Business Processes Modelling

**MPB (6 cfu, 295AA)**

Roberto Bruni

[http://www.di.unipi.it/~bruni](http://www.di.unipi.it/~bruni)

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
Condition / Event Systems

A **C/E system** is a Petri net whose places have all capacity equal to 1 (i.e., each place can contain one token at most)

Markings are just subsets of $P$ (not multisets)

Firing rule is more restrictive: $t$ is enabled at $M$ if

$t \subseteq M$ and $t \cdot \cap M = \emptyset$

Is $t_1$ enabled?
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\[ t \text{ is enabled at } M \text{ if } \bullet t \subseteq M \text{ and } t\bullet \cap M = \emptyset \]

Is \( t_1 \) enabled?

No, a token is already in \( p_3 \)
A **P/T net** is a Petri net \((P,T,F)\) together with a weight function \(w : F \to \text{Nat}\).

Firings consume and produce tokens according to the weight function.

Sometimes a place capacity function \(c : P \to \text{Nat} \cup \{\infty\}\) is also considered.

Firings cannot lead to markings where the capacity of a place is exceeded.
P/T net: examples

Capacity $\infty$ is omitted from places
Weight 1 is omitted from arcs
P/T net: examples

Is $t_1$ enabled?
P/T net: examples

Is $t_1$ enabled?

No, $p_3$ can contain one token at most

No, two tokens are needed from $p_1$

Yes, the firing leads to $3p_3$
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)
Workflow nets
Workflow nets features

Tailored to the representation of business processes

Formal (unambiguous) semantics

Structural restrictions

Decorated graphical representation
Workflow net: idea

start

work

WFN

end
Definition:
A Petri net \((P, T, F)\) is called \textbf{workflow net} if:

1. there is a distinguished \textit{initial place} \(i \in P\) with \(\cdot i = \emptyset\)

2. there is a distinguished \textit{final place} \(o \in P\) with \(o\bullet = \emptyset\)

3. every other place and transition belongs to a path from \(i\) to \(o\)
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

Definition:
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WF net: Example
Basic properties

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

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

Exercise: Guess which nodes are those

Exercise: Prove the above lemmas (hint: suppose the nodes are not unique, reach a contradiction)
Question time: WF net?
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Question time: WF net?
Syntax sugar: split

AND-split

stands for

XOR-split

stands for
Syntax sugar: join

AND-join

stands for

stands for

XOR-join
Hierarchical structuring

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

A transition can be realized by another workflow net
The language of a workflow net is the set of firing sequences that go from $i$ to $o$

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

$L(N)$ defines the admissible traces of the workflow.
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
Parallelism
(“sugared” version)

Decorated version for business process stakeholders
Explicit choice
(XOR-split + XOR-join)

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

Decorated version for business process stakeholders
Deferred choice

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

Explicit choice $\neq$ 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 for business process stakeholders
Iteration
(zero or more times)

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

Decorated version for business process stakeholders
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 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?
Exercises

• Which "patterns" can be found in the workflow net below?
• "Sugarize" the net
• 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?

![Workflow Net 1](image1)

![Workflow Net 2](image2)
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

- Send request
- Collect response
- Archive file
- Send reminder
Triggers: example

Diagram:

- Start node: i
- Event: charge credit card success or failure
- Event: spam customer
- Event: cancel order
- Event: update billing info updated or canceled
- Decision: Pack complete or incomplete
- Decision: Backorder
- End node: Ship
Explicit vs Implicit XOR-split

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

(b) *Implicit xor split* enables A and B concurrently
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 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"?