Using Formal Methods for QI Information System

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Workflow

- Today's open global market changes the nature of business.
- Company that wants to compete must leave traditional organization structure and not convenient leading methods.
- Company should be focused on customer, should be managed by market requirements.
- From an inner point of view, company should focus on processes and team cooperation.
- Modern organization that wants to be able to compete on market society should be based on automation processes

Workflow

Workflow means whole or part automation of enterprise process, during which are documents, information or tasks handed over from one process participant to another, according to a set of procedural rules so, that it contributes the performance of global enterprise objectives.

Workflow systems

Workflow system defines, creates and manages the process flow. This system is able to interpret process definition, communicate with workflow participants and if needed, run another applications (Hollingsworth, 1994).

Workflow system:

◆ Graphical workflow design, which defines the flow of tasks and activities.

◆ Roles assigning to activities.

◆ Rules defining the logic of process without programming.

◆ Exception solving, monitoring of process instances, measurement, statistic reports.

◆ Process simulation and testing, database interface, document affiliation.

Enterprise infrastructure

- Enterprise infrastructure – set up by combination of its processes.
- Unfortunately is infrastructure not completely described and documented (the major part are advances designed and held in employees heads, are overspread through different directives or are respected as an informal rules).
- Any improvement or extension demands infrastructure documentation first.
- Process can include elements that are unclear. When we use strict definition, we are not able to capture these elements. One approach how to include unclear (vague) elements into process description is the use of fuzzy logics.

Process wizard   1

The name could invoke mighty capability, but in IT, the wizard is program or component, which helps user or developer to create or finalize some document, application class, application component, form, etc.

General SW wizard has following qualities:

- All wizard data compose a single transaction.
- Steps are processed in sequence from given beginning to given end.
- There exist one starting step, several intermediate steps, and one ending step.
- The wizard validates its state before advancing to the next step.
- There can be several different paths to reach the ending step.
- It is possible to navigate back to review and update values entered in previous steps.
- A wizard can be cancelled before completion.

Process wizard   2

Process wizard leads user through whole process or through its important part. For dynamical form generation according to valid process, we need:

1. Process description – description of application domain, for this purpose are Petri nets or finite state machine used.
2. User defined data – this is, what user want to see, update or validate.
3. Data sources (which can be used for given form) including their hierarchy and possible synchronizations.
4. Storage for application data and for model data (process description) as well.

Why to choose Petri net for process modelling

- ◆ Formalisms based on FSM are often used for process description. FSM has some limitations
  - parallelism, distribute and complex system modelling
- ◆ Other tools for process modelling in IT (UML activity diagrams, BPMN – Business Process Management Notation, ARIS notation, etc).
- ◆ The first argument for Petri nets - tools mentioned above do not have mathematical apparatus (for simulation and automatic generation) as Petri nets do.
- ◆ The second one – possibility of use fuzzy Petri net for unclear (vague) process definitions.

Petri net elements

- ◈ Place (circle) – for expressing system states.
- ◈ Transition (rectangle) – represents system changes.
- ◈ Arcs (arrow) – unconditionally oriented, connects place with transition or vice versa. Every ordered pair (place, transition) or (transition, place) can be at most connected by one arc.
- ◈ Marking (small circle in place) – token represents actual system state, can be used only in places, initial state is called M_0.
- ◈ Inhibitory arcs – special sort of arc, connects place with transitions.

Petri net example
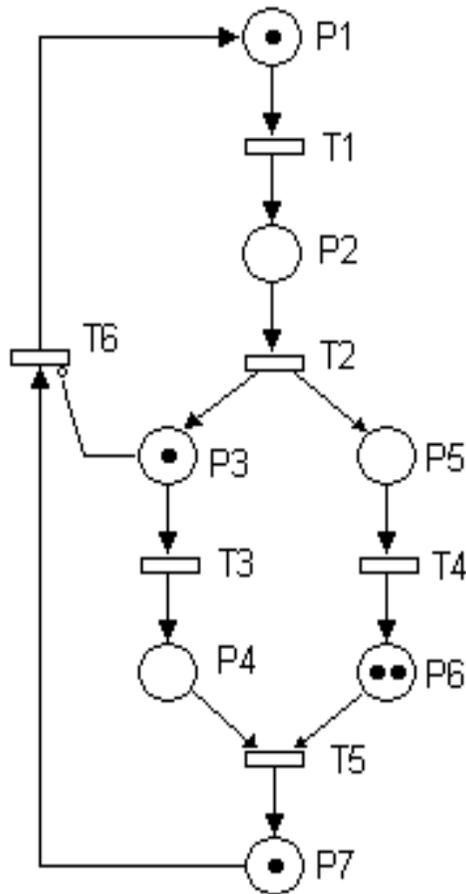
PTN (place/transition) definition:

PTN = (P, T, A, IA, AF, IF)

Where:

P is a finite non-empty set of places

T is a finite non-empty set of trans.

