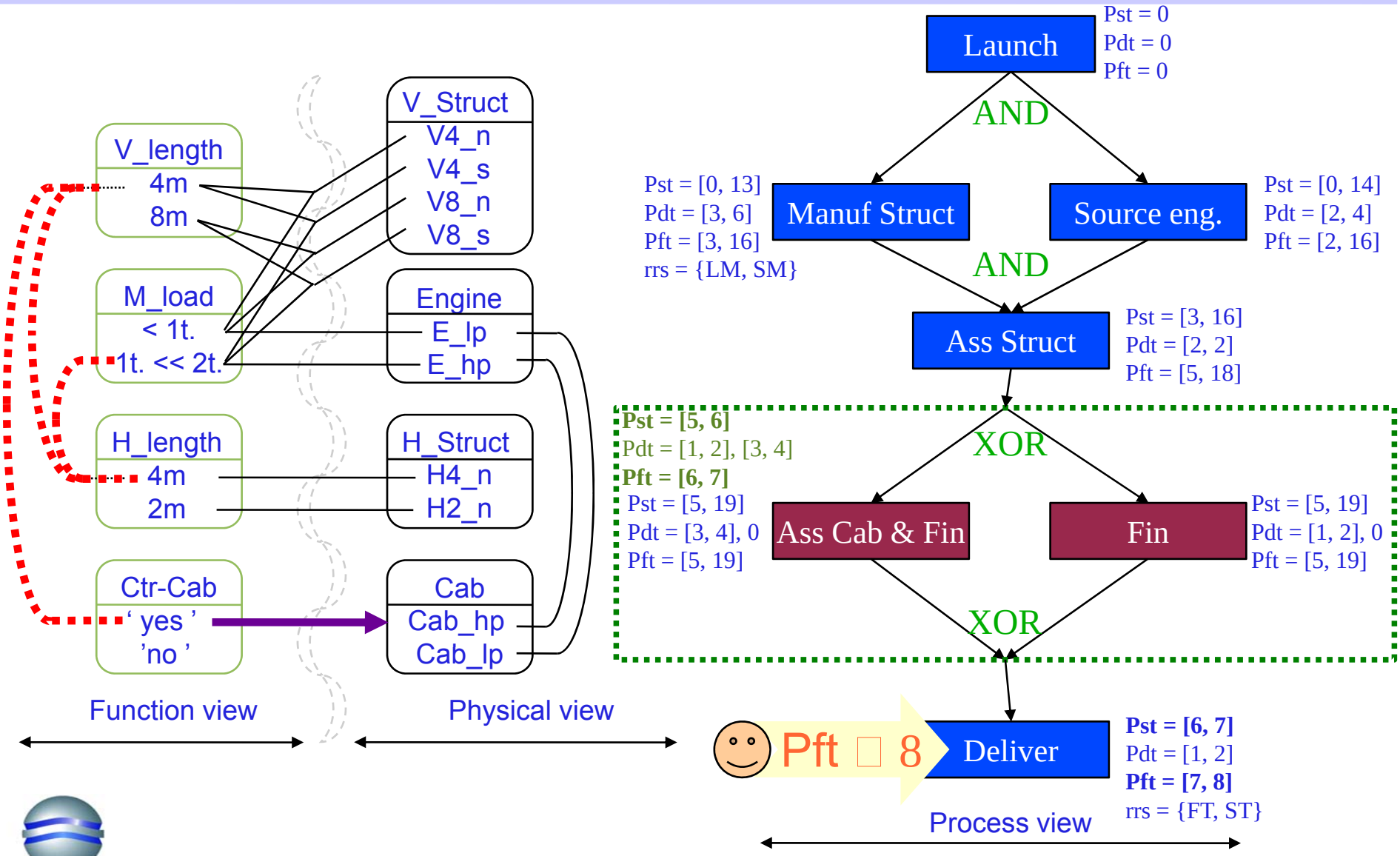

