# Object model for planning and scheduling integration on discrete manufacturing enterprises

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# Outline

- Introduction
- System Framework
- Ontologies / Object Classes
- Planning and Scheduling Integration
- Implementation issues
- Experimental Results
- Conclusion



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# What is a problem?

- MPS can not be followed by the detail production schedule that becomes critical in a short term supply chain.
- Types of businesses with customers become more complicated so that a simple MRP technique doesn’t work well.
- Detailed production scheduling is hard to have capability to maintain the latest data of products and processes without system integration.
- Scheduling system on computers has not been welcome to plant floor operators because of its invisibility and unreliability.



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# Source of the problem

- Management issues
  - Separation of enterprise manager's view and plant floor manager's view
  - Separation of real objects and data in computer systems
- Technical issues
  - Separation of material (item) consideration and capacity (resource) consideration
  - Separation of planning decision process and scheduling decision process



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# System Framework



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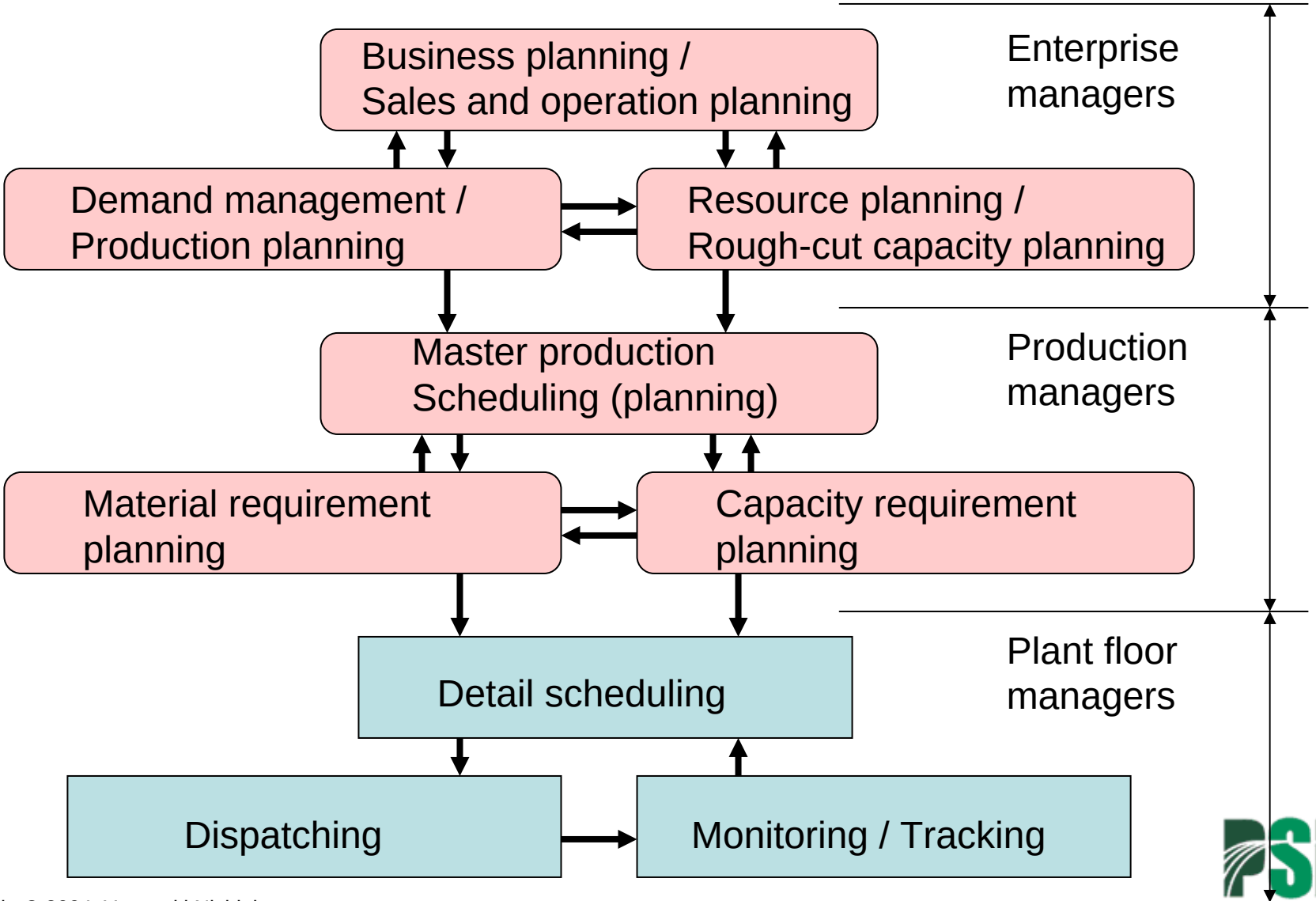
# Traditional systems (MRPII / ERP)