$P \cap T = \varnothing$ (their intersection is an empty set)

$A \subseteq (P \times T) \cup (T \times P)$ is a finite set of arcs

$IA \subseteq (P \times T)$ is finite set of inhibitory arcs

$AF: (A \cup IA) \rightarrow N$ is an arc function

$IF: P \rightarrow N_0 \cup \{\omega\}$ is initialisation function.

Initial net marking: (1, 0, 1, 0, 0, 2, 1)

Vague elements in process

- When modelling process sometimes we need depict state, which we do not know if occurs or not.

- Standard Petri net expresses states using tokens. Token is included into place, if given expression is true (1), if false (0), token is not included.

- We can employ fuzzy values ("small", "many", "middle", etc.) into Petri net. To work with these values we use fuzzy logics, specifically IF-THEN rules.

Fuzzy Petri net

Fuzzy Petri net dissimilarity:

- Token holds fuzzy set definition.

- Arcs are evaluated by natural language expressions.

- Transitions represent fuzzy relation corresponding to given IF-THEN rule. Relation creation depends on chosen inference method (closer explanation is out of range of this paper, for more information see paper Dvořák, Habiballa, Novák, Pavliska, 2003).

- Fuzzy Petri net extends Petri net formal definition with:

  D: set of expressions

  h: $P \rightarrow D$ function represents relation place – expression

  a: $P \rightarrow [0, 1]$ function represents place value

  l: $T \rightarrow [0, 1]$ functions represent value transition

Fuzzy Petri net example

Situation: subscriber wants to buy a lot of goods (costs a lot) and has huge debit (but not more than we tolerate), system should make decision if sell everything required or not.

D (Debit)

Huge

R

Huge

Low

(Request)

(Permitted purchase)
P
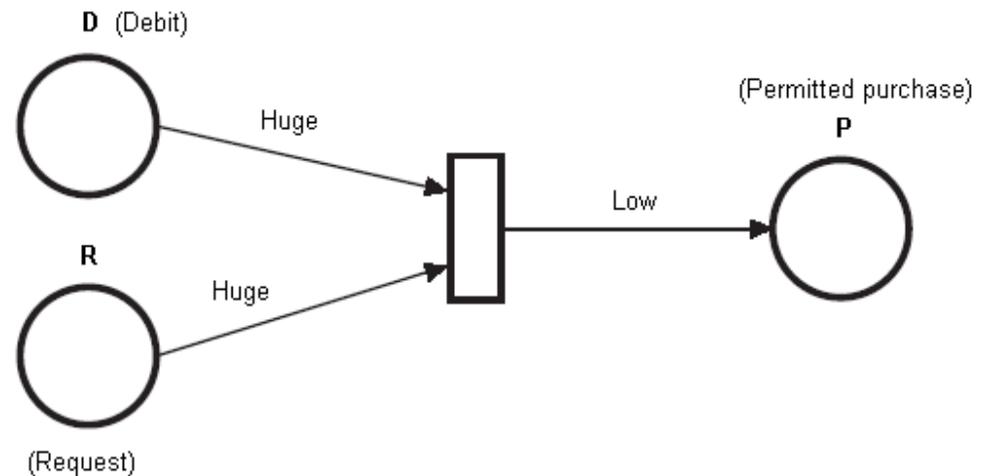
IF-THEN rule will look like:

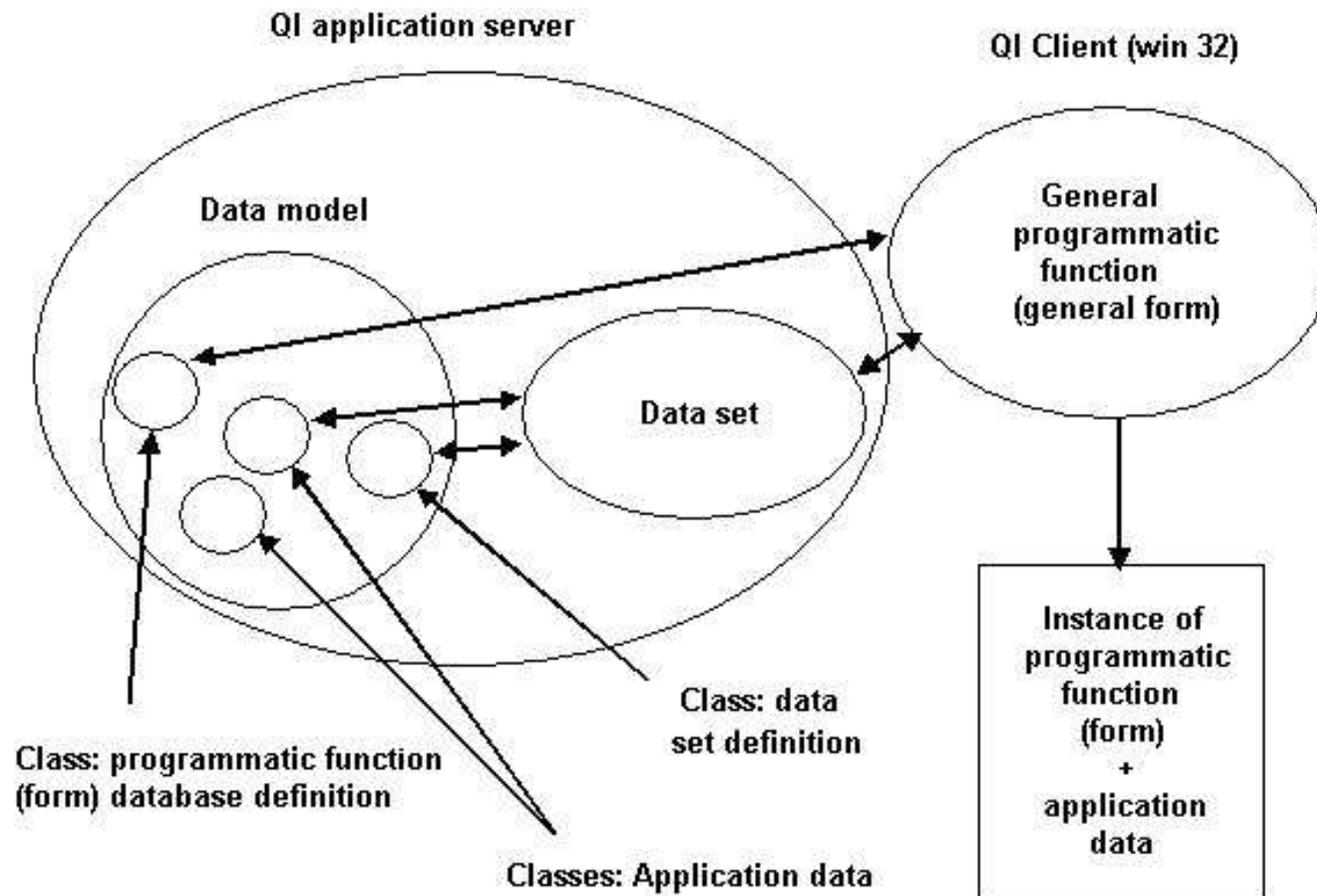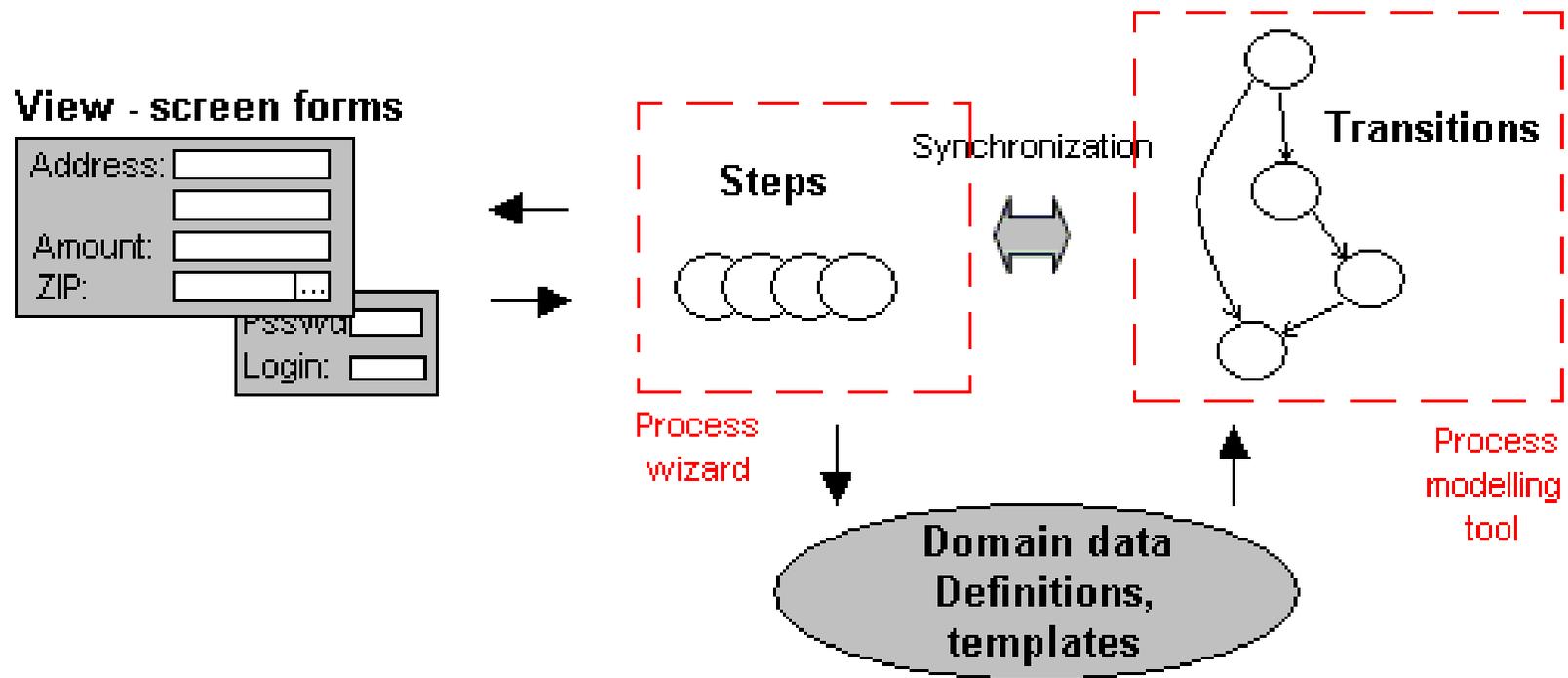**IF** D is huge **AND** R is huge **THEN** P is low