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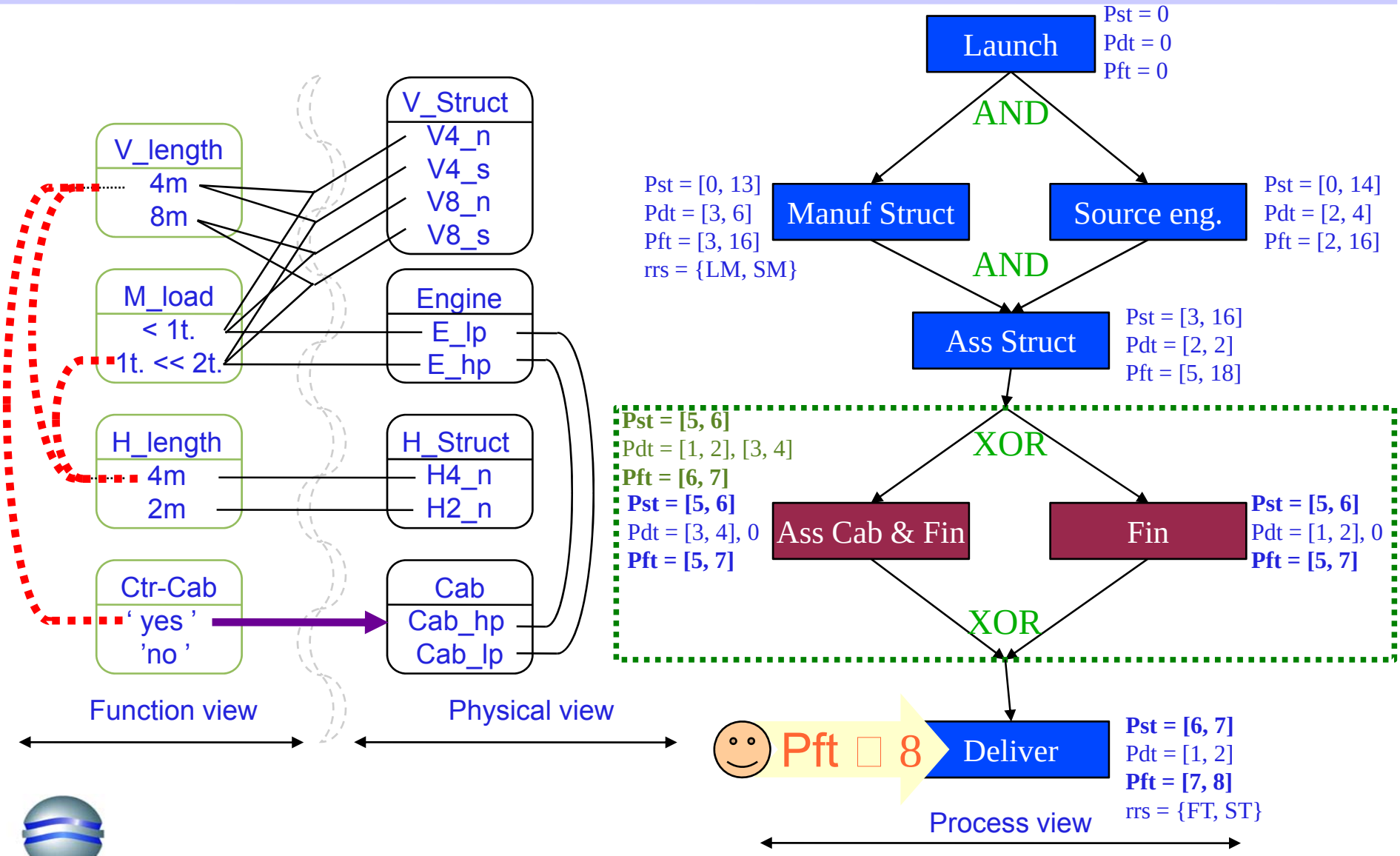