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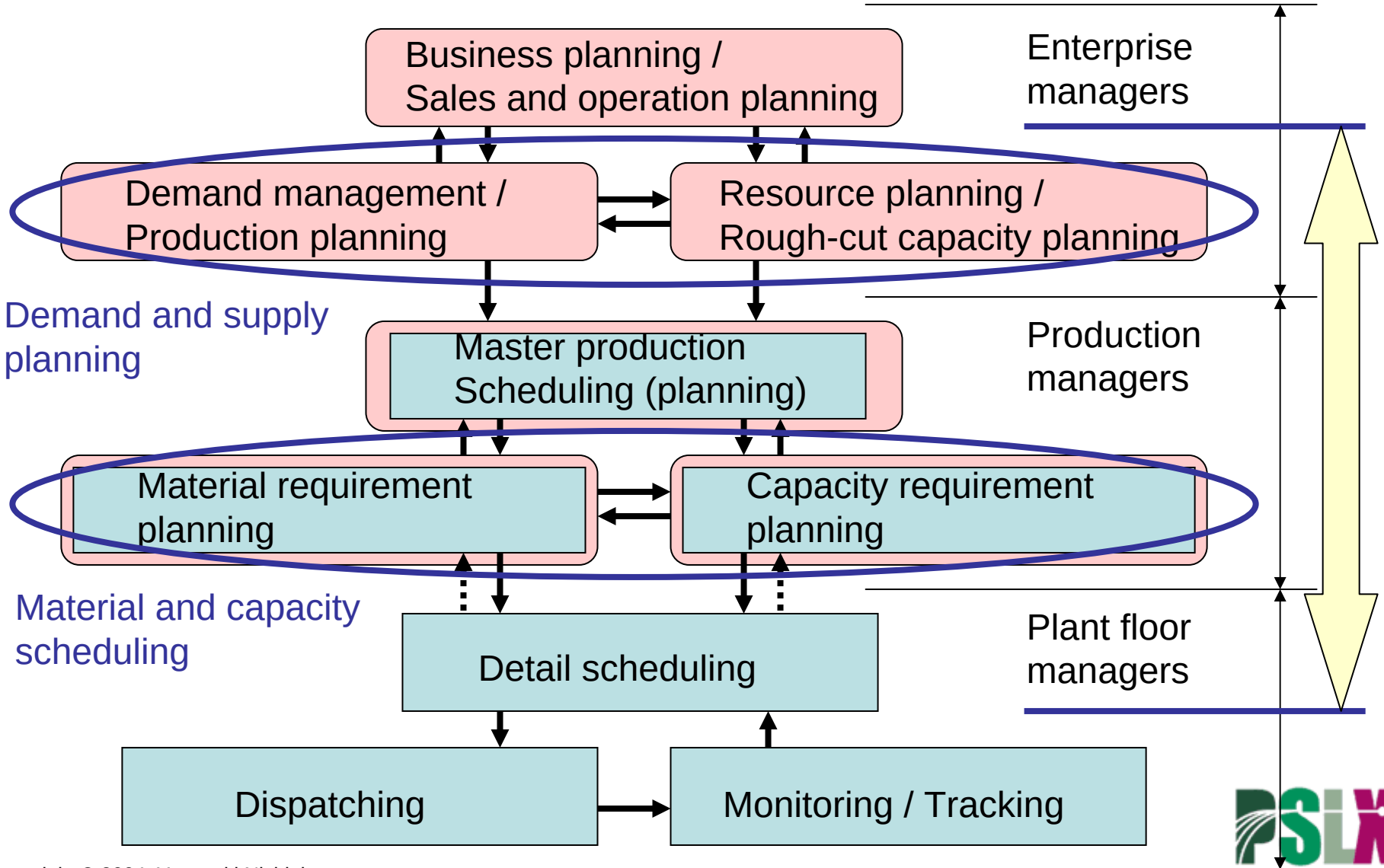
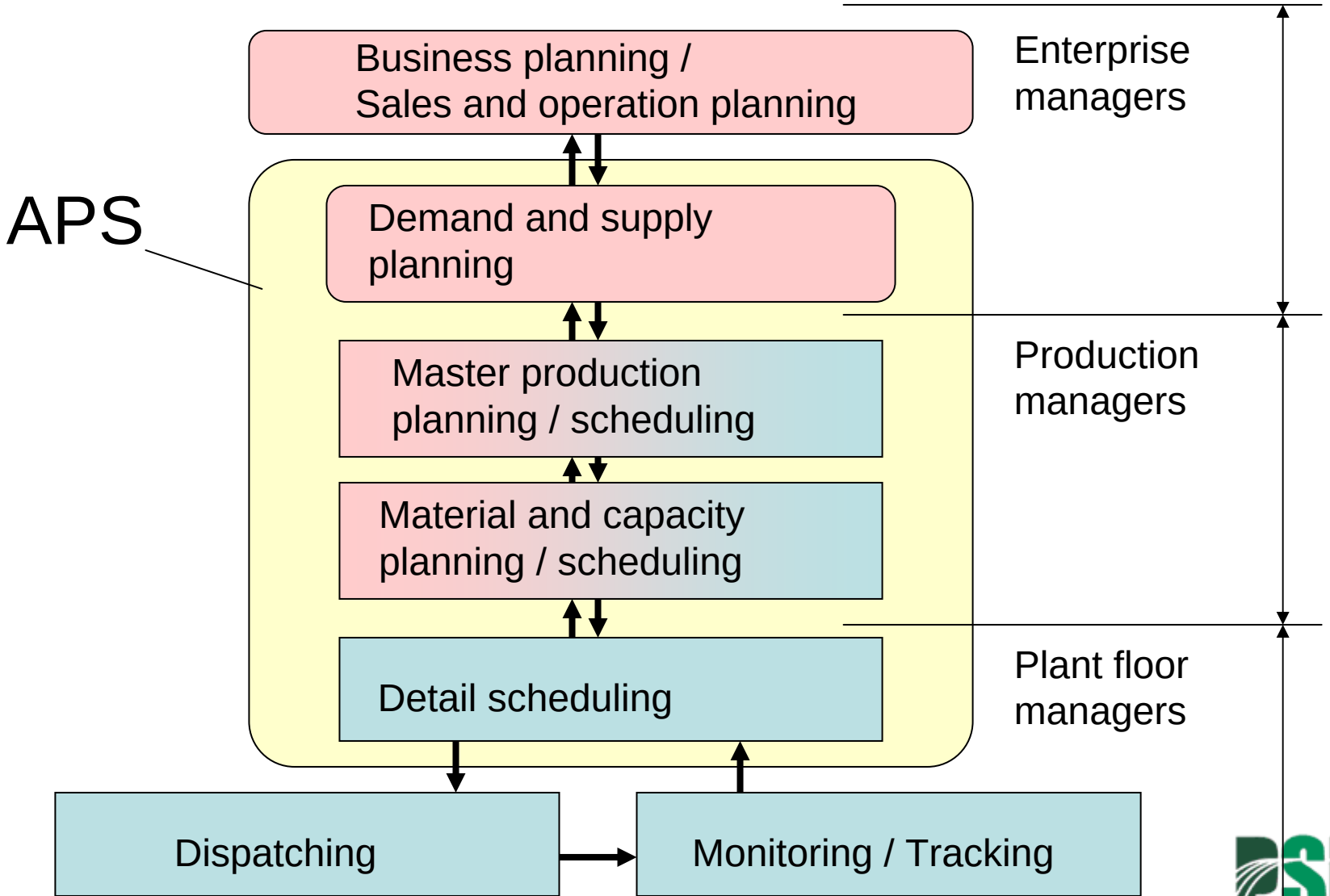
# Traditional systems (MRPII / ERP)



