Checking Business Process Evolution

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joint work with

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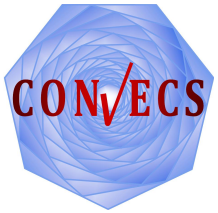
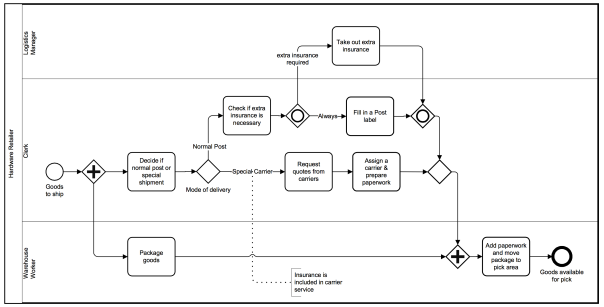
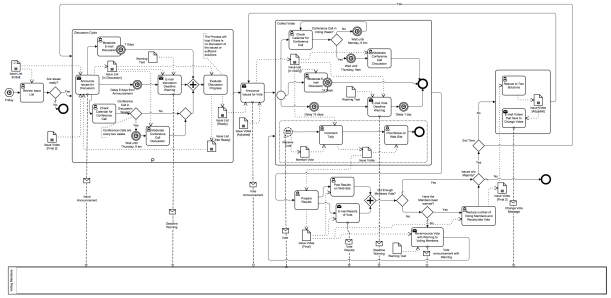


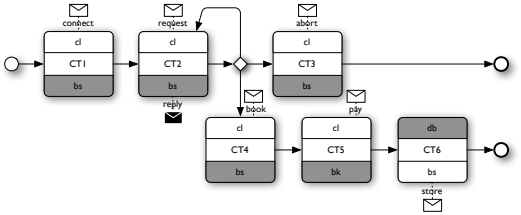
Introduction (1/2)

- A business process is a set of structured, related activities or tasks designed to produce a specific output for a customer or market

- BPMN 2.0 (Business Process Modelling Notation) was published as an ISO/IEC standard in 2013







- Modern software exhibits a high degree of dynamicity and is subject to continuous evolution

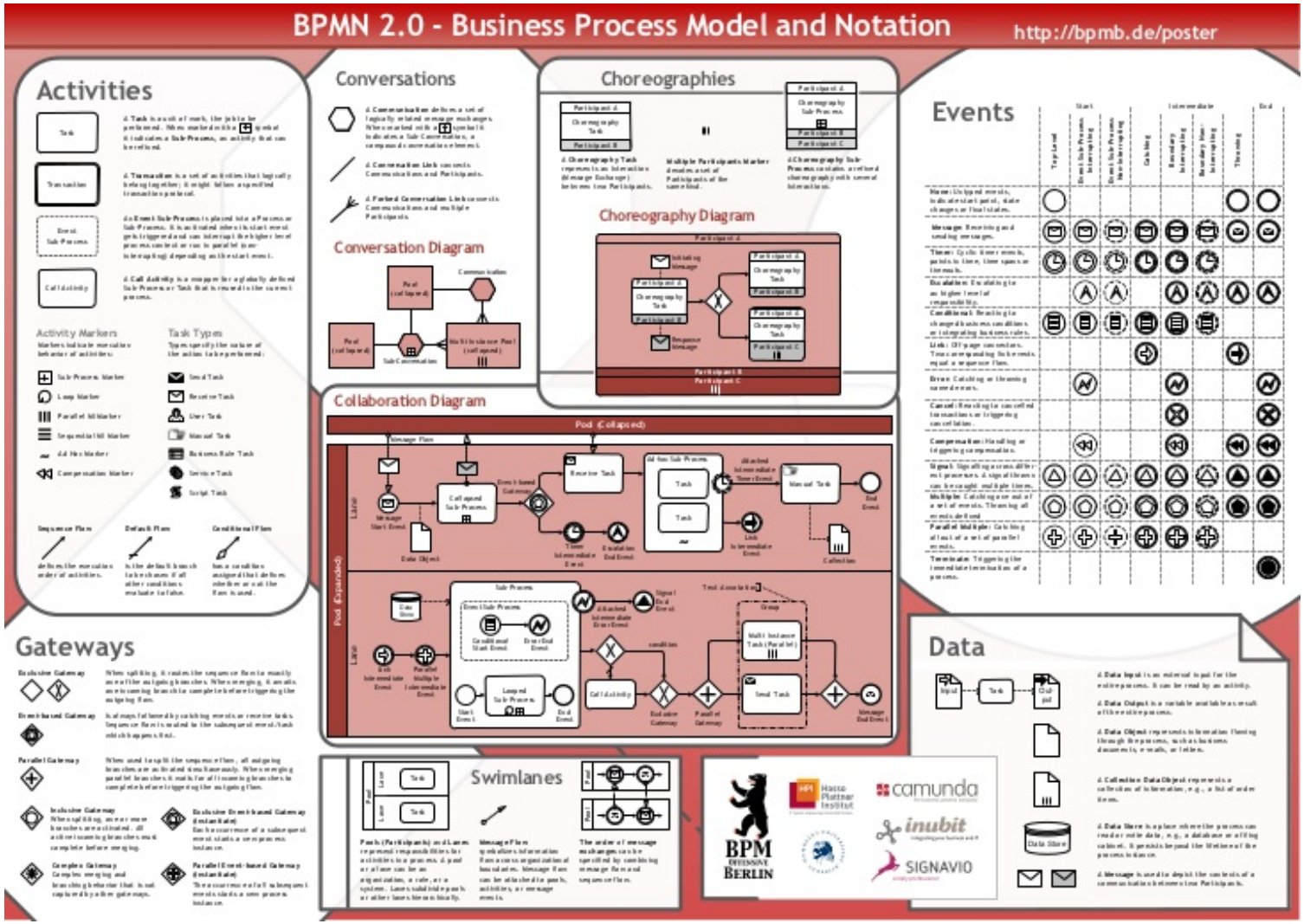
Introduction (2/2)