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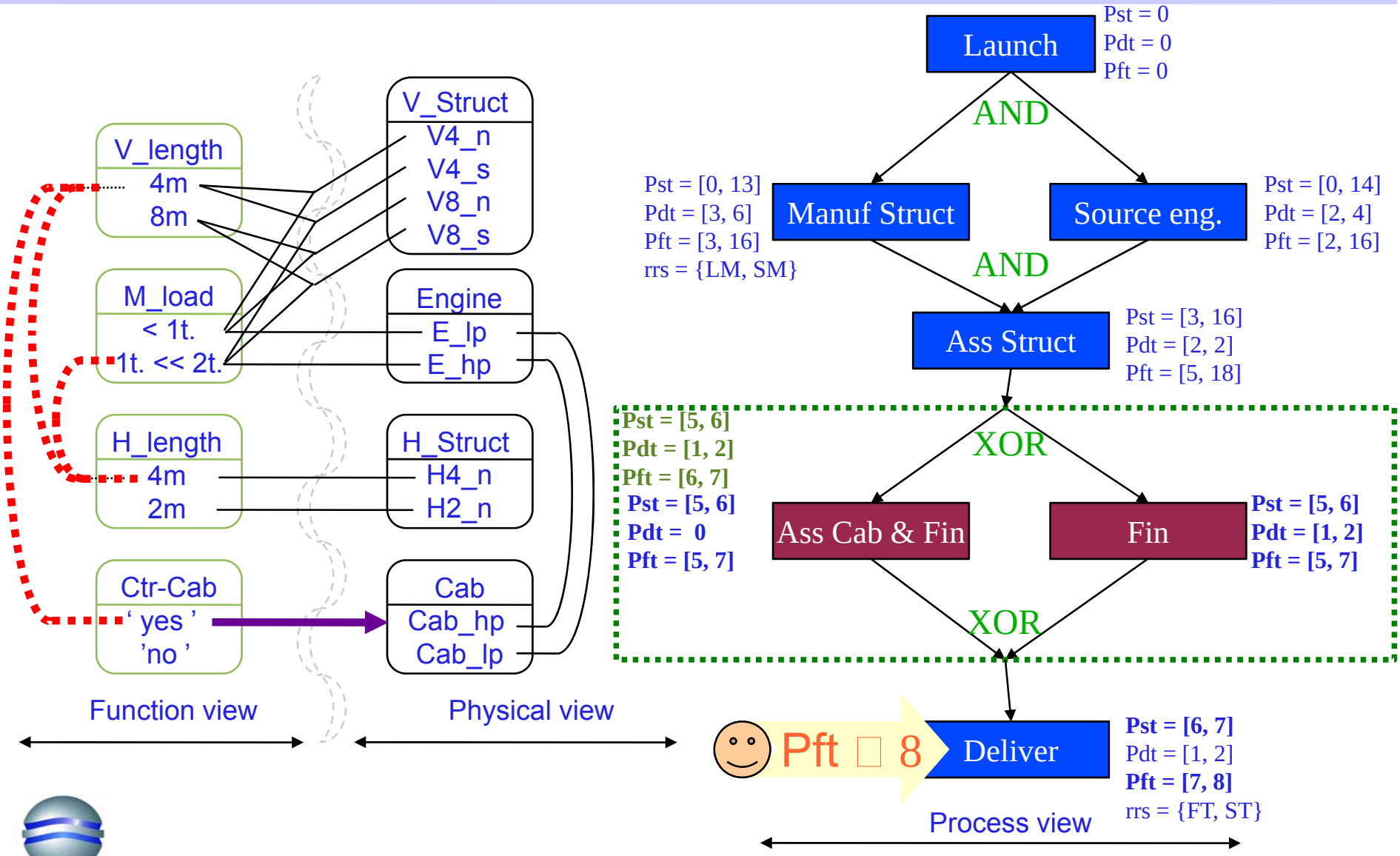
Coupling example



