

CMMN implementation in executable model of business process at order-based manufacturing enterprise

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About ZAO «Mosflowline»

- “ Established in 1994
- “ The market leader in production and supply of PPU-preinsulated components for oil and district heating pipelines
- “ About 800 employees, ~ 200 computers, ~ 10 servers
- “ Annual turnover: ~ 2 bln RUR

The plan of presentation

- “ Business environment and requirements
- “ Adaptive business management system ensuring the achievement of business goals
- “ Development of business management system
- “ The results achieved
- “ Theoretical background
- “ CMMN implementation
- “ Proposed extensions to the standard

Business environment and requirements

- “ Modern business environment is highly competitive and dynamic
- “ Business goals (increase of ROI, ROCE, $\tilde{\sigma}$) should be achieved
- “ Enterprise agility - flexible, adaptive business processes
- “ Process transparency . problems and bottlenecks are quickly identified and resolved

The solution is ã

To develop and establish adaptive business management system ensuring achievement of the business goals by:

- a. organizing goal-oriented, flexible and coordinated business processes, organization structures
- b. effecting control and analysis of business process execution

The solution is \tilde{o} (2)

To develop and establish adaptive business management system ensuring achievement of the business goals by:

- c. ~~to~~ navigating an employee in the business system state space through
online monitoring the current state of the business, comparing it to the planned one, analyzing causes of deviation and generating the corrective responses by updating the plan, launching, pausing/stopping the relevant business processes

Development of business management system requires:

Development of Agile Enterprise Model, integrating:

- “ **business process definitions**
- “ **goals** represented as integrated metrics identifying the planned state of the business at different levels of management
- “ **definition of the management system** ensuring the monitoring of business process execution and achievement of the identified goals
- “ **definitions of resources** (material, human, information) used in business processes

Development of Agile Enterprise Model Engine that should

- enable direct execution** of declarative definitions of the business processes without the need to translate them into software code
- provide** selection of the specific business process implementation depending on the current state of the business and user preferences
- enable** modification of business processes in the course of their execution

Development of business management system (2)

Development of Agile Enterprise Model, including:

” **organization structure** identifying subordination of business process participants and responsibility for the goal achievement

The Agile Enterprise Model should allow for computer-aided verification at the stage of initial development as well as at the stage of modification due to process improvement or adaptation

The results achieved

- “ Business system operation and information **metamodels** containing the basic concepts to define the enterprise operation and information context
- “ **Executable Declarative Agile Enterprise Model:**
 - . The enterprise is represented as set of declarations including: hierarchy of goals, organizational structure, mapping of the goal tree onto the organizational structure, the hierarchy of activities based upon IDEF0 notation, mapping of activities on the enterprise organizational structure, definitions of material, information, human and other resources as the single semantic network (entities, relationships, entities)

The results achieved (2)

- “ Executable Declarative Agile Enterprise Model:
 - . The declarations are represented by first order logic predicates using the business system operation and information metamodels
 - . Enables verification of consistency between services in the decomposition of business process, correctness of the model after changes are made to business process models and their information models

The results achieved (3)

- “ The enterprise model engine providing
 - . direct execution of the model without intermediate translation into software code
 - . implementation of the basic concepts of CMMN standard:
 - active planning during execution of case instances
 - declarative/rules . based behavior specifications
 - tasks, (hierarchical) stages and milestones and uses precise mathematical definition for operation semantics

The results achieved (4)

- “ The enterprise model engine providing
 - . simulation of different cases/situations
 - . flexible navigator that can suggest the most appropriate way to handle particular case by choosing specific implementation of the corresponding business process
 - . the standard data access interface
 - . the standard (self-adapting) user web-interface

The results achieved (4)

- “ The business management system:
 - . with about 100 online users (each of them can have several dozens of processes running). Scalability of the system is limited to the hardware capacity only (now it runs on 4 x Intel Xeons with 16 GB of RAM)
 - . integrated with accounting, PDM, production scheduling systems and other applications using ESB (ApacheMQ).

Agile Enterprise Model fundamentals

An enterprise is a complex system, which behavior is described by its trajectory in a multidimensional state space:

$$F(x, \dot{x}, w) = 0, \text{ where:}$$

- x - vector of state variable,
- v - derivatives of state variables (direction and speed of movement)
- w - vector of environment variables

directed to the goal . a point or surface in the state space

Iliia Bider, AdaptiveCM Workshop 2012

Agile Enterprise Model fundamentals (2)

$$BS = \langle S, \{G\}, \{A\}, SS, \{R\} \rangle$$

- “ BS . the enterprise (business system)
- “ S . state space of the enterprise,
- “ {G} . set of goals organized in a tree with logically dependent nodes,
- “ {A} . set of the activities implemented by the business processes to achieve the goals (e. g. order-based manufacturing of products, making changes to the order, etc.),
- “ SS . structure of the system that ensures implementation of the activities and achievement of the goals,
- “ {R} . set of resources utilized and consumed in the business processes (materials, equipment, staff, information)

Agile Enterprise Model basic blocks

Goal tree integrated with the organizational structure, defining the structure of the state space

Models of services implementing the business system transitions between the states in its state space

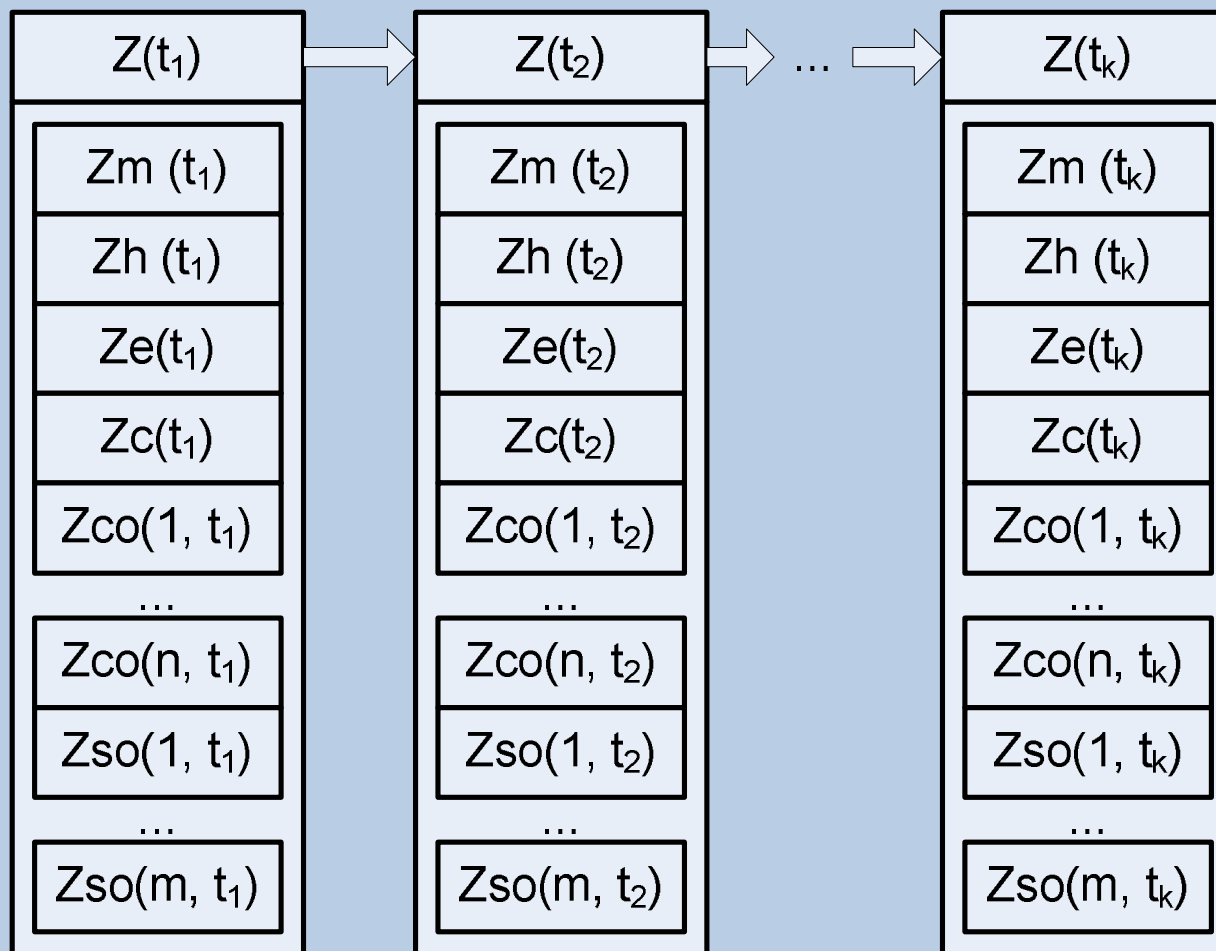
Semantic network describing the application domain