- Given two BPMN business processes, we want to support the process designer in the evolution activity with automated verification techniques
- Formal modelling and analysis is important and required to ensure correctness, efficiency, and quality of the whole process execution
- Our contributions:
  - An LTS (Labelled Transition System) semantics for a subset of BPMN obtained via process algebra encoding
  - A set of evolution notions based on LTS equivalences / preorders that one can use to compare two processes
  - A tool support for fully automating the evolution checks that can be accessed via a Web application

Outline

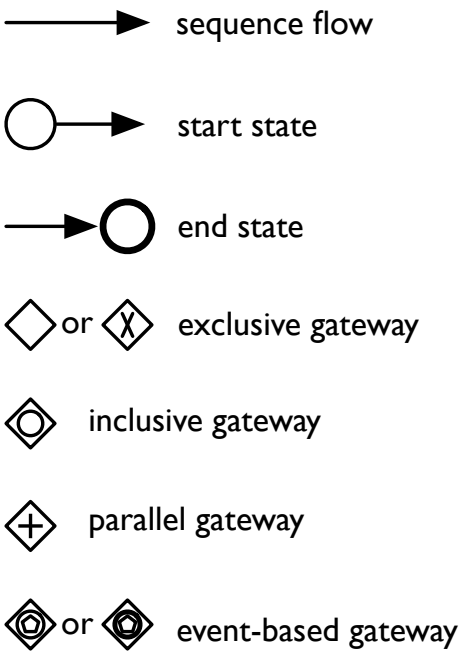
1. BPMN
2. From BPMN to LTS
3. Process Comparison
4. Tool Support
5. Concluding Remarks