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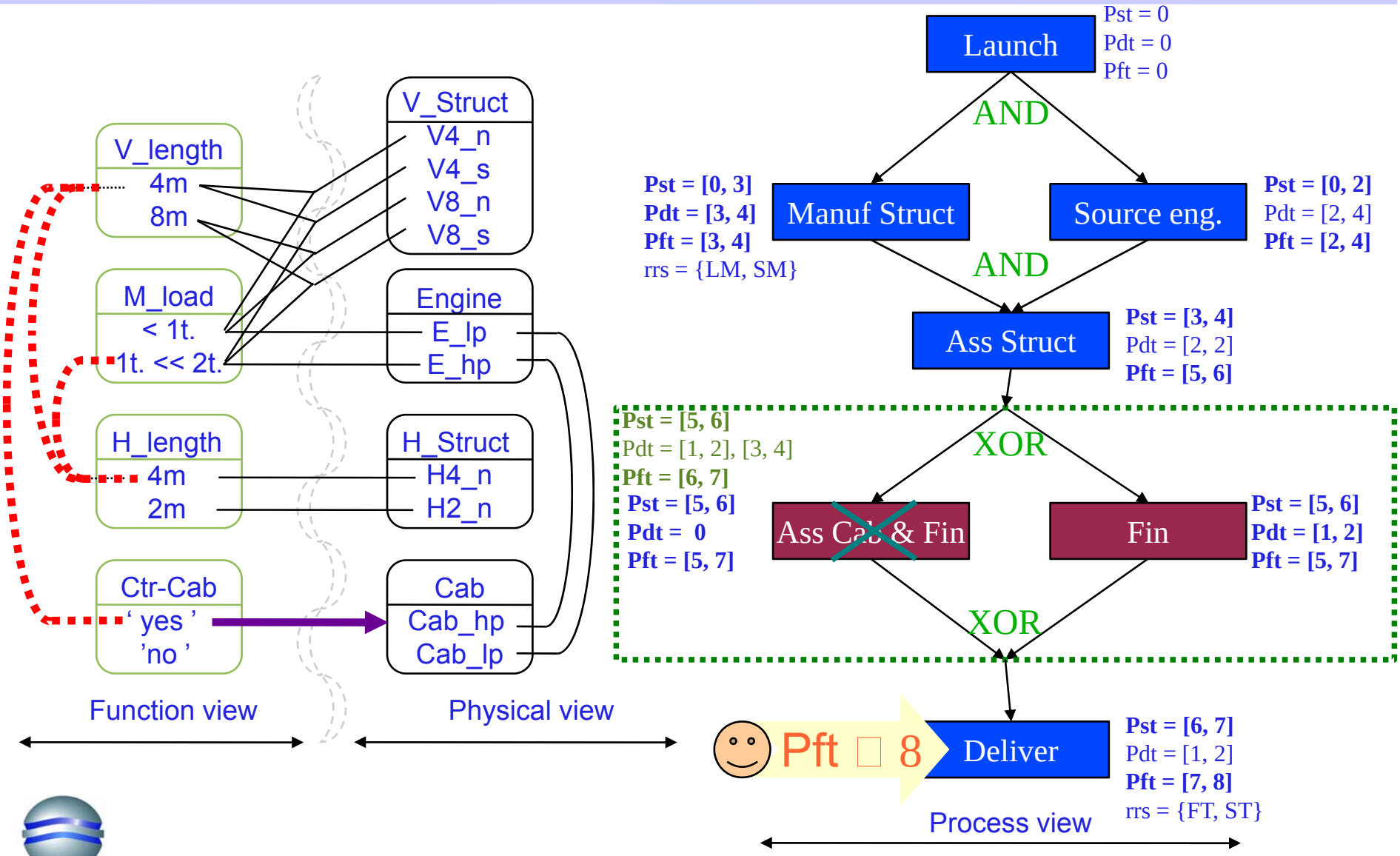