Formal representation of the state space

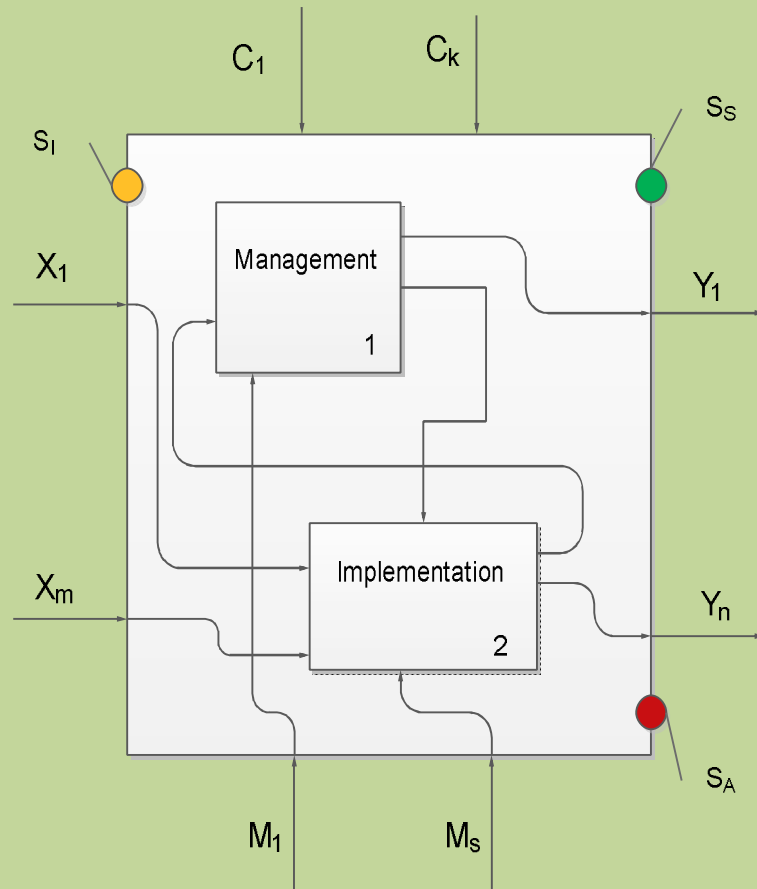
$$\mathbf{Z} = \mathbf{Z}_m \times \mathbf{Z}_d \times \mathbf{Z}_e \times \mathbf{Z}_h \times \mathbf{Z}_c \times \mathbf{Z}_{co} \times \mathbf{Z}_{so}$$

- ” \mathbf{Z}_m - Materials
- ” \mathbf{Z}_d - Documents (inf. objects)
- ” \mathbf{Z}_e - Equipment
- ” \mathbf{Z}_h - Staff
- ” \mathbf{Z}_c - Cash
- ” \mathbf{Z}_{co} - Orders from the customers
- ” \mathbf{Z}_{so} - Orders to the suppliers

Trajectory of the business system in its state space



Formal definition of a business system service (activity)



$\{X_i(t)\}$ - input resources

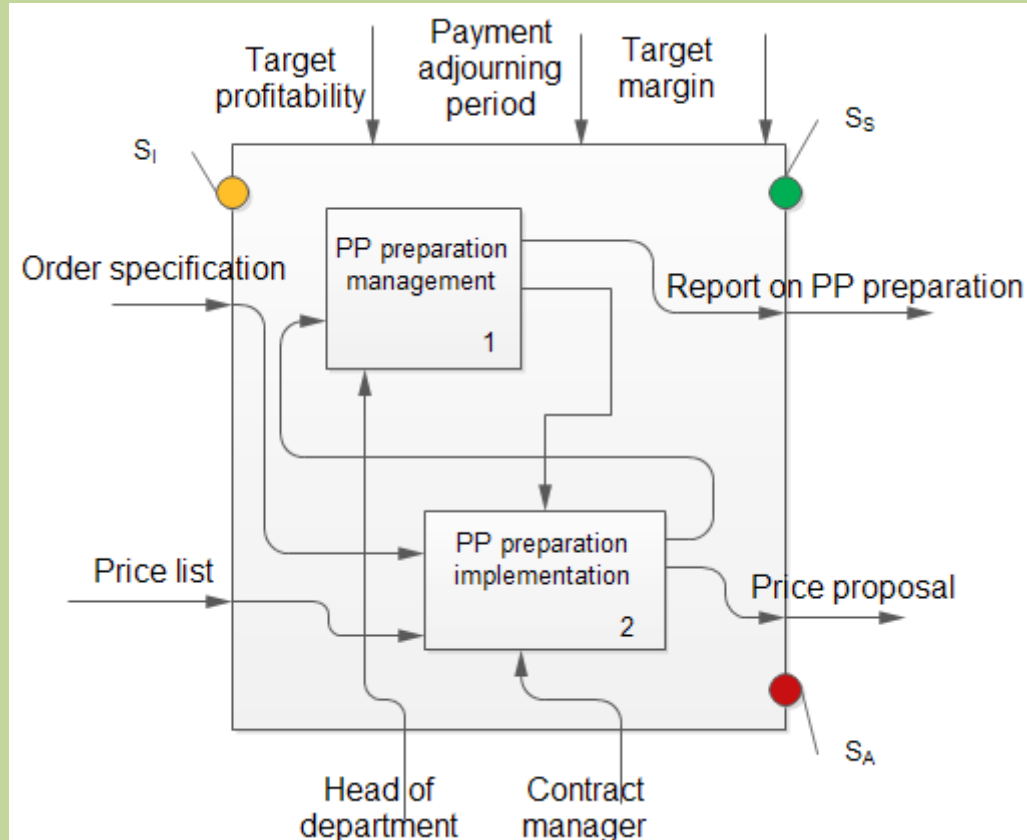
$\{C_k(t)\}$ - control signals (goals)

$\{Y_j(t)\}$ - output resources

$\{M_s\}$ - staff, equipment and tools

$\{S_m\}$ - start, finish and abort states

Service examples (1)