# Advanced planning and scheduling



# Definitions

- Planning
  - Decision making relate to activities in general.
  - Given a periodical suffix to a decision variable, the value to determine is not a time.
- Scheduling
  - Decision making of time-dependent problems
  - The final decision variable is a kind of time or sequence of activities.

# Ontologies / Object Classes



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# Primarily important objects

- Order
  - Actual requirements for products or services, which have a certain time and place
- Operation
  - Class of specific activities relative to a production process
- Item
  - Significant object that is produced or consumed by production activities
- Resource
  - Functional capability that is necessary to carry out production activities



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# Other useful objects

- Process
  - Operations that are requested by orders coming from out of the decision making unit
- Product
  - Items that are requested by orders coming from out of the decision making unit
- Area
  - Aggregation of resources corresponding to local decision making units
- Storage
  - Resources used to keep items for a particular period of time
- Route
  - Resources connecting between storages taking into account traffic availability
- Party
  - Business unit of stakeholders outside from the enterprise



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# Relational objects

- Source
  - Relation between product and area that can supply the product
- Loading
  - Relation between process and area that can provide capacity during the process
- Assignment
  - Relation between operation and its resource that is used by the operation
- Material use
  - Relation between operation and item that is used as a material for the operation
- Item structure
  - Part-of relation between two items such as a relation of product and its material
- Precedence
  - Relation between two operation such as predecessor and successor