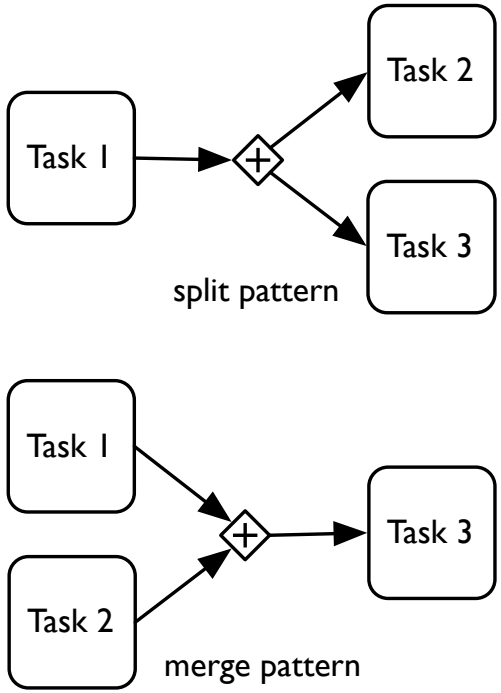
BPMN



Several modelling and development frameworks: Activiti, Bonita BPMN, jBPM, …

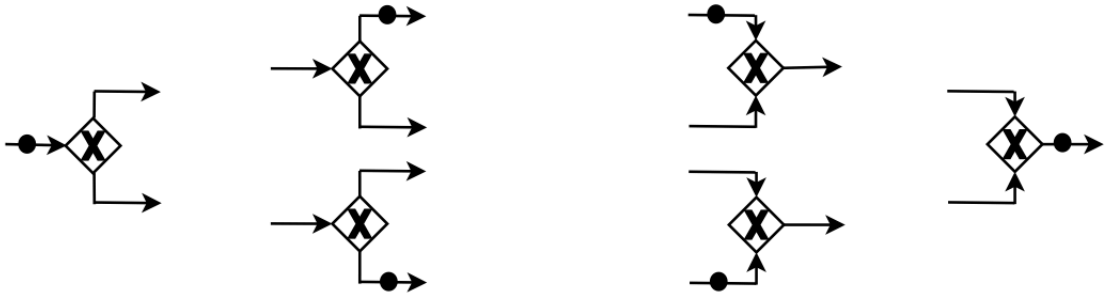
Control Flows and Gateways





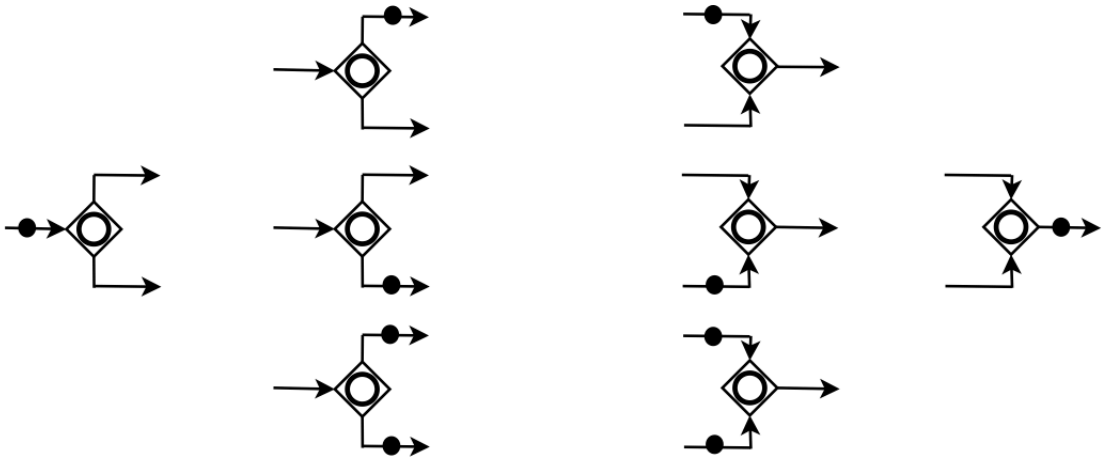
Semantics

Exclusive gateway (similar for Event-based gateway): split (left) and merge (right)

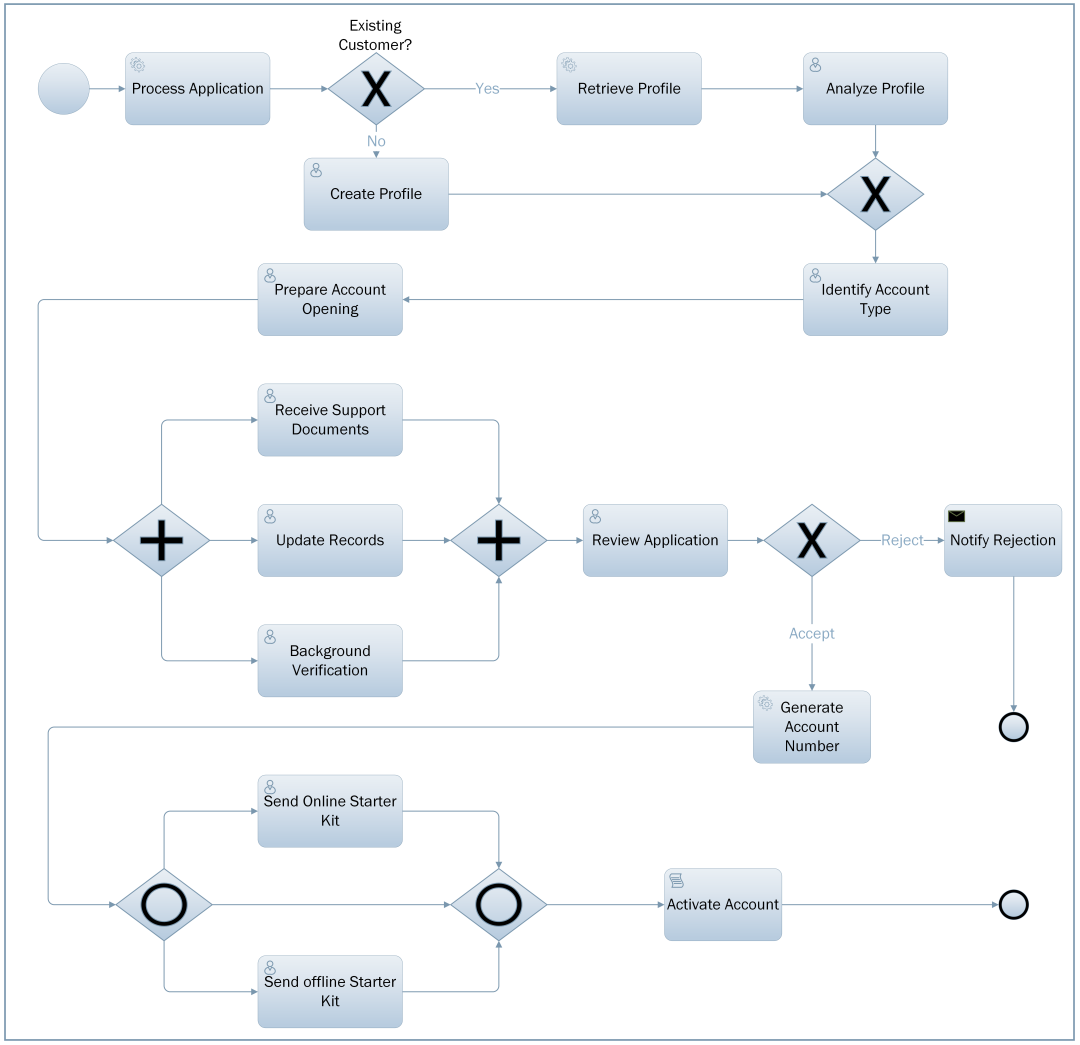


Parallel gateway : split (left) and merge (right)

Inclusive gateway : split (left) and merge (right)