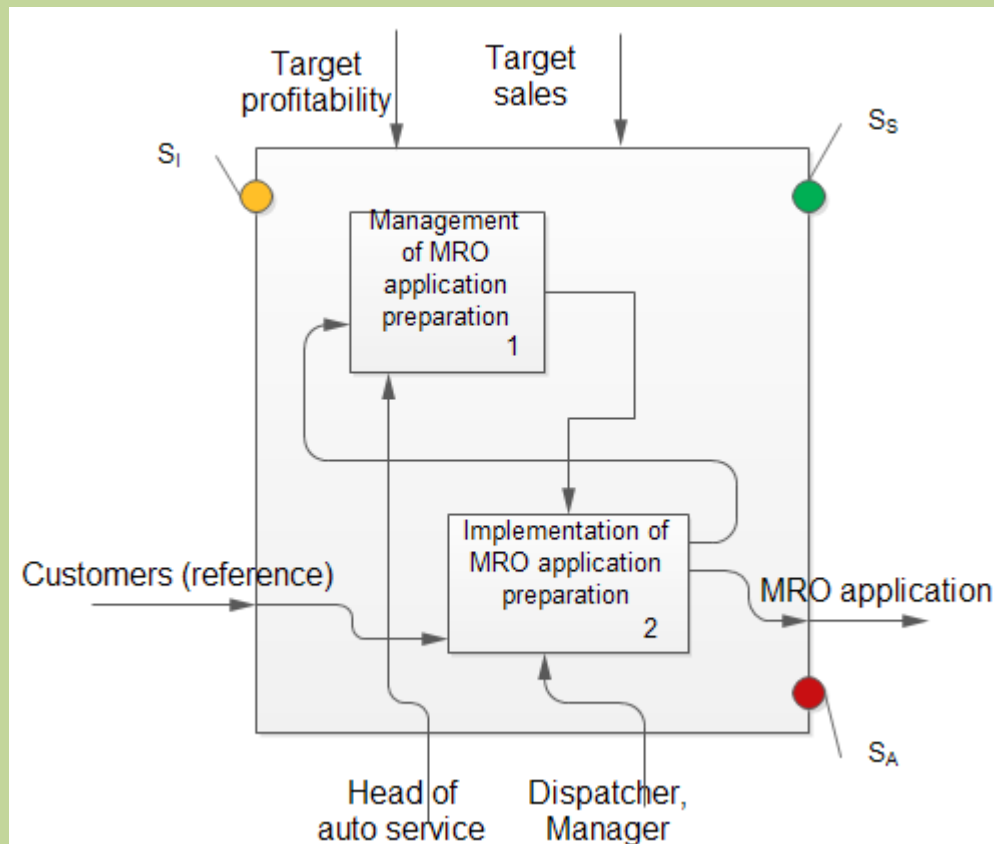


Si - Order specification is finished by technical department and ready for pricing

Ss- Price proposal has been prepared and accepted by the customer

Sa- Price proposal has been prepared but not approved OR has not been prepared in due time because of non-standard requirements

Service examples (2)



S_i - true

S_s - MRO application has been prepared and accepted by the customer

S_a - MRO application has been prepared but rejected by the customer

Service is implemented

- “ Either by business process (subtrajectory in the business system state space)
- “ Or by an algorithm of creating/editing/transforming the instances of entities from the business system information model

Abbreviations:

- CDO - commercial director office,
- CD - commercial department,
- TD - technical department,
- PD - procurement department,
- SM - sales manager,
- HCD - head of CD (commercial director),
- PP - price proposal

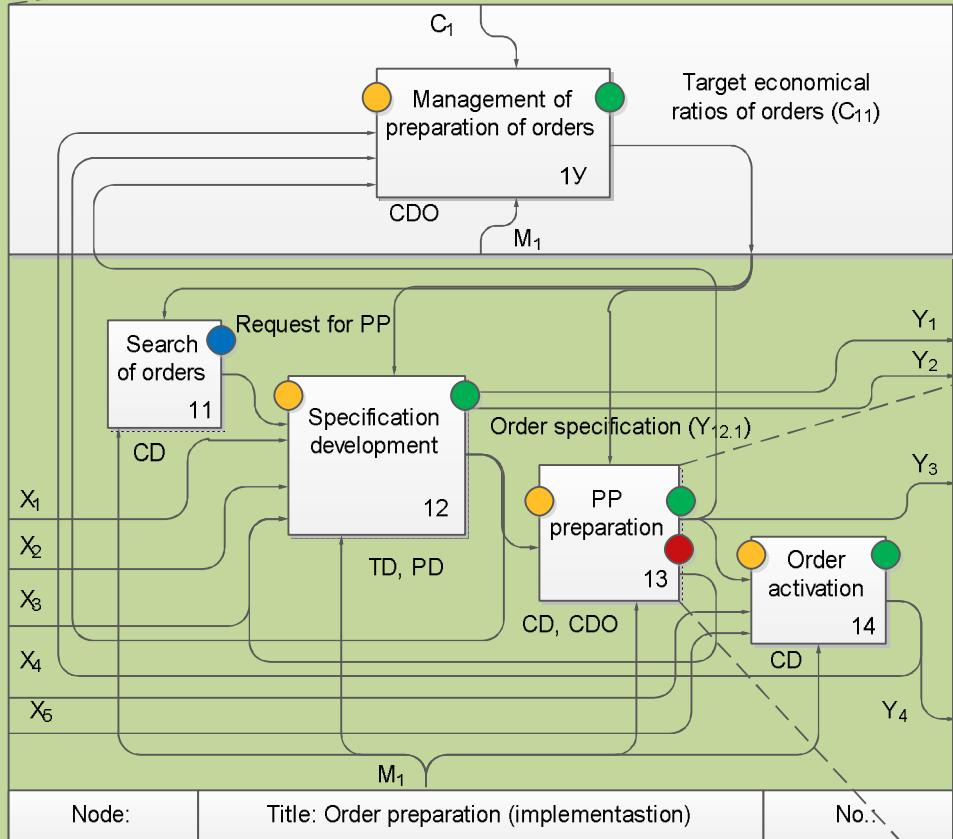


Fig. 2b

- State of business system where business function execution is started
- State of business system where business function execution is successfully completed
- Time when business function execution completes
- State of business system where business function execution is aborted

10.09.2013

ZAO "Mosflowline", 2013 (e)