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# Objects for management

- Inventory
  - A temporal status of storages or areas with respect to the volume of items or products
- Capacity
  - A temporal status of resources or areas to represent availability of making reservations for orders
- MPS (Master Production Schedule)
  - Orders that actually request to produce some products within each period of time
- MRP (Material Requirement Plan)
  - Actual requirement of materials that are needed for accomplishing production requests in MPS
- Lot tracking
  - Connection from one order to another with respect to dependency of their actual production lot
- Order pegging
  - Relation from one order in a plant floor level to a final customer order that is managed by business divisions



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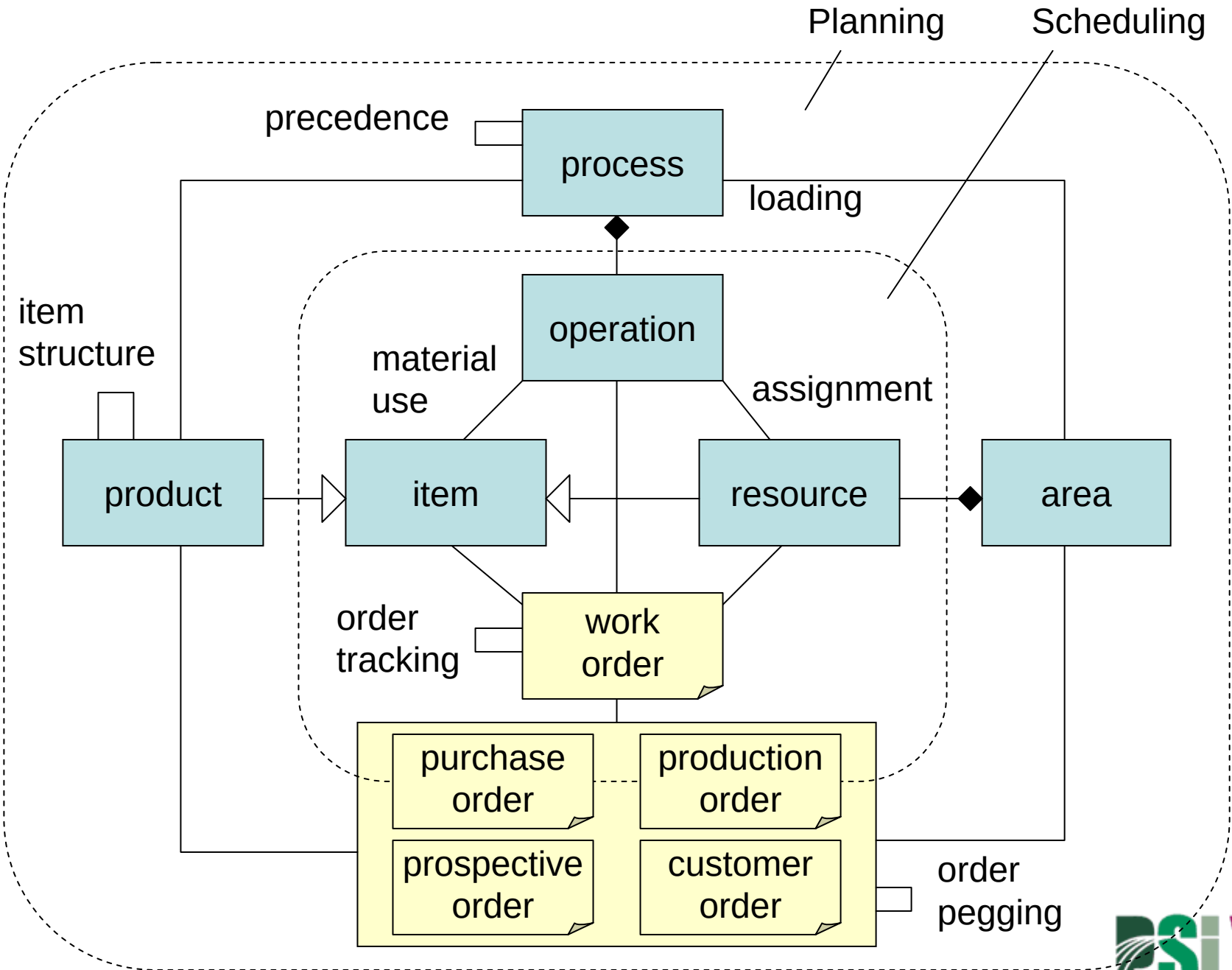




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# Planning and Scheduling Integration



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# Object for Integration

- Sub classes of order are distributed to both planning part and scheduling part
- Pegging classes connect orders across the border
- Product, process and area in planning have their subsidiaries of item, operation and resource respectively in scheduling
- Inventory can be consistently defined both for storage (scheduling) and area (planning)
- Capacity can be consistently defined both for resource (scheduling) and area (planning)