Example of BPMN Process



Bank account opening process

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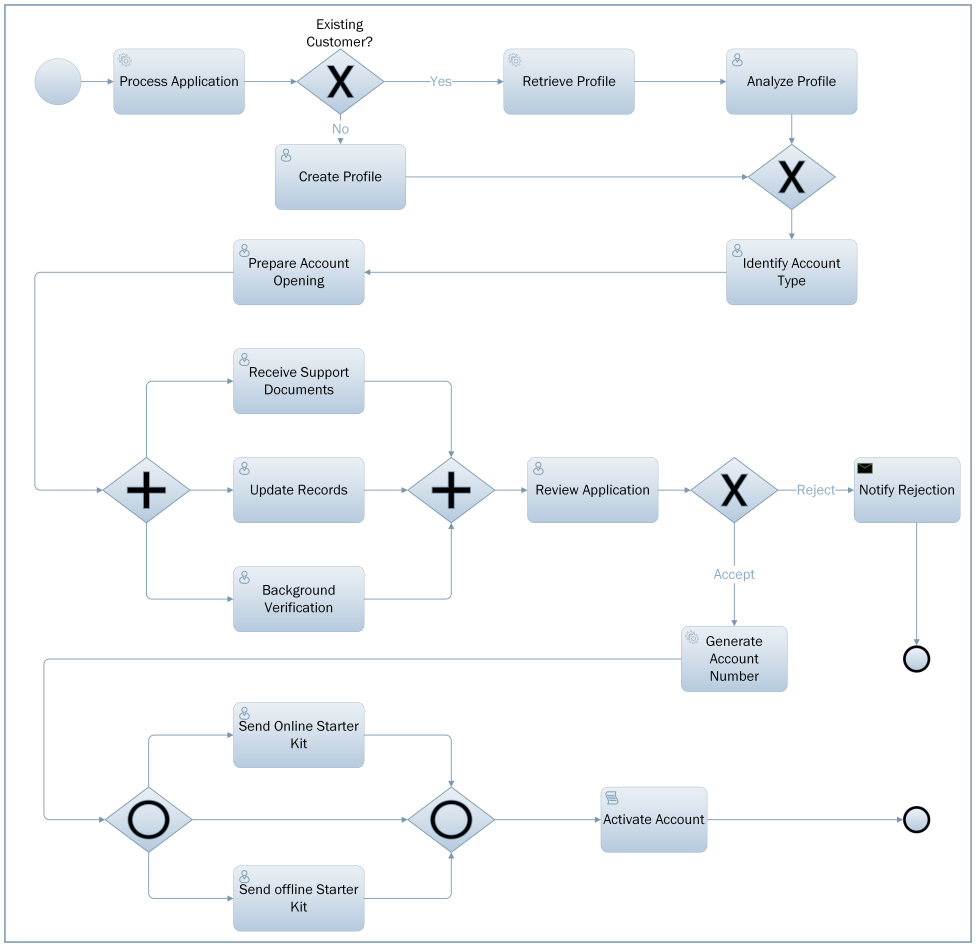
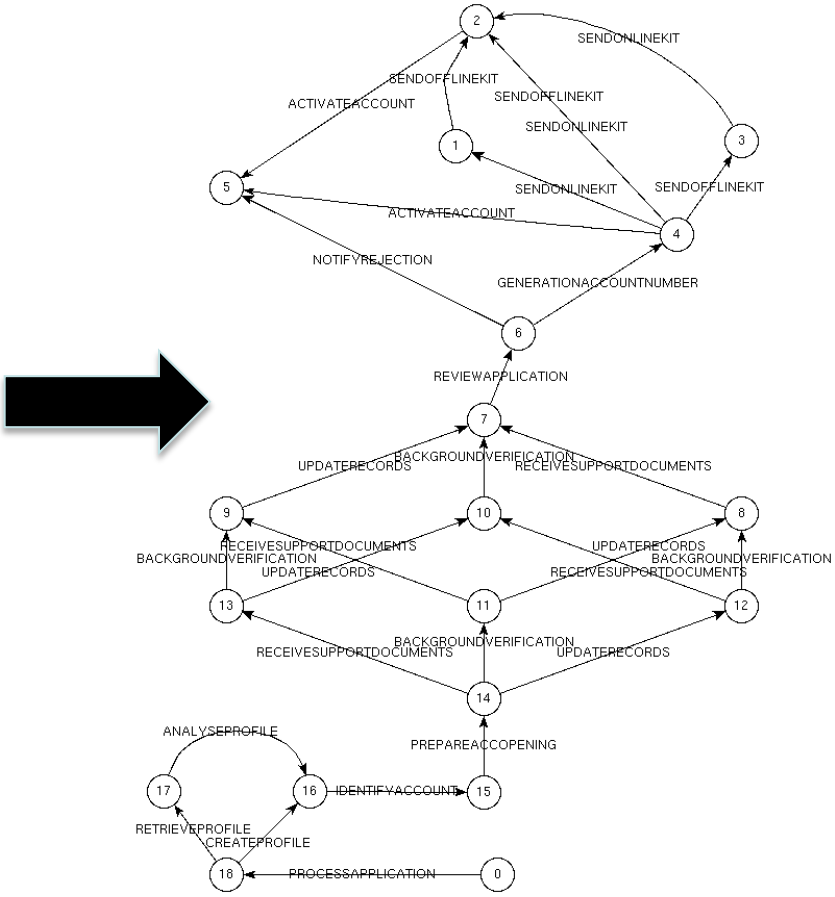
LTS Models