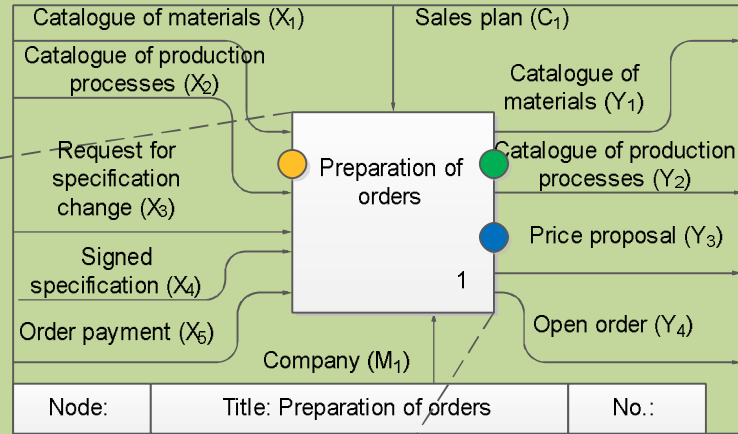


Fig. 2a

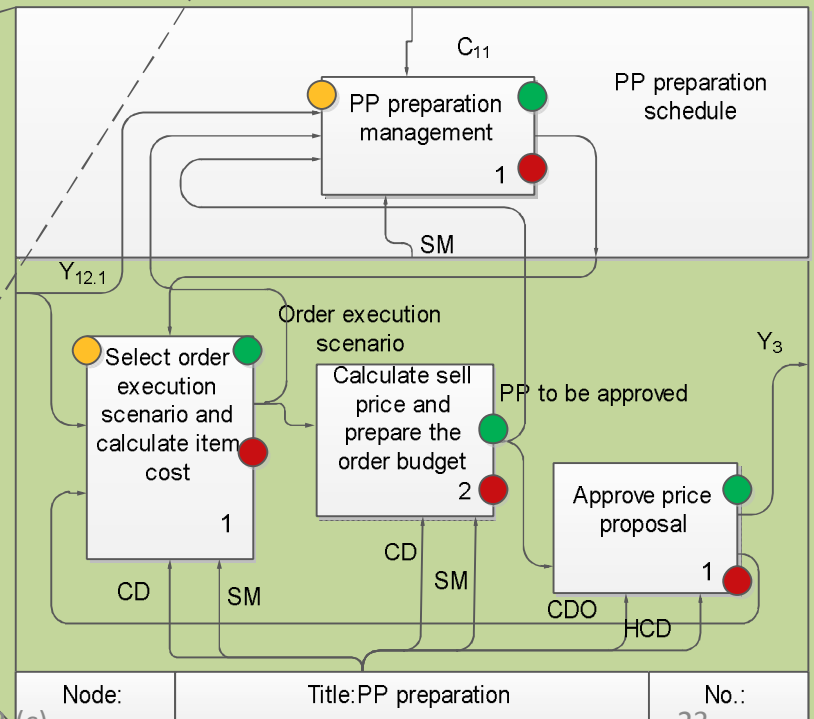
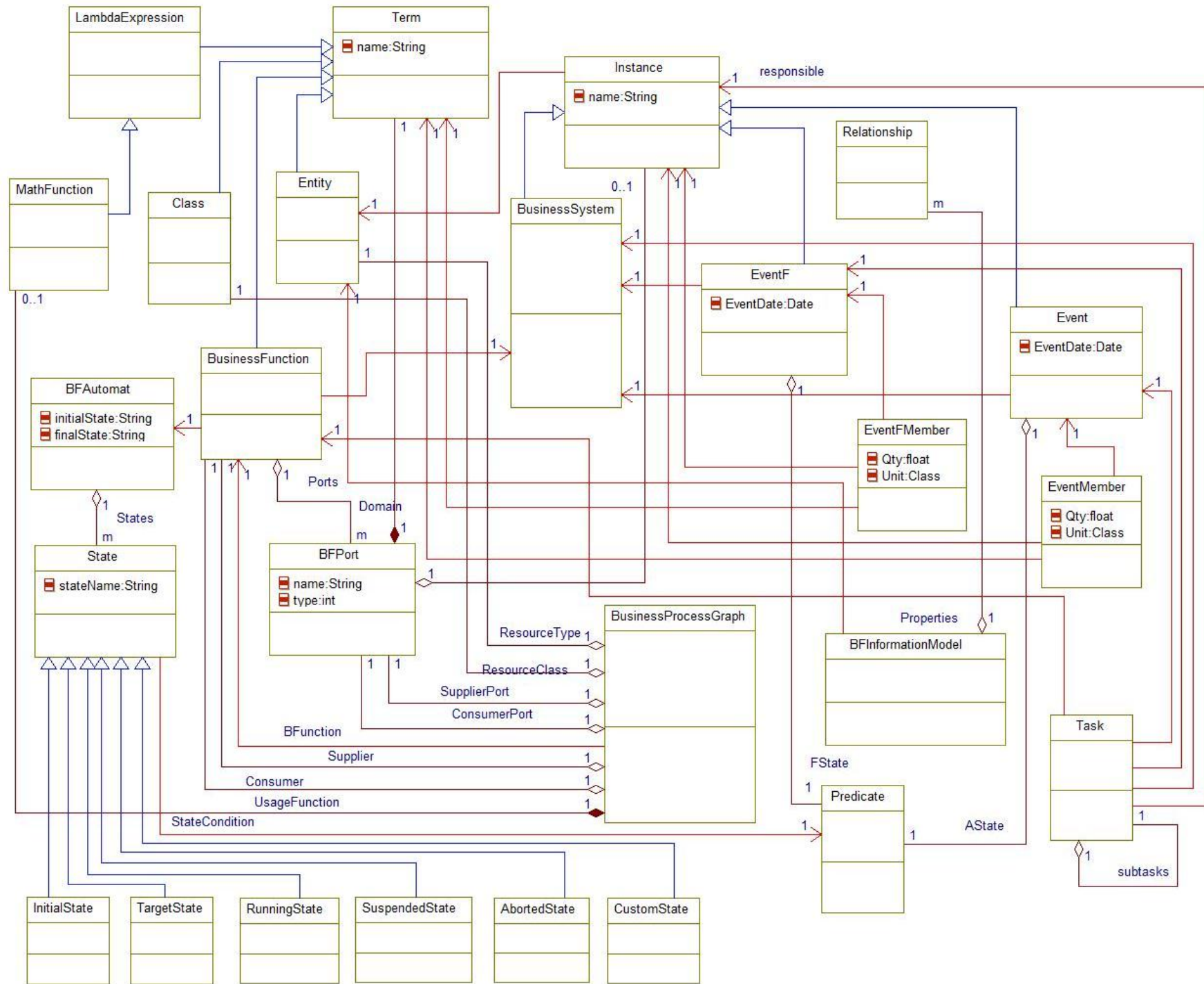


Fig. 2c

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Formal representation of the business system - metamodel

- “ Mathematical language: first order logic
- “ Basic entities: Business System, Service, Business Process, Planned Event, Planned Event Participant, Actual Event, Actual Event Participant, etc.
- “ Available at: <http://en.acm-systems.ru/business-system-operation-metamodel>