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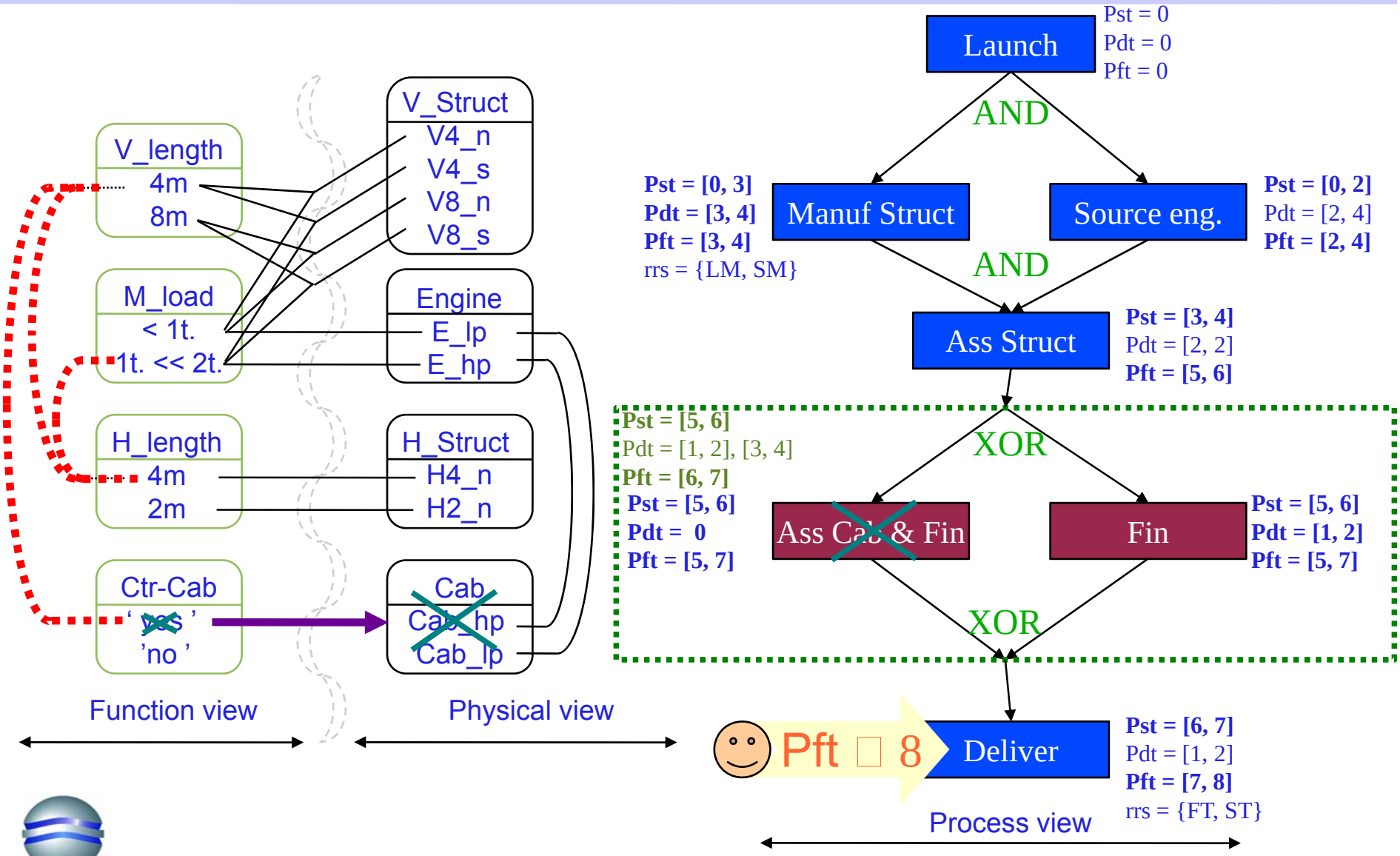

Conclusions

- About aiding configuration and planning with constraint approaches :
  - Many studies have been carried out separately for each domain,
  - As far as we know, none has tried to associate them, in order to propagate consequences between the two problems…

- Interests of the proposed approach :
  - Interactive-simultaneous assistance on configuration and planning
  - User friendly modelling with constraints,
  - Robust and simple filtering techniques,
  - …

- Work to be done :
  - Large problems, scaling aspect,
  - Limited capacity planning,
  - …

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