Where:

D is subscriber's debit

R is subscriber's purchase request

P is our permitted purchase amount

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Design isuess – QI architecture

Design issues – parts

View - screen forms

Address:

Amount:
ZIP:

Psswo
Login:

Steps

Synchronization

Process wizard

Transitions

Process modelling tool

Domain data Definitions, templates

Design issue - mapping

The first design issue is to map all process elements to Petri net. It means that activities, participants, sources (people, money, machine), documents (bill, contract, ...) and all its relations have appropriate position in Petri net.

E.g. activity is represented by place (place includes token, activity is performed).

This task we need to do before we include fuzzy elements to Petri net.
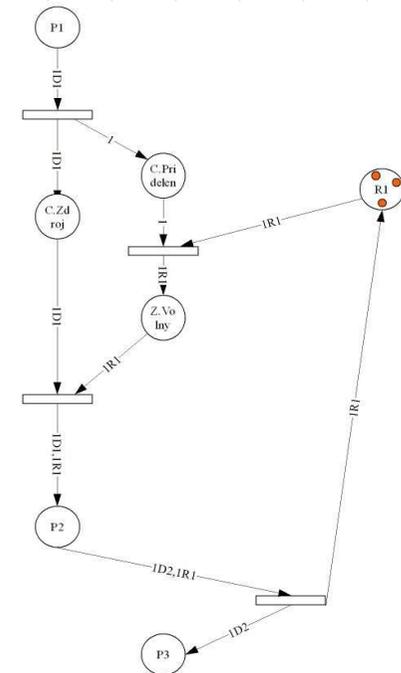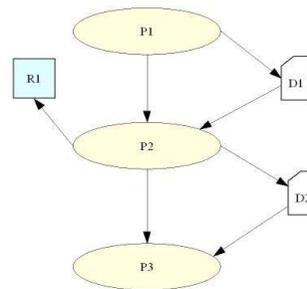
Design issue – including fuzzy rules

◆ Other design issues deals with inclusion fuzzy elements to IS.

List of fuzzy design issues:

1. Representation and data structure for fuzzy set.
2. Definition IF-THEN rules.
3. Storing mechanism for fuzzy sets and rules.
4. Defuzzification – using methods for defuzzificaton.

Conclusion

- Workflow and process management,
- Process wizard – visions,
- Process modelling using Petri net concept,
- Fuzzy Petri net concept,
- Design issues for implementing into IS.

Thank you for your attention.