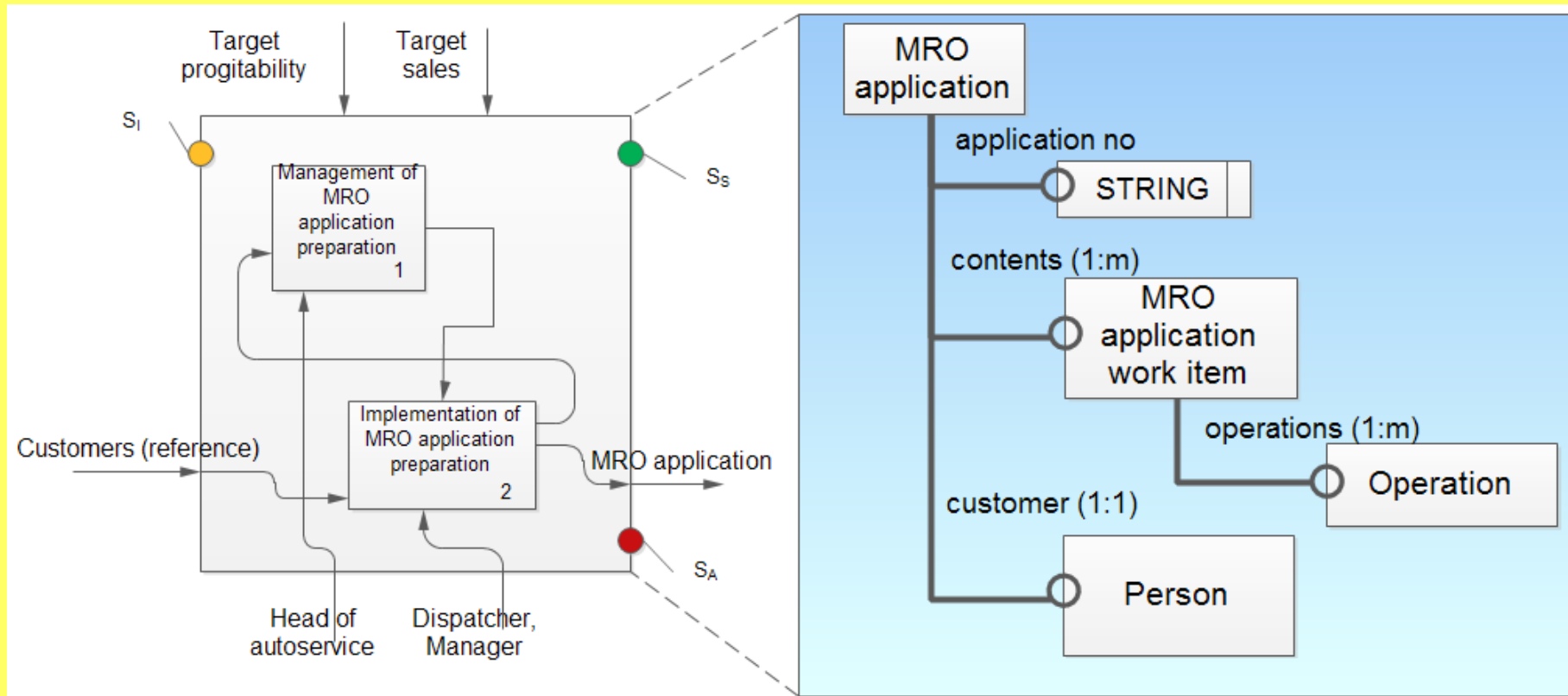
CMMN implementation (fragment)

CMMN construct	Is represented in the metamodel by:
Case	Service (BusinessFunction)
Role	Staff identified for the service (BFPort)
Stage	Task (with subtasks) . instance of service
Milestone	{Ck(t)} . control signals (EventFMember)
Task	Task
Sentry	Si . BS state to start the service (State)

Agile Enterprise Model verification

- “ Verification of services (matching inputs, outputs, pre-conditions, post-conditions, goals)
- “ Verification of changes (what services should be modified upon the information model change)
- “ Business process simulation

Service information model (a fragment)



The business system information model

- semantic network based upon:

- “ Entity

- “ Relationship

- . Explicitly set

- . Derived

- “ Predicate

- “ Lambda expression

- “ Class (set), defined as

- . enumeration

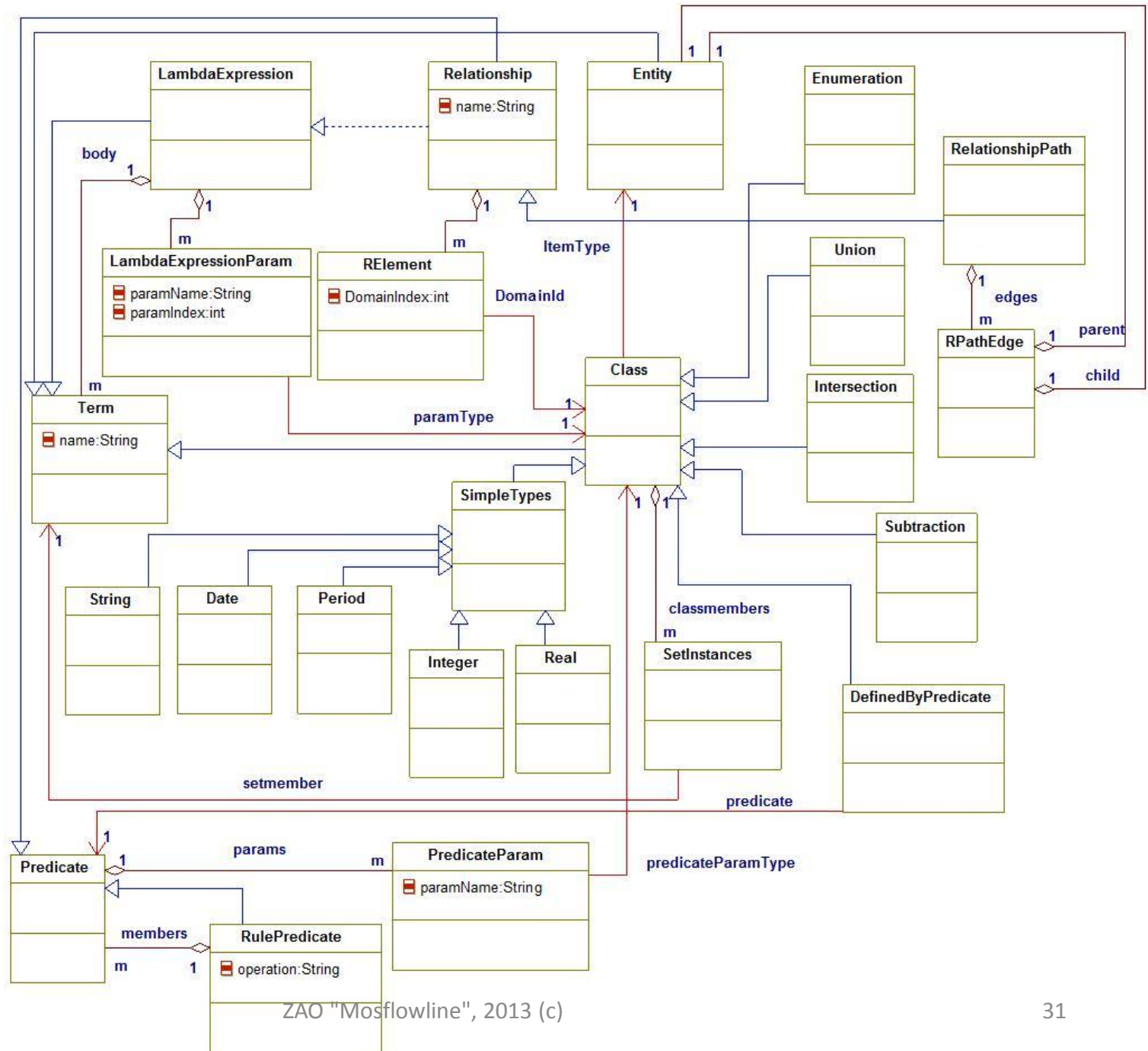
- . result of operations over sers (+, /, *, x)