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# Order management

- Planning level
  - Prospective order (product / capacity)
  - Customer order (product / capacity)
  - Production order (product / capacity)
  - Purchase order (material / process)
- Scheduling level
  - Work order (make / prepare / check / move)
  - Shipping order / Material receipt order
  - Inventory issue order / Inventory receipt order
  - Design order / Maintenance order



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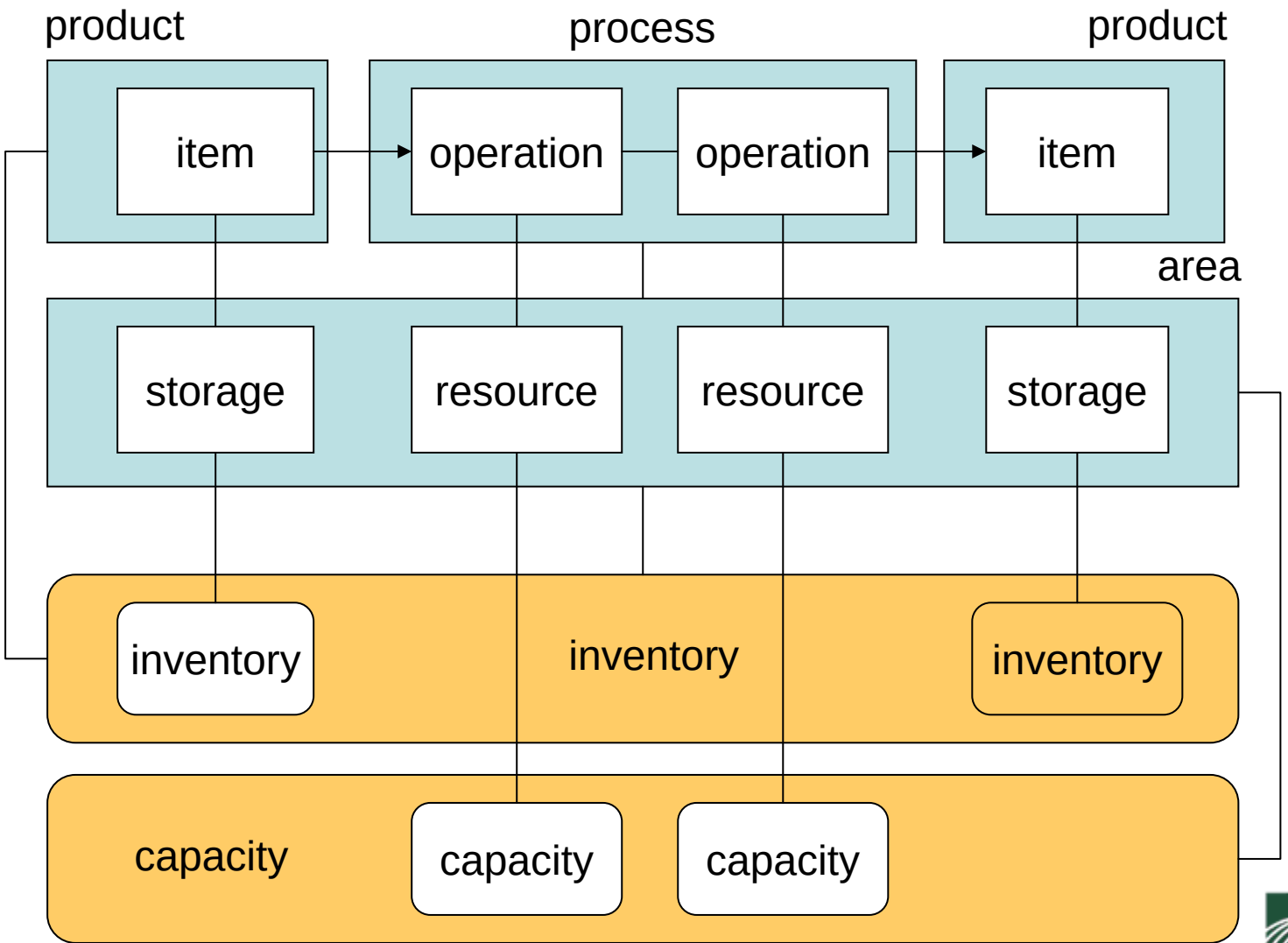
# Relation in object hierarchy



