Business Processes Modelling

MPB (6 cfu, 295AA)

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13 - Workflow nets
We study some special kind of Petri nets, that are suitable models of workflows.
There are many, many variants of Petri nets
Example: Coloured nets (also called High-Level)

A coloured net is a Petri net whose tokens can carry data and whose transitions can check data (see exact definition in Weske’s book)

[Paula, 15000], [Mary, 22000], [Peter, 23000]

If $a > 20000$ $(c, a)$

If $a \leq 20000$ $(c, a)$

Credit Request

AssessRisk

AdvancedRisk Assessment

SimpleRisk Assessment

[BeginsWith $(c, I-Z)$]

Inform Customer I-Z

[BeginsWith $(c, A-H)$]

Inform Customer A-H
Workflow nets
Workflow nets features

Tailored to the representation of business processes

- Formal (unambiguous) semantics
- Structural restrictions
- Decorated graphical representation
Workflow net: idea
Definition:
A Petri net \((P, T, F)\) is called workflow net if:

1. there is a distinguished initial place \(i \in P\) with \(\bullet i = \emptyset\)
2. there is a distinguished final place \(o \in P\) with \(o \bullet = \emptyset\)
3. every other place and transition belongs to a path from \(i\) to \(o\)
Lemma: In a workflow net there is a unique node with no incoming arc.

Proof:
Let $i$ be the initial place and $o$ the final one. Suppose there is another node $v$ with no incoming arc. Node $v$ must appear in a path from $i$ to $o$ since $\bullet v = \emptyset$, $v$ must be the first node of the path. Thus $v = i$. 
Basic properties

Lemma: In a workflow net there is a unique node with no outgoing arc

(the proof is analogous to the previous one)
Workflow net: Rationale

1. a token in $i$ represents a process instance not yet started
2. a token in $o$ represents a finished case
3. each place and each transition can participate in a case

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WF net: Example
Question time: WF net?
Question time: WF net?

Yes
Question time: WF net?
Question time: WF net?

No
(no initial place)
Question time: WF net?
Question time: WF net?

No
(no path from i to o with t2)
Question time: WF net?
Question time: WF net?

Yes
Question time: WF net?
Question time: WF net?
Question time: WF net?
Question time: WF net?

Yes
Syntax sugar (denotations)
Syntax sugar: split

AND-split stands for

XOR-split stands for
Syntax sugar: join

AND-join stands for

XOR-join stands for
Syntax sugar: any combination is also possible

stands for
Syntax sugar: any combination is also possible

stands for
Syntax sugar: a personal note

Chosen decorations are too similar!

Different meanings if differently placed!

Unnecessary for AND (redundant)!
Syntax sugar: a personal note

Why there? Because of gateways
Syntax sugar: a personal note

Let us avoid any source of confusion!

XOR-join

XOR-split
Subprocesses
Hierarchical structuring

Uniqueness of entry / exit point facilitate the hierarchical structuring of WF nets

A transition can be realized by another workflow net
L(N)
Language of a workflow net

The language of a workflow net is the set of firing sequences that lead from marking $i$ to marking $o$

$$L(N) = \{ \sigma \mid i \xrightarrow{\sigma} o \}$$

$L(N)$ defines all the admissible traces of the workflow
Question time: $L(N)$

$L(N) \supseteq \{ A \ (B \ R1 \ R2)^k \ C \mid k \geq 0 \}$

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No

No

Yes

Yes
Some patterns
Typical control flow aspects

Sequencing

Parallelism (AND-split + AND-join)

Selection (XOR-split + XOR-join)

Iteration (XOR-join + XOR-split)

Capacity constraints:
  Feedback loop
  Mutual exclusion
  Alternating
Sequencing

B is executed after A
Parallelism

(AND-split + AND-join)

A and B are both executed in no particular order
Explicit choice
(XOR-split + XOR-join)

Either A or B is executed (choice is explicit)
Explicit choice
("sugared" version)

Decorated version
Deferred choice

Either A or B is executed (choice is implicit)
Remember

Explicit choice ≠ Implicit choice

The decision is made at different points in time
Iteration
(one or more times)

A is executed 1 or more times
One-or-more iteration ("sugared" version)

Decorated version
One-or-more iteration
BPMN-like version

Decorated version
Iteration
(zero or more times)

A is executed 0 or more times
Zero-or-more iteration ("sugared" version)

Decorated version
Zero-or-more iteration
BPMN-like version

Decorated version
One serve per time

Multiple activations are handled one by one
Mutual exclusion

A and B cannot execute concurrently
Alternation

A and B execute one time each (A first)
Question time

Consider the workflow net below

How many times can A be executed?
How many times can B be executed?
Can a firing sequence contain two As in a row?
Can a firing sequence contain two Bs in a row?
Can a firing sequence contain more Bs than As?
Question time

Consider the workflow net below

How many times can A be executed? 1 or more
How many times can B be executed? 0 or more
Can a firing sequence contain two As in a row? yes
Can a firing sequence contain two Bs in a row? no
Can a firing sequence contain more Bs than As? no
Exercises

- Which "patterns" can be found in the workflow net below?
- Draw the corresponding Reachability Graph
- What is its language?
Exercises

• Which "patterns" can be found in the workflow net below?
• "Sugarize" the net (where it makes sense)
• Name all places and draw the Reachability Graph
• What is its language?
Exercises

• "Desugarize" the workflow net below
• Name all nodes and draw the Reachability Graph
• What is its language?
Exercises

• "Desugarize" the workflow nets below
• Name all nodes and draw the Reachability Graphs
• What are their languages?
Triggers
WoPeD
Workflow Petri Net Designer
Download WoPeD at sourceforge!
Triggers

Execution constraints can depend on the environment in which processes are enacted.

In workflow nets, transitions can be decorated with the information on who (or what) is responsible for the "firing" of that task.

Such annotations are called **triggers**
Triggers

Triggers can be:

a human interaction

the receipt of a message

the expiration of a time-out

Transitions with no trigger can fire automatically
Symbols for triggers

Automatic Trigger: Task enacted automatically

User Trigger: A human user takes initiative and starts activity

External Trigger: External event required to start activity

Time Trigger: Activity started when timer elapses
Triggers: example

User
send request

External
collect response

archive file

Timer
send reminder
Triggers: example
Explicit vs Implicit choices (again)

(a) *Explicit xor split* does not enable A and B concurrently

(b) *Implicit xor split* enables A and B concurrently
An insurance company uses the following procedure for the processing of the claims:

- Every claim, reported by a customer, is registered.
- After the registration, the claim is classified.
- There are two categories: simple and complex claims.
  - For simple claims two tasks need to be executed: check insurance and phone garage. These tasks are independent of each other.
  - The complex claims require three tasks: check insurance, check damage history and phone garage. These tasks need to be executed sequentially in the order specified.
- After executing the two/three tasks a decision is taken with two possible outcomes: OK (positive) or NOK (negative).
- If the decision is positive, then insurance company will pay.
- In any event, the insurance company sends a letter to the customer.
Question time
Net design: Car Damage

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Question time

Net design: Car Damage
Motivation for the analysis

$L(N)$ shows the correct ways to run the process if it is empty there is clearly some problem.

Are we guaranteed that nothing can go wrong?
Are all tasks necessary?
Are we guaranteed that once a case is started it will reach an end?

BPs are large, with increasing complexity flawed situations are frequent.
Is this WF net ok? 

What does it mean "to be ok"?