- . predicate

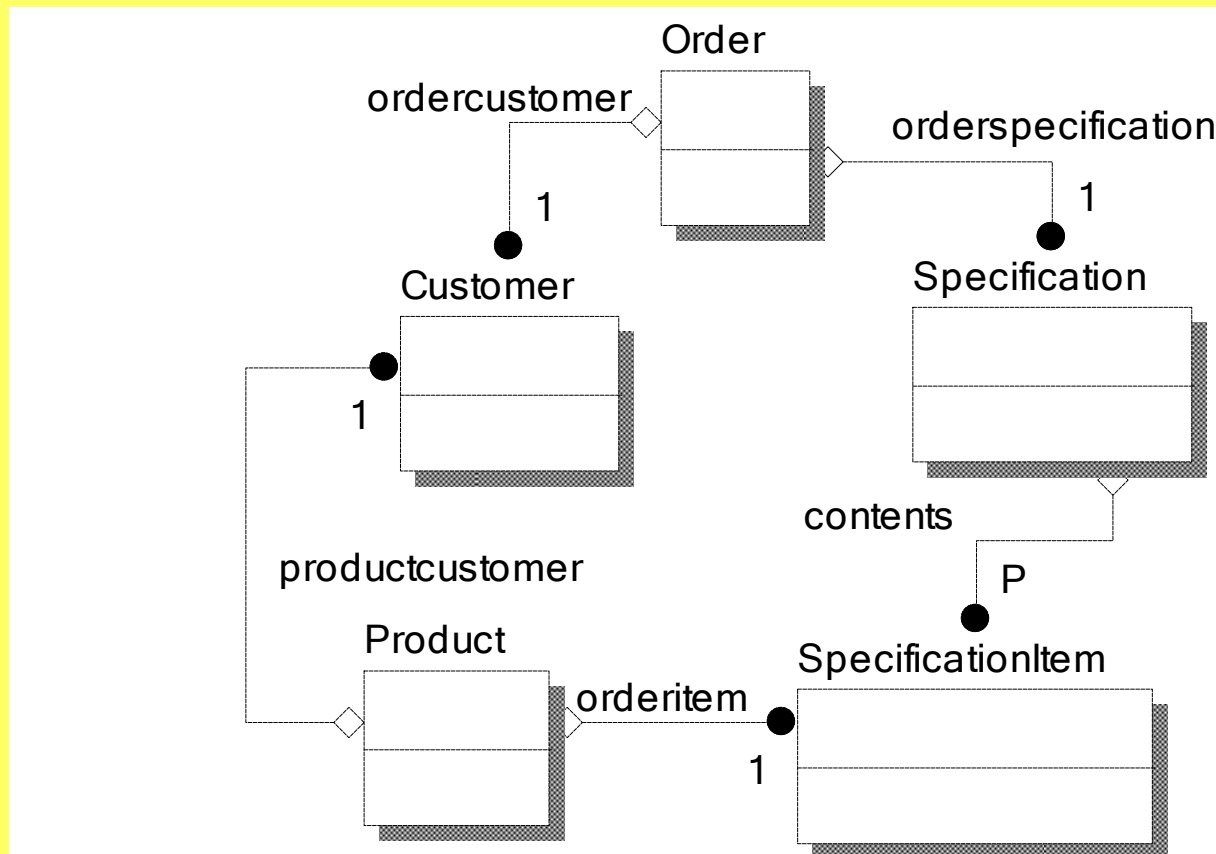
Formal representation of the business system information model - metamodel

- “ Mathematical language: first order logic
- “ Available at: <http://en.acm-systems.ru/description-of-acm-and-im-interpretters/>

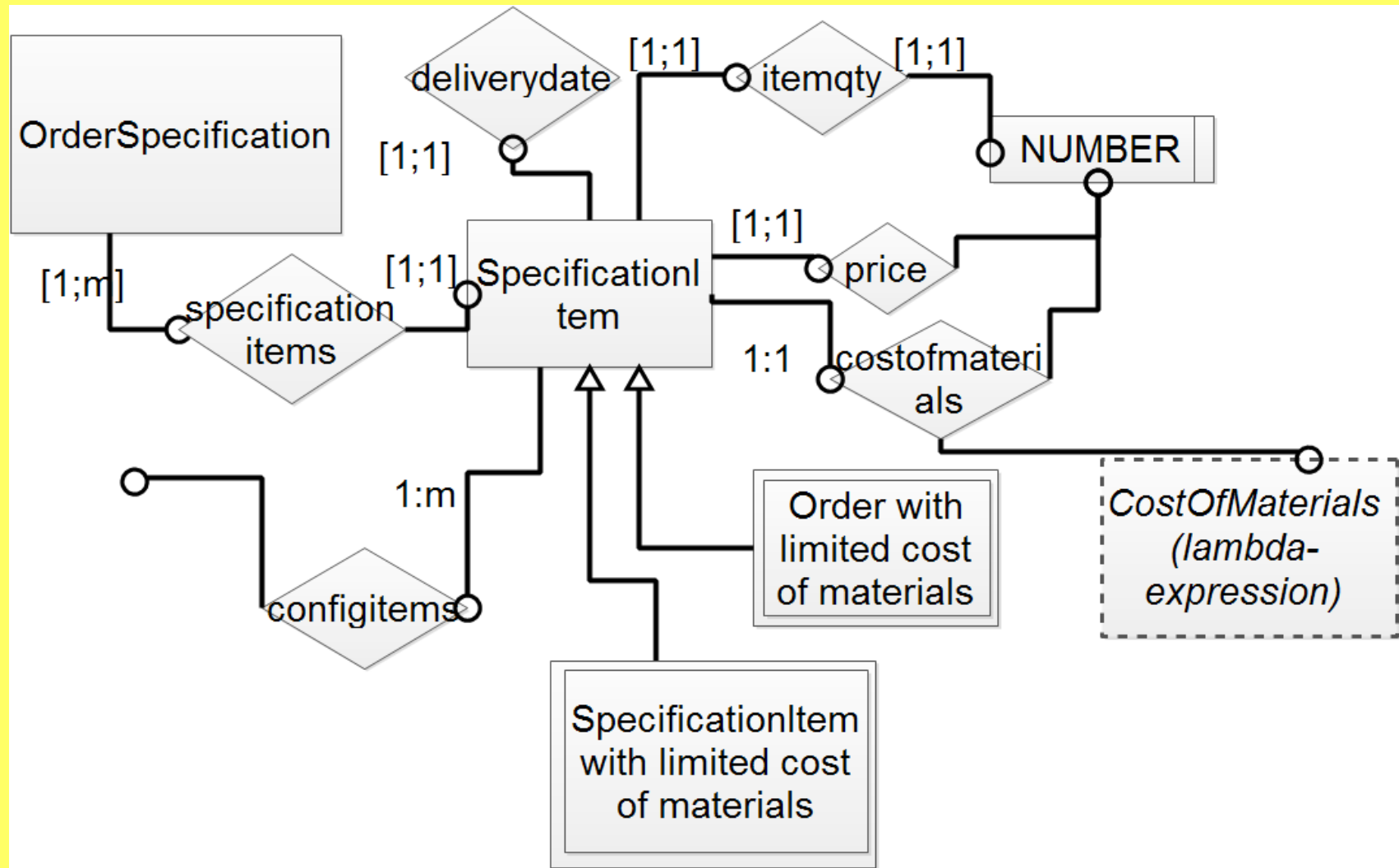
The semantic network metamodel



The semantic network (example 1)