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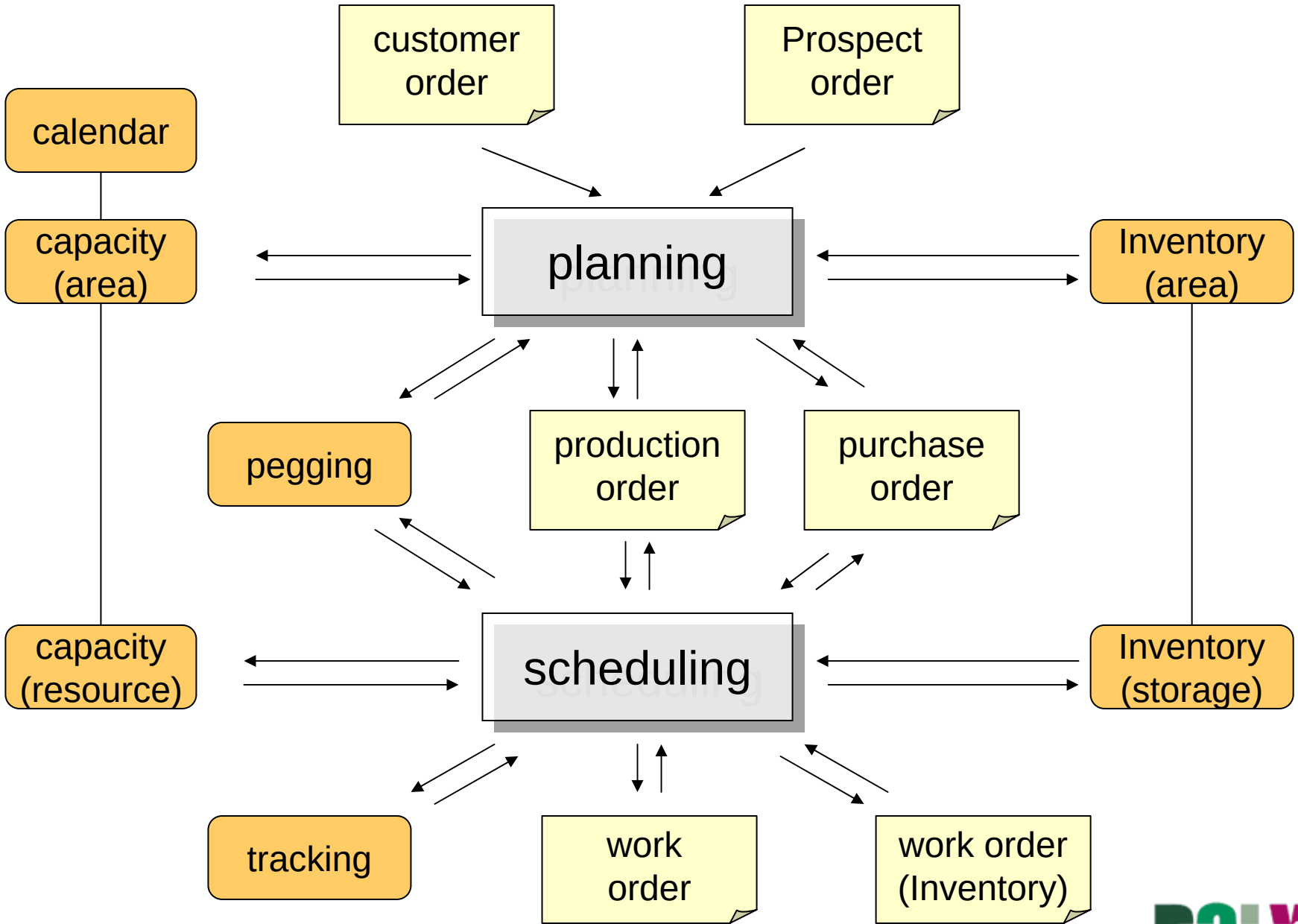




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# Implementation Issues



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# Implementation issues

- Software architecture
  - Attachable/detachable software modules for business functions
  - Software suite approach does not work well
- XML messaging
  - Different software modules should communicate on demand basis
  - Application data is decentralized for each business function
- Standard RDB
  - An integrated conceptual data schema as a template
  - Customization should be easy and systematically manageable