Existing Customer?
Process Application
Yes
No
Retrieve Profile
Analyze Profile
Create Profile
Identify Account Type
Prepare Account Opening
Receive Support Documents
Update Records
Review Application
Reject
Notify Rejection
Background Verification
Accept
Generate Account Number
Send Online Starter Kit
Activate Account
Send offline Starter Kit


SENDONLINEKIT
SENDOFFLINEKIT
ACTIVATEACCOUNT
NOTIFYREJECTION
GENERATIONACCOUNTNUMBER
REVIEWAPPLICATION
UPDATERECORDS
BACKGROUNDVERIFICATION
RECEIVESUPPORTDOCUMENTS
ANALYSEPROFILE
PREPAREACCOPENING
IDENTIFYACCOUNT
RETRIEVEPROFILE
CREATEPROFILE
PROCESSAPPLICATION

LNT

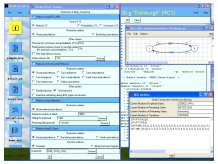
- LOTOS NT (LNT) is a value-passing process algebra with user-friendly syntax and operational semantics

- LNT is an imperative-like language where you can specify data types, functions (pattern matching and recursion), and processes

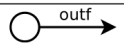
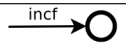
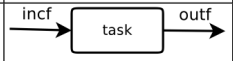
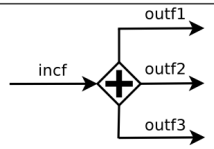
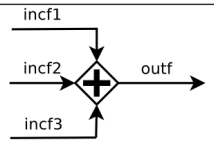
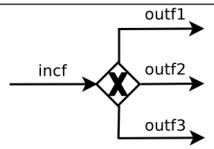
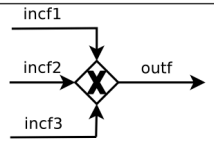
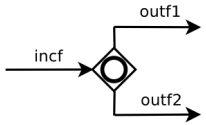
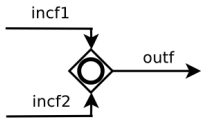
- Excerpt of the LNT process grammar:

B ::= **stop** | G(!E, ?X) **where** E' | **if** E **then** B1 **else** B2 **end if**
| x:=E | **hide** G **in** B **end hide** | P [G1,...,Gm] (E1,...,En)
| **select** B1 **[]** … **[]** Bn **end select** | B1 **;** B2
| **par** G **in** B1 **||** … **||** Bn **end par**

- Compilation to LTS and verification using the CADP toolbox



LNT Encoding (1/2)

BPMN construct	BPMN notation	LNT encoding
Initial event		begin ; outf
End event		incf ; finish
Sequence flow		**loop** begin ; finish **end loop**
Task		**loop** incf ; task ; outf **end loop**
Parallel gateway (split)		incf ; **par** outf1 || outf2 || outf3 **end par**
Parallel gateway (merge)		**par** incf1 || incf2 || incf3 **end par** ; outf
Exclusive gateway (split)		incf ; **select** outf1 [] outf2 [] outf3 **end select**
Exclusive gateway (merge)		**select** incf1 [] incf2 [] incf3 **end select** ; outf
Inclusive gateway (split)		incf ; **select** (* *si if one matching merge* *) outf1 ; *s1* [] outf2 ; *s2* [] **par** outf1 || outf2 **end par** ; *s3* **end select**
Inclusive gateway (merge)		**select** (* *si if one matching split* *) *s1* ; incf1 [] *s2* ; incf2 [] *s3* ; **par** incf1 || incf2 **end par** **end select** ; outf

LNT Encoding (2/2)

```
process main [processApplication:any, reply:any, createProfile:any, ...] is
 hide begin:any, finish:any, flow1_begin:any, flow1_finish:any, ... in
   par flow1_begin, flow1_finish, flow2_begin, flow2_finish, ... in
    par
      flow [flow1_begin, flow1_finish] ||... || flow [flow29_begin, flow29_finish]
    end par
   ||
    par
      init [begin,flow1_begin]
    || final [flow21_finish, finish] || final [flow27_finish, finish]
    || task [flow1_finish, processApplication, flow2_begin] || task [...] || ...
    || xorsplit [flow2_finish, flow3_begin, flow4_begin]
    || xormerge [flow6_finish, flow7_finish, flow29_begin]
    end par
   end par
 end hide
end process
```

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Evolution

Given two BPMN processes P_1 and P_2, we can define several notions of comparison using concurrency theory