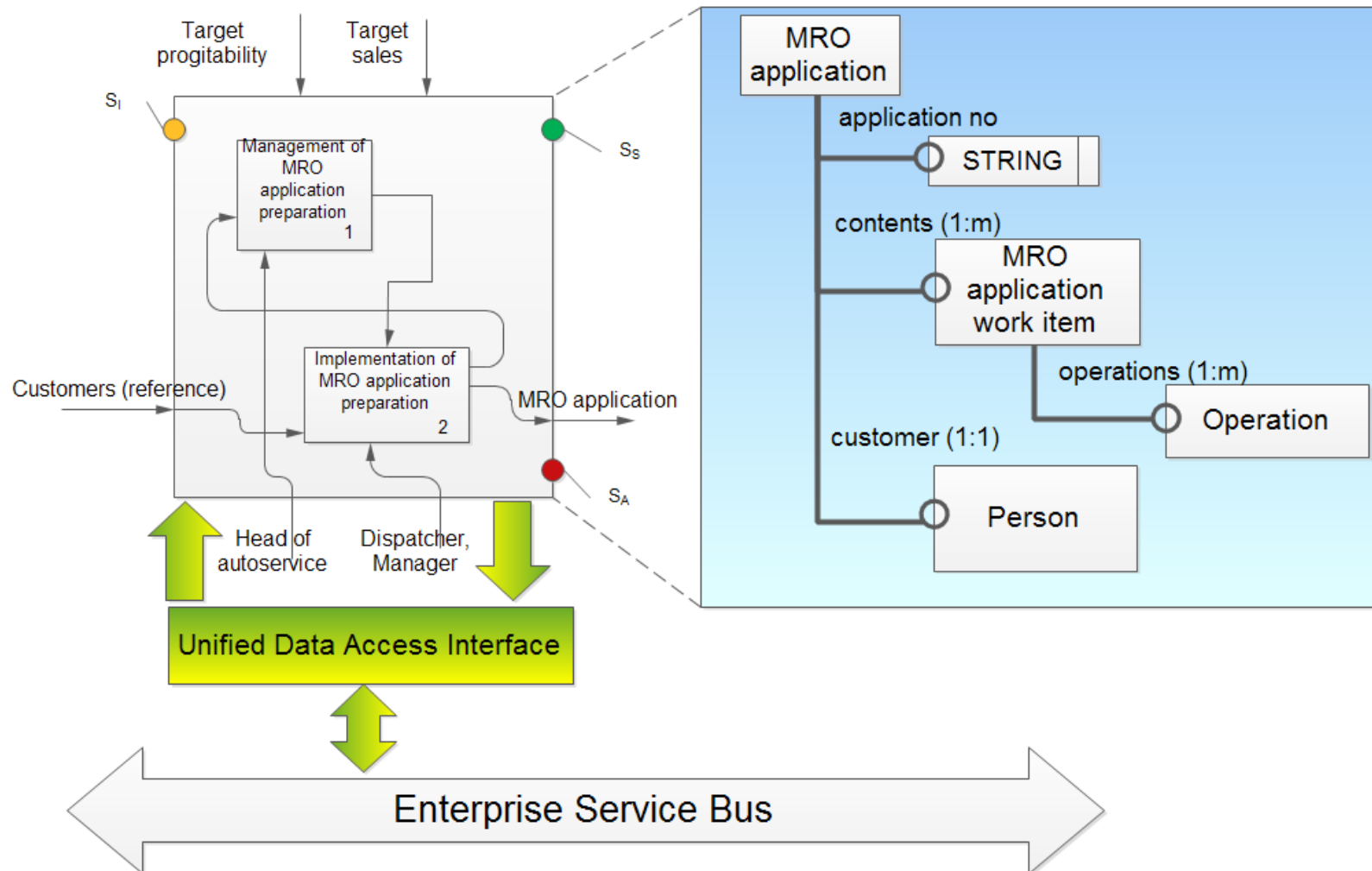
The semantic network (example 2)



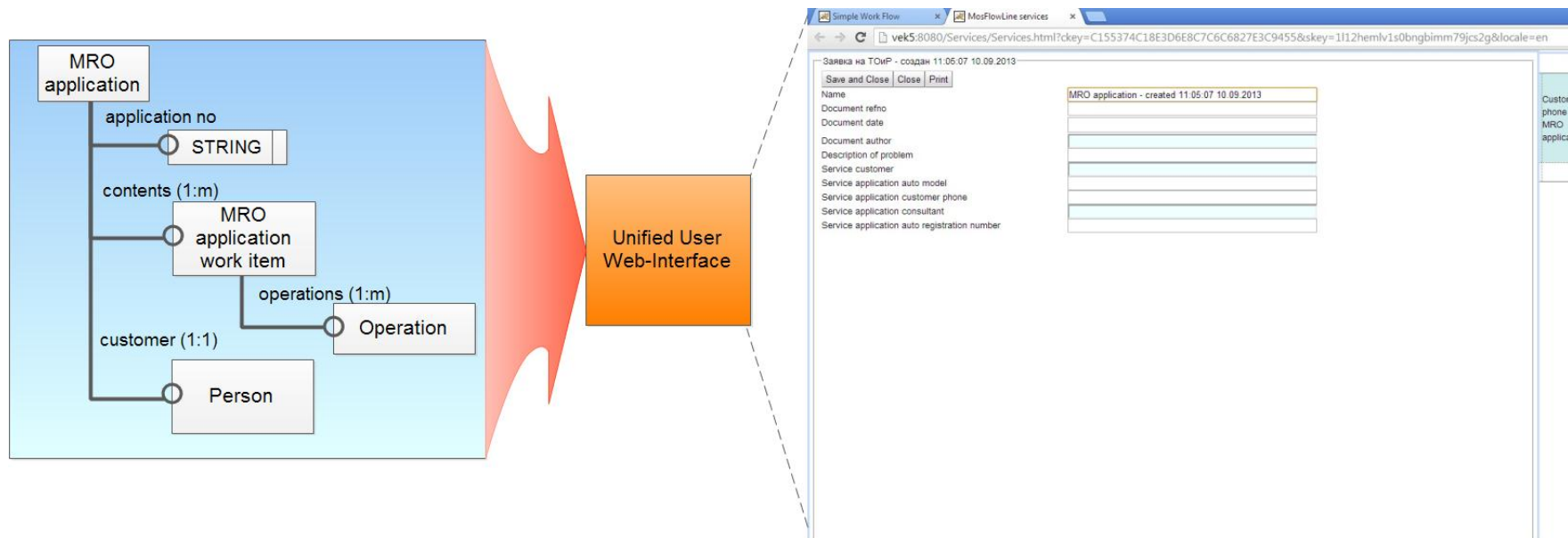
Agile Enterprise Model execution

- “ Implementation of the transition in the business system state space
- “ Unified Data Access Interface
- “ Unified User Web-Interface
- “ Unified constructor of information objects
- “ Navigator in the business system state space