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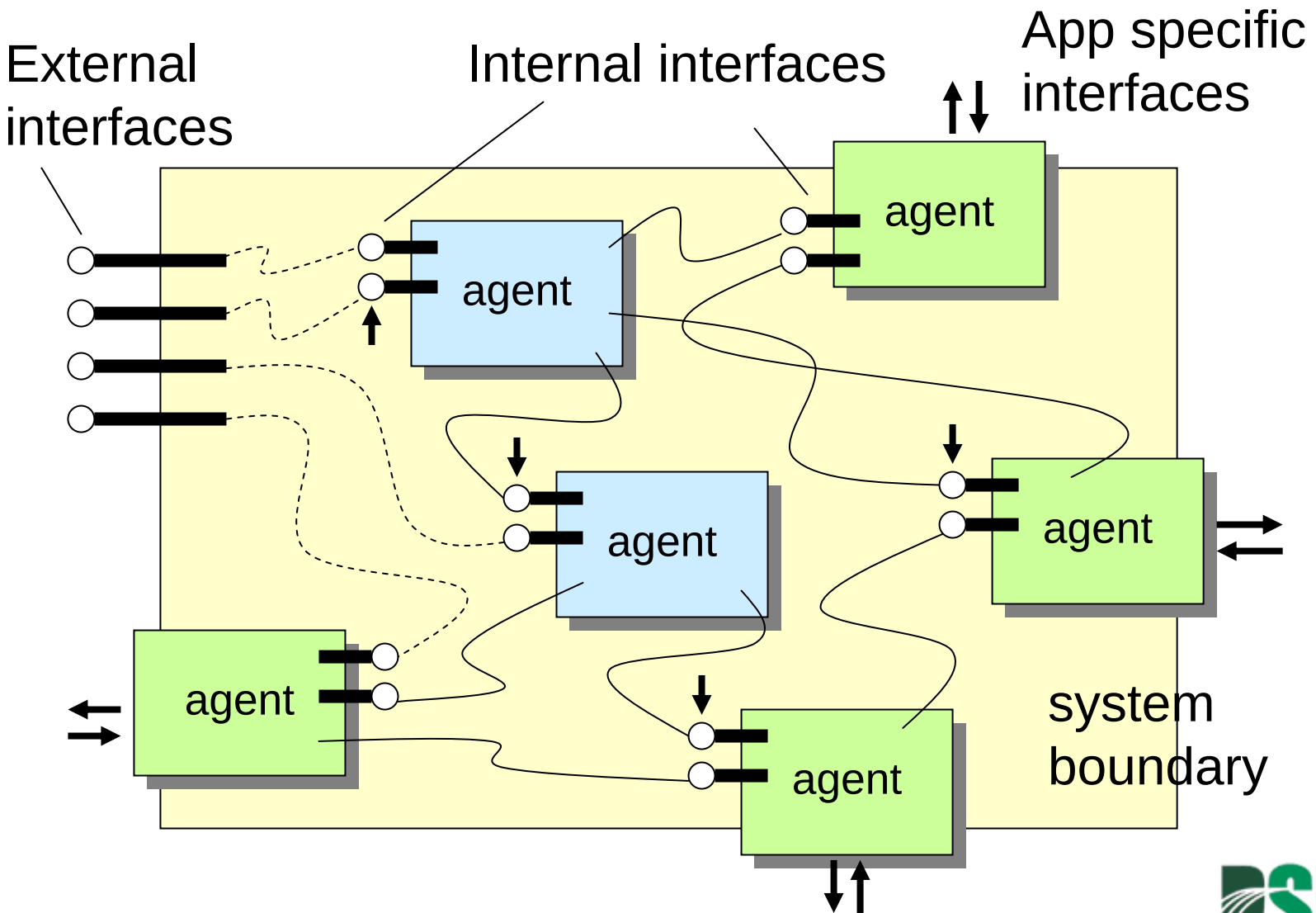
# Software architecture



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# XML messaging

## Continuous time scale

```
<dispatch name="K03-01" operation="K03">
<start><time value="2004-08-09T12:00:00" /></start>
<end><time value="2004-08-09T14:15:00" /></end>
</dispatch>
```

## Discrete time scale

```
<scale name="S1" value="P1W" base="2004-08-09T00.00.00"/>
<resource name="R01">
<load><qty value="100"/><time scale="S1" count="1"/></load>
<load><qty value="130"/><time scale="S1" count="2"/></load>
</resource>
```