- Conservative evolution: both processes exhibit exactly the same behaviour

$$LTS(P_1) =_{br} LTS(P_2)$$

- Inclusive / exclusive evolution: one process simulated by the other

$$LTS(P_1) <_{br} LTS(P_2) \quad (LTS(P_1) >_{br} LTS(P_2), \text{ resp.})$$

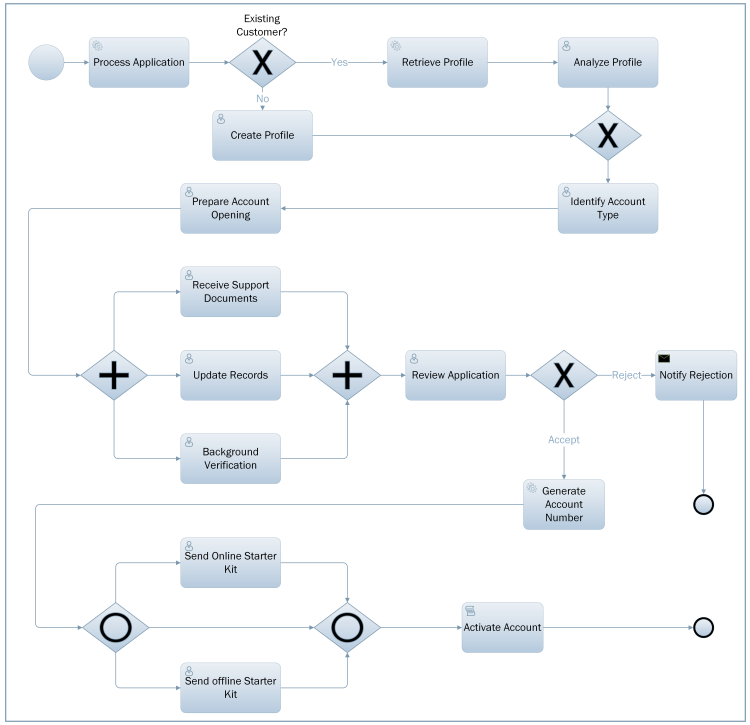
- Up-to-alphabet / up-to-renaming evolution: checking former relations hiding or renaming parts of the alphabet

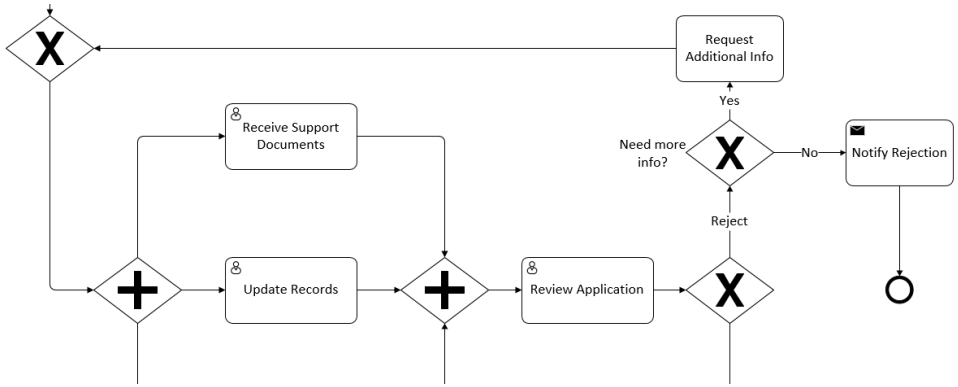
$$LTS'(P_1) =_{br} LTS'(P_2) \text{ where } LTS'(P_i) = \text{hide } A \text{ in } LTS(P_i)$$

- Property preserving evolution: both processes satisfy a same temporal property P

$$LTS(P_1) \models P \text{ and } LTS(P_2) \models P$$

Example (V2)





Conservative evolution ✗
Inclusive evolution ✓
Exclusive evolution ✗
Property preserving evolution *« any process execution eventually terminates by a rejection notification or by an account activation »* ✗