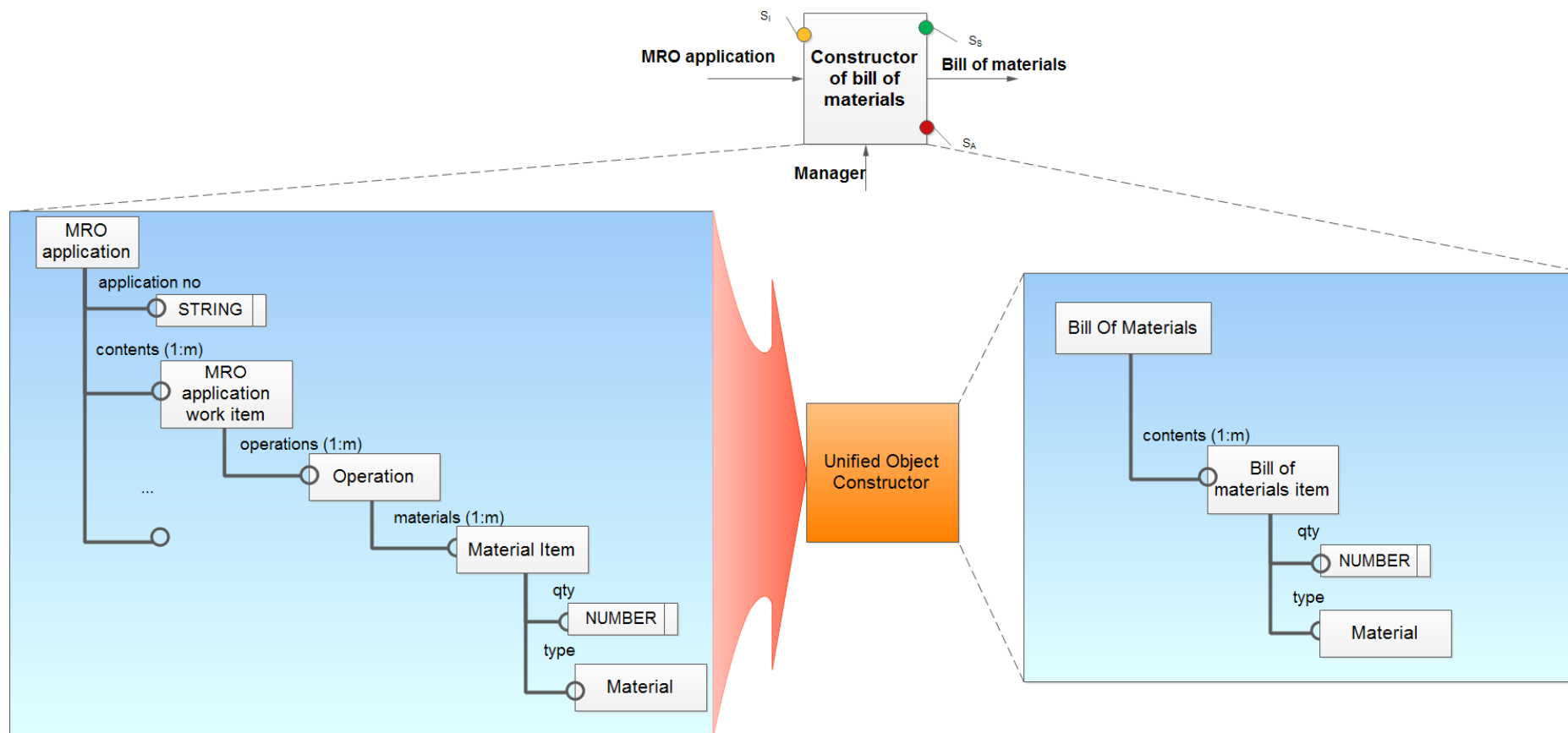
Unified Data Access Interface



Unified User Web-interface



Unified constructor of information objects



Thank you for your attention!

Questions?

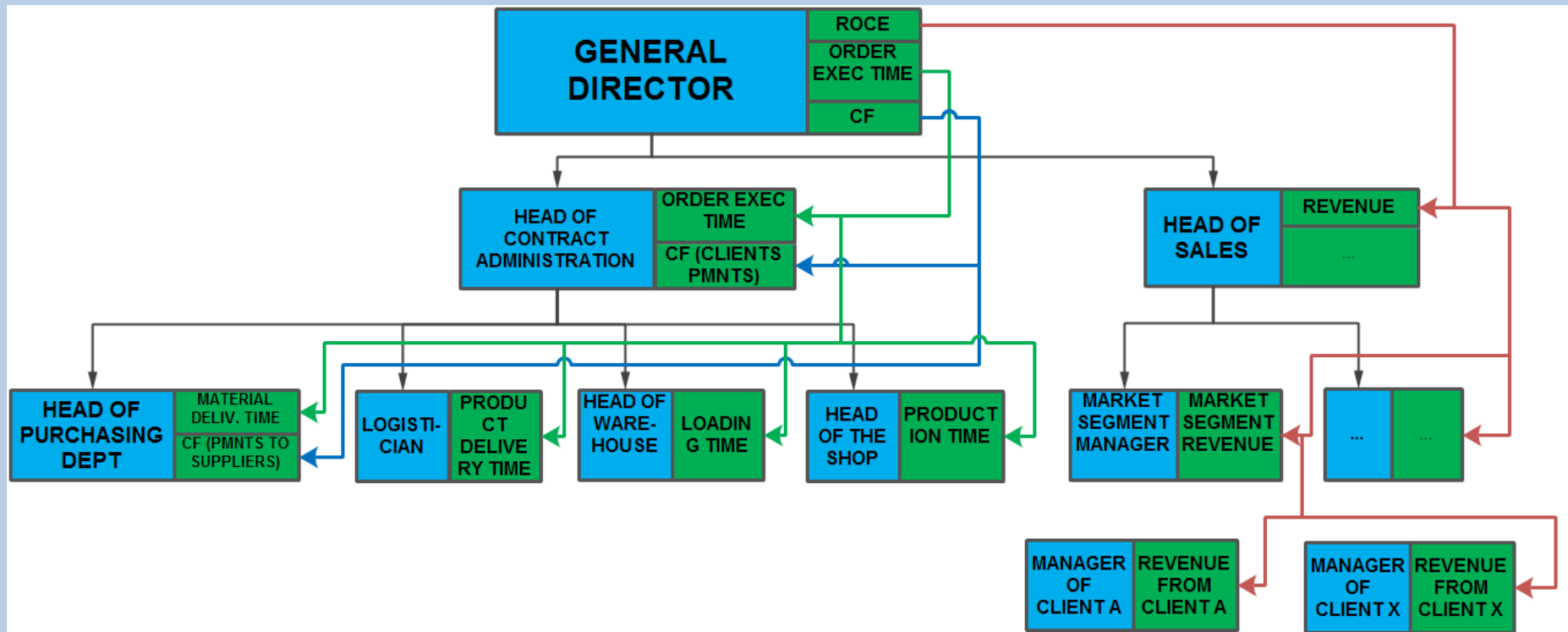
Appendix

- “ Rules to design the business system goal tree (+example)
- “ Rules to design business processes
- “ Implementation of business system transition between its states

Rules to design a goal tree

- “ Each goal G_i in the tree should be assigned to the employee responsible for its achievement.
- “ If goal G_i is decomposed into subgoals $\{G_{ij}\}$, then the conjunction $G_{i1} \wedge G_{i2} \wedge \dots \wedge G_{ik}$ should imply G_i .
- “ Each terminal goal G_i in the tree should be achievable: there should exist a service which execution will finish in the state where the goal has been achieved.

Goal tree integrated with the organizational structure



Rules to design the business process implementing the service

- “ Decomposition is done in accordance with the goal tree (possibly in parallel with the goal tree development)
- “ If the unit of the business system implementing the service has its own management . the service is decomposed into management and implementation subprocesses first, then the rest of the decomposition takes place

Rules to design the business process implementing the service (2)

- “ Pre- and post conditions of the services starting and finishing the business process should match the corresponding conditions of the service being decomposed
- “ Input and output resources of the business process correspond the input and output resources of the service being decomposed (inheritance is allowed)

Implementation of the transition between states

1. Starting the service implementing the transition
2. Identifying the services in the decomposition of the started service that could be started in the current state of the business system by calculating the predicates of their preconditions
3. Starting the services with preconditions evaluated to true

Implementation of the transition between states (2)

4. The execution of the started services changes the state of the business system
. evaluation of the postconditions takes place along with evaluation of preconditions of the services not executed yet
5. If the postcondition of the service evaluates to true+the service execution is completed

Implementation of the transition between states (3)

The described process repeats until the postcondition of the first started service evaluates to true (successful or emergency completion)