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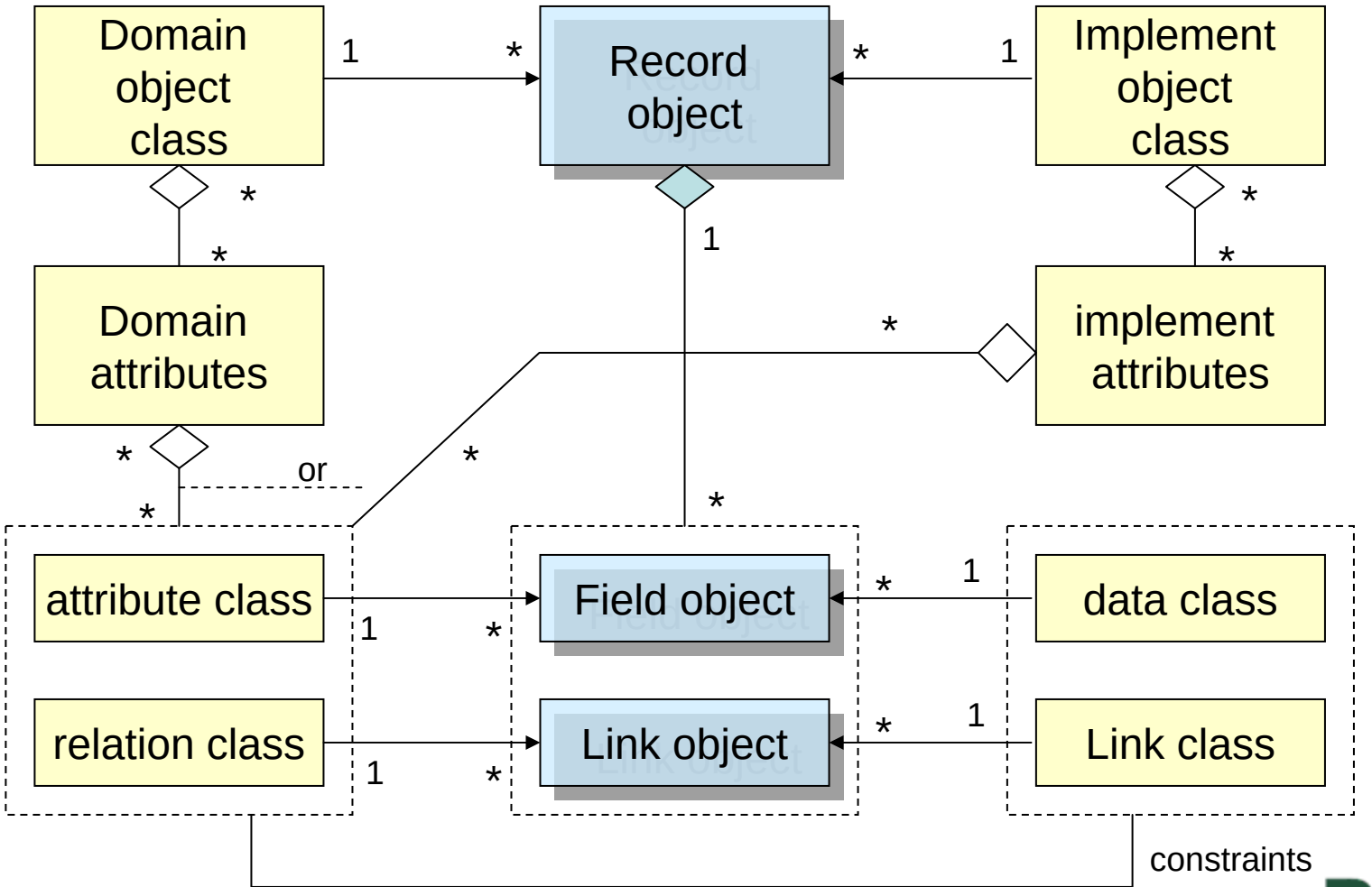
# Standard RDB



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# Implement object class

- Master data class
- Relation table class
- Order data class
- Performance class
- Transaction data class
- Summary data class
- Temporal list class



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# Customization procedure

- Step 1: Create and delete primitive objects for the application
- Step 2: Modify relational information among the object
- Step 3: Modify properties for each object
- Step 4: Move or duplicate attribute through the links
- Step 5: Define data type object for each attribute



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# Experimental Results



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# Case studies

- Case 1:
  - A tier two automotive supplier that repetitively makes pipes.
- Case 2:
  - A firm that provides one-of-a-kind laser cutting manufacturing services
- Case 3:
  - A firm that provides mechanical pumps on a make-to-order basis

# RDB table template

- Inventory master
- Staff master
- Area master
- Resource master
- Operation master
- Process master
- Destination master
- Delivery master
- Shift master
- Party master
- Item master
- Assign table
- Precedence table
- Outsourcing table
- Item structure
- Work order
- Purchase order
- Shipping order
- Production order
- Prospective order
- Customer order
- Material table
- Capacity data
- Calendar data
- Invoice data
- Inventory data
- Shipping receipt
- Material requirement
- Master schedule



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# Applicability of the framework

| | Total qty of table | Qty in template | Apply rate (%) | |
|---|---|---|---|---|
| | | | table | field |
| Case 1 | 9 | 6 | 67% | 82% |
| Case 2 | 8 | 6 | 75% | 79% |
| Case 3 | 11 | 6 | 55% | 72% |



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# Conclusion



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# Conclusion

- Standardized object model for discrete manufacturing enterprise management is illustrated
- The model is designed to integrate production planning and scheduling in order to achieve agile manufacturing
- Industrial case studies are briefly introduced to evaluate applicability of our framework



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# Thank you !

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