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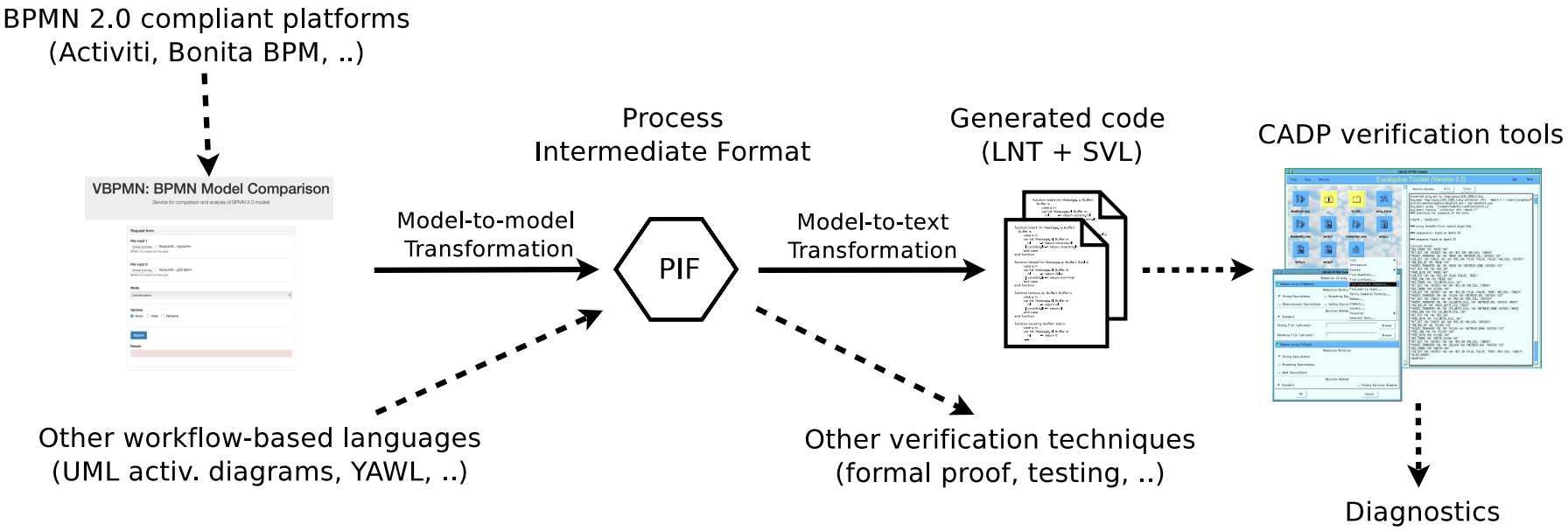
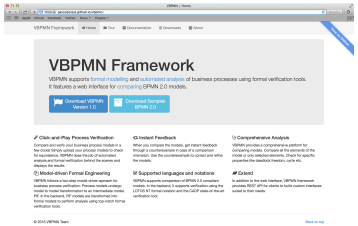
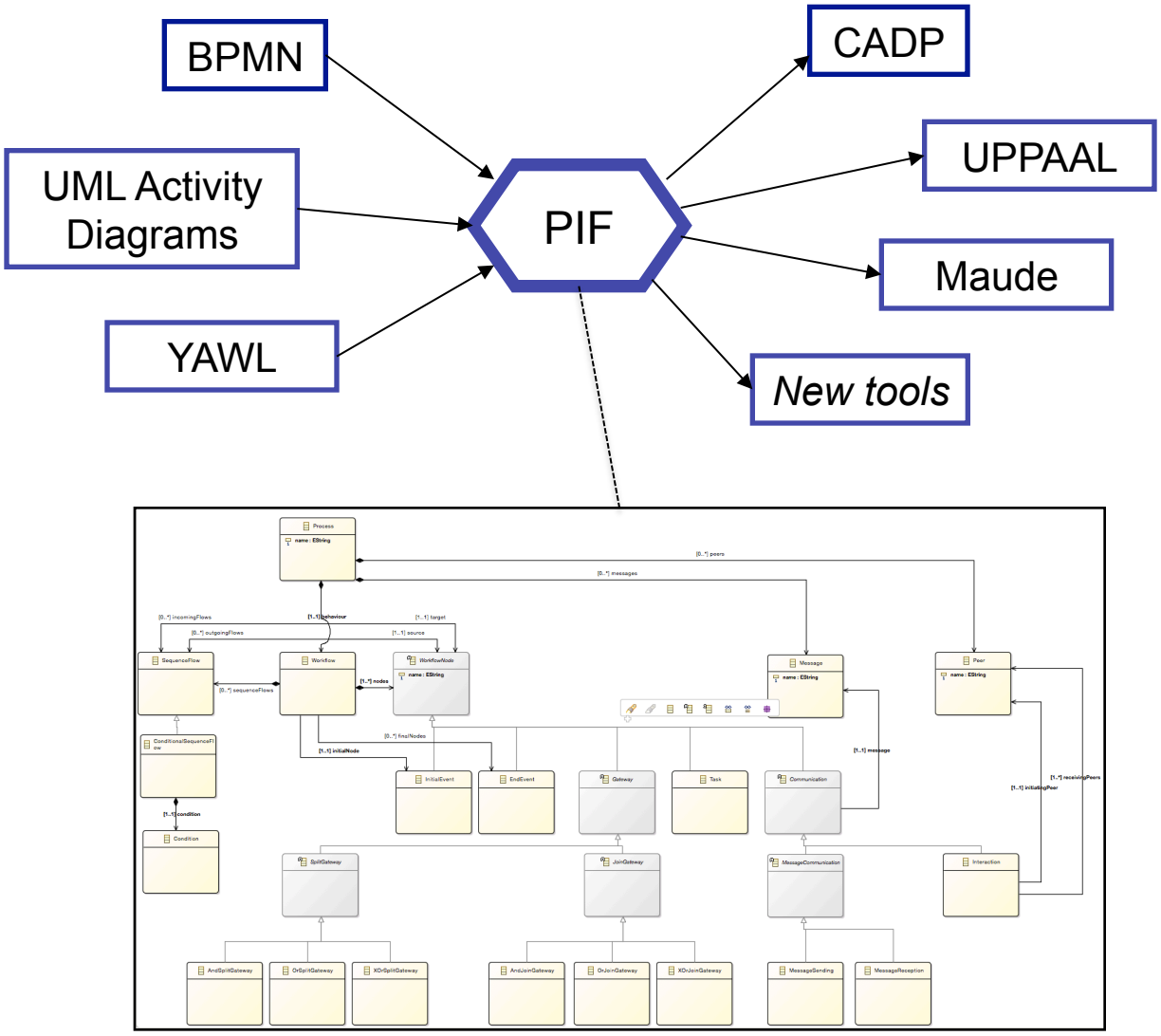
The VBPMN Platform



