Performance Analysis Modeling Applied to Business Processes

Kelly R. Braghetto\textsuperscript{1,2}, João E. Ferreira\textsuperscript{1} and Jean-Marc Vincent\textsuperscript{2}

\textsuperscript{1} Institute of Mathematics and Statistics, Department of Computer Science
University of São Paulo – Brazil
kellyrb@ime.usp.br, jef@ime.usp.br

\textsuperscript{2} Laboratoire d’Informatique de Grenoble, INRIA MESCAL Project
Grenoble University – France
Jean-Marc.Vincent@imag.fr

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Performance Analysis of Business Processes

To improve efficiency in organizations we need

- To understand how the operational processes work
- To optimize their functioning

Main challenges

- Business processes generally are large-scale systems with complex structure
- Difficulty to express quantitative aspects using business process modeling languages
- Resource utilization – where and how the business process components are executed
Cost of a Medical Service in the French Health-Care System

⇒ Service used by thousands of people concurrently

medical service

Get the Service's Type and Cost (a)

Verify Patient's Coverage (b)

Evaluate Amount Refundable by Private Insurance (d)

Evaluate Amount Refundable by Public Insurance (c)

Calculate Final Cost (e)

payment order
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t = 2 s r = 0.50
t = 5 s r = 0.20
t = 4 s r = 0.25
t = 10 s r = 0.01
t = 1 s r = 1.00
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80% of people are covered by the public insurance

73% of people are covered by some private insurance

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Objective: compare quantitative modeling methods in the business process management domain

Methodology

- Selection of 3 modeling environments to performance evaluation
- Definition of several business process scenarios
- Mapping of the scenarios to performance evaluation models
- Numerical analysis of the models
- Comparison of the results under different criteria
Outline of the Talk

Business Processes
  Context
  Example in BPMN (Business Process Model and Notation)
  Goal

Comparison of Formalisms
  Methodology
  Main Results

Split/Merge Example
  Business Process Model
  Mapping to a Performance Analysis Model

Synthesis
  Concluding Remarks
  Ongoing Work and Future Plans
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Selected Techniques for Performance Evaluation

Stochastic formalisms

- Generalized Stochastic Petri Nets (GSPN) [Marco Marsan, Gianni Conte, Gianfranco Balbo – 1984]
- Performance Evaluation Process Algebra (PEPA) [Jane Hillston – 1996]
- Stochastic Automata Networks (SAN) [Brigitte Plateau – 1985]

Software tools

- SMART (http://www.cs.ucr.edu/~ciardo/SMART)
- PEPA Plug-in (http://www.dcs.ed.ac.uk/pepa/tools/plugin)
- PEPS (http://www-id.imag.fr/Logiciels/peps)
Business Process Scenarios Characteristics

Basic structures
- Sequences, OR splits/joins, AND splits/joins and cycles

Complex branching and merging structures
- Examples: multi-choice, multi-merge, etc.

Features of performance modeling formalisms
- Examples: functional transitions, variable activity rates
Comparison Criteria

Modeling perspective

- Expressive power – direct representation of the scenarios
- Abstraction power – level of generality of the process models
- Facility to enlarge – extensions without impacting the previous modeled behavior
- Readability – view of the business logic from the model

Analysis perspective

- Computational resources (execution time and memory consumption)
- Supporting tool
### Under the modeling perspective

<table>
<thead>
<tr>
<th>Modeling criteria</th>
<th>GSPN</th>
<th>PEPA</th>
<th>SAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressive power</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Abstraction power</td>
<td>+</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>Facility to enlarge</td>
<td>-</td>
<td>+</td>
<td>+/-</td>
</tr>
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French Health-Care System (BPMN Annotated Model)

1. Get the Service's Type and Cost (a)
2. Verify Patient's Coverage (b)
3. Evaluate Amount Refundable by Public Insurance (c)
4. Evaluate Amount Refundable by Private Insurance (d)
5. Calculate Final Cost (e)

- **Verify Patient's Coverage (b)**
  - 80% of people are covered by the public insurance
  - 73% of people are covered by some private insurance

- **Evaluate Amount Refundable by Public Insurance (c)**
  - 80% of people are covered by the public insurance
  - 73% of people are covered by some private insurance
  - t = 2 s, r = 0.50
  - t = 4 s, r = 0.25
  - t = 10 s, r = 0.01

- **Evaluate Amount Refundable by Private Insurance (d)**
  - 80% of people are covered by the public insurance
  - 73% of people are covered by some private insurance
  - t = 2 s, r = 0.50
  - t = 4 s, r = 0.25
  - t = 10 s, r = 0.01