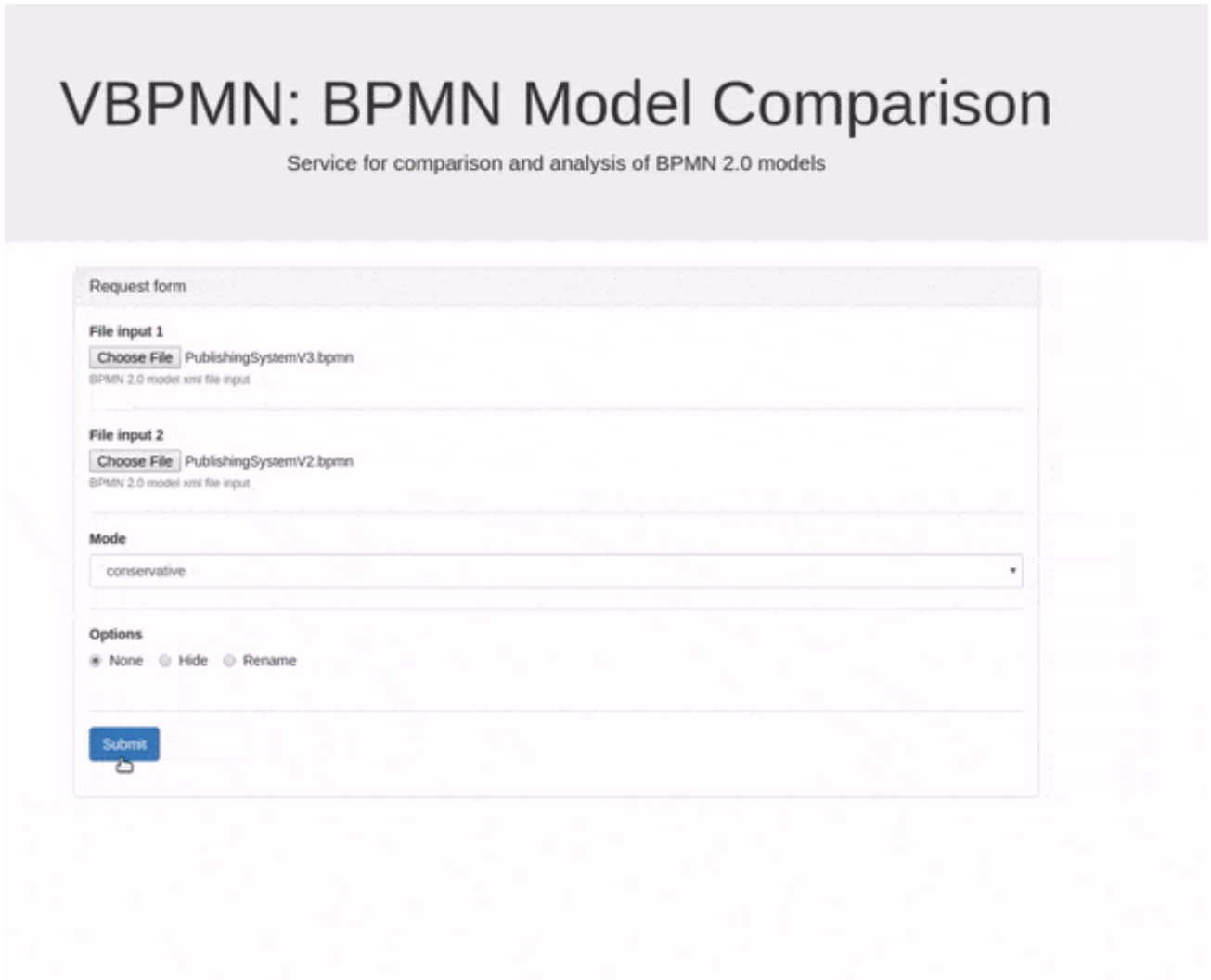


https://pascalpoizat.github.io/vbpmn/

Process Intermediate Format



Web Interface



Experiments

BPMN Proc.	Size			LTS (states/transitions)		Evol.
	Tasks	Flows	Gateways	Raw	Minimized	$\equiv$ $<$ $>$
1	6	11	2	29/29	8/9	$\times$ $\surd$ $\times$
1'	7	15	2 + 2	78/118	11/14	15s
2	4	7	1	70/105	7/9	$\surd$ $\surd$ $\surd$
2'	8	14	2	36/38	10/12	15s
3	7	14	2 + 2	62/87	10/11	$\times$ $\times$ $\times$
3'	8	16	4	1,786/5,346	28/56	15s
4	15	29	3 + 2 + 2	469/1,002	24/34	$\times$ $\surd$ $\times$
4'	16	33	5 + 2 + 2	479/1,013	26/37	15s
5	12	24	6	742,234/3,937,158	148/574	$\times$ $\times$ $\surd$
5'	12	24	4 + 2	6,394/21,762	60/152	31s
6	20	43	6 + 6	4,488,843/26,533,828	347/1,450	$\times$ $\surd$ $\times$
6'	20	39	8	4,504,775/26,586,197	348/1,481	9m31s

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Concluding Remarks

- We have presented an approach for automatically checking the evolution of BPMN processes
- We have defined a BPMN to LNT translation, which allows to provide an LTS semantics for BPMN
- We have proposed several notions of evolution taking inspiration in concurrency theory
- We have implemented our approach in a tool, VBPMN, which can be used via a Web application

- Perspectives: support of unbalanced workflows, extending the BPMN subset considered, quantitative analysis, …