- **Calculate Final Cost (e)**
  - t = 1 s, r = 1.00

- **Get the Service's Type and Cost (a)**
  - t = 5 s, r = 0.20

- **Payment Order**
Complexity of the Multi-Choice / Multi-Merge Structure

- medical service
- Get the Service's Type and Cost (a)
- Verify Patient's Coverage (b)
- Evaluate Amount Refundable by Public Insurance (c)
- Evaluate Amount Refundable by Private Insurance (d)
- Calculate Final Cost (e)
- Multi-Merge
Complexity of the Multi-Choice / Multi-Merge Structure

- Get the Service's Type and Cost (a)
- Verify Patient's Coverage (b)
- Evaluate Amount Refundable by Public Insurance (c)
- Evaluate Amount Refundable by Private Insurance (d)
- Calculate Final Cost (e)

Medical service flowchart:
- "Multi-Choice" node
- "Multi-Merge" node
- Payment order

Performance Analysis Modeling Applied to Business Processes
Complexity of the Multi-Choice / Multi-Merge Structure

medical service

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payment order
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Medical service

Multi-Choice

Multi-Merge

payment order
Mapping to a Performance Analysis Model

**GSPN Model**

<table>
<thead>
<tr>
<th>Rate</th>
<th></th>
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<tbody>
<tr>
<td>( t_a )</td>
<td>0.50</td>
</tr>
<tr>
<td>( t_b )</td>
<td>0.20</td>
</tr>
<tr>
<td>( t_c )</td>
<td>0.25</td>
</tr>
<tr>
<td>( t_d )</td>
<td>0.01</td>
</tr>
<tr>
<td>( t_e )</td>
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**Multi-Choice**

- \( p_1 \)
- \( t_a \)
- \( p_2 \)

**Probabilities**

- \( prob(c) \)
- \( 1 - prob(c) \)
- \( prob(d) \)
- \( 1 - prob(d) \)

**Event Rates**

- \( t_a = 0.50 \)
- \( t_b = 0.20 \)
- \( t_c = 0.25 \)
- \( t_d = 0.01 \)
- \( t_e = 1.00 \)
SAN Model

Event Rate

<table>
<thead>
<tr>
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<th>Rate</th>
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<tbody>
<tr>
<td>a</td>
<td>0.50</td>
</tr>
<tr>
<td>b</td>
<td>0.20</td>
</tr>
<tr>
<td>c₁</td>
<td>prob(c) * 50</td>
</tr>
<tr>
<td>c₂</td>
<td>(1 - prob(c)) * 50</td>
</tr>
<tr>
<td>c</td>
<td>0.25</td>
</tr>
<tr>
<td>d₁</td>
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<tr>
<td>e</td>
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PEPA Model

// Execution rates and probabilities associated with the activities
r_a = 0.50; r_b = 0.20; r_c = 0.25;
r_d = 0.01; r_e = 1.00; r_immediate = 50.00;
prob_c = 0.85; prob_d = 0.73;

// Medical service cost calculation components
PCalc = (a,r_a).(b,r_b).(e,r_e).PCalc;

// Public insurance refund
P1 = (b, ⊤).((c1,prob_c * r_immediate).(c,r_c).(e, ⊤).P1 +
       (c2,(1-prob_c) * r_immediate).(e, ⊤).P1);

// Private insurance refund
P2 = (b, ⊤).((d1,prob_d * r_immediate).(d,r_d).(e, ⊤).P2 +
       (d2,(1-prob_d) * r_immediate).(e, ⊤).P2);

PCalc <b,e> P1 <b,e> P2 // Whole system
## Comparison Summary of the Formalisms

For the example of the Health-Care System

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Modeling perspective

- The 3 modeling environments attend the basic scenarios

- **Immediate transitions** (GSPN)  → advanced branching / merging without impacting readability nor analysis results

- **Functional transitions** (GSPN and SAN)  → (i) functional dependencies between activities or (ii) rates that vary with the load of the system or the number of available resources

- **Compositionality** (PEPA and SAN)  → (i) to build the model in a modular way or (ii) to enable a structured analysis
Steps for Performance Evaluation of a Business Process

1. Create BP model
2. Decompose BP model
3. Gather Quantitative Aspects
4. Create Stochastic Models
5. Integrate Results
6. Analyze Numerically
7. Set of SAN models
Steps for Performance Evaluation of a Business Process

- **Create BP model**
- **Decompose BP model**
- **Gather Quantitative Aspects**
- **Create Stochastic Models**
- **Integrate Results**
- **Analyze Numerically**

- **performance analysis modeling applied to business processes**

**Ongoing work and future plans**
Steps for Performance Evaluation of a Business Process

1. Create BP model
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4. Create Stochastic Models
5. Integrate Results
6. Analyze Numerically
7. Set of resource models

Business process → BPMN model → set of BPMN elementary models → set of resource models

Ongoing work
Next steps
Performance Analysis Modeling Applied to Business Processes

Thank you for your attention

For more details