JCircus 2.0: an extension of an automatic translator from Circus to Java

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Outline

Why translating formal specifications into code?

It is possible to reduce the occurrence of errors in the implementation of software systems from formal specifications...

Figure : Formal specification to code

Goal

To extend JCircus by providing

- an optimized strategy to translate the Multi-synchronisation primitive;
- a strategy to translate communications with arbitrary field decorations (e.g. $c?x!y.10$);
- a strategy to translate alphabetized parallelism;
- the translation of deadlock-free GUI processes to interact with the generated processes;
- the integration of JCircus with a refinement tool, called CRefine;

Circus Syntax

- Z + CSP + Refinement Calculus + G.C. language;
- Circus Specification - formed by paragraphs:
  Z paragraph,
  Channel declaration paragraph,
  Channel set declaration paragraph and
  Process paragraph;

Roulette

$$\begin{array}{l}\textbf{process } Roulette \mathrel{\widehat=} \\ \textbf{begin} \\ \qquad \bullet\ \mu\, X \bullet start \rightarrow \left(\begin{array}{l} result.RED \rightarrow X \\ \sqcap\ result.BLACK \rightarrow X \end{array}\right) \\ \textbf{end}\end{array}$$

Figure : The Roulette process

Croupier

$$
\begin{array}{l}
\textbf{process}\ Croupier \mathrel{\widehat=} \\
\textbf{begin} \\
\quad StartRoulette \mathrel{\widehat=}\ start \rightarrow TakeBet \\
\quad TakeBet \mathrel{\widehat=}\ enter?id \rightarrow bet.id?b \rightarrow result?x \\
\qquad\qquad \left(\begin{array}{l} \textbf{if}\ (x = b) \rightarrow (pay.ident \rightarrow Skip) \\ [\!](x \neq b) \rightarrow Skip \\ \textbf{fi} \end{array} \right) \\
\qquad\quad \sqcap\ stopBet \rightarrow Skip \\
\bullet\ \mu\, X \bullet StartRoulette;\ X \\
\textbf{end} \\
\textbf{process}\ Table \mathrel{\widehat=}\ Roulette \,[\![\, \{\!|\ start, result\ |\!\} \,]\!]\, Croupier
\end{array}
$$

Figure : The Croupier process

JCSP concepts

- Java API for implementing CSP constructs;
- Processes are classes with the CSProcess interface;
- The behavior of each process is implemented in its run method;
- Parallelism: Parallel class;
- External choice: Alternative;
- Multi-Synchronisation: AltingBarrier;

JCSP limitations

- Concurrency model different from CSP's concurrency model;
- Partial implementation of the Communication primitive: JCSP channels only communicate one value at most;
- Multi-synchronisation without communication;
- External choice without alting processes;

JCircus' definition

Java application that translates Circus specifications into Java code;

JCircus' modules

- Parser
- Typechecker
- Pre-processor
- Translator

JCircus' initial screen

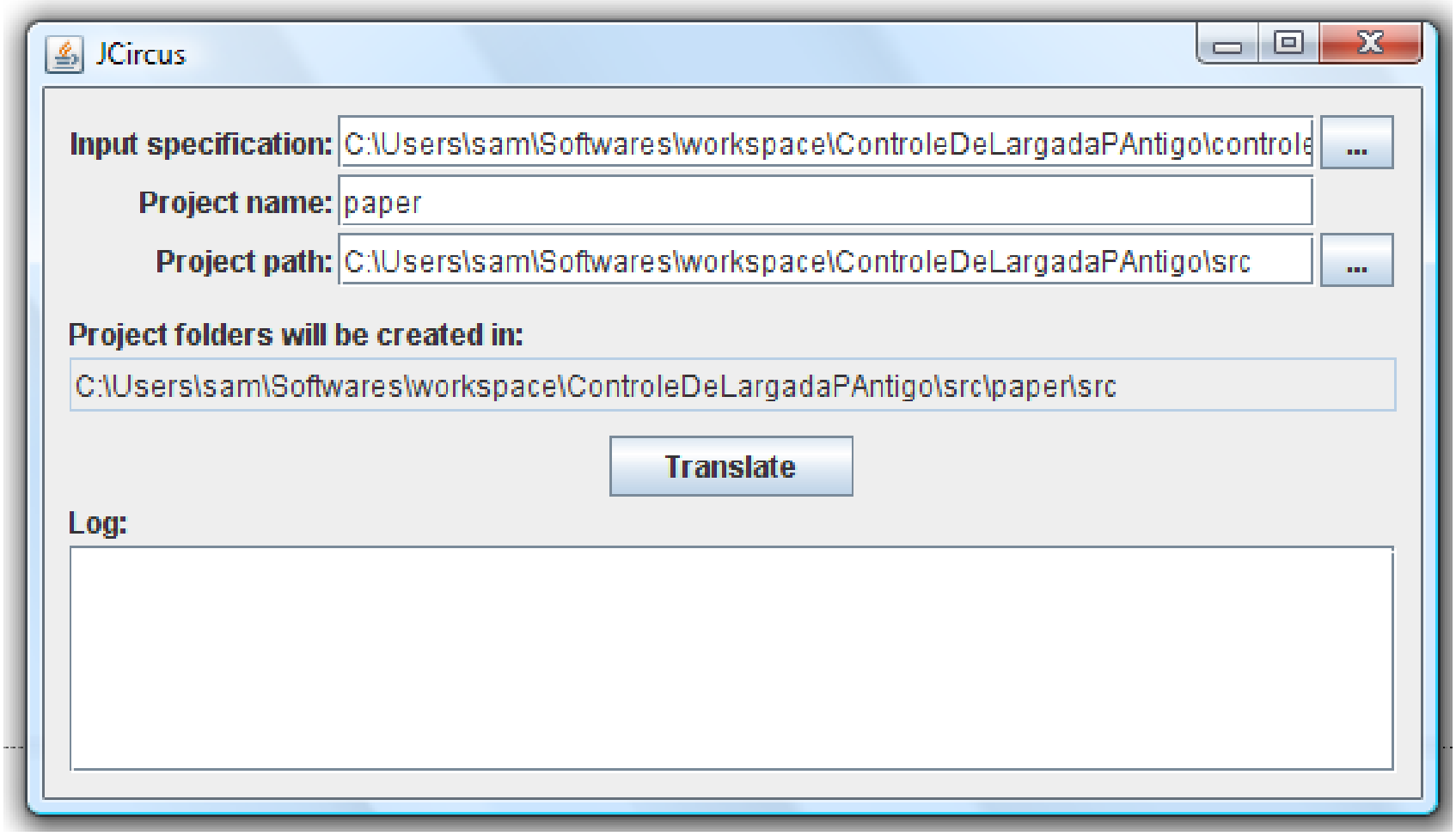


Figure : JCircus' initial screen

Extensions provided to JCircus

- Optimized Multi-synchronisation;
- Complex communications;
- Alphabetized parallelism;
- Deadlock-free GUI;
- Integration with CRefine;

Optimized Multi-synchronisation

- Protocol x Alting Barriers;
- Use of alting barriers;

Complex communications :: Definition

- Simple communication x Complex communication;
  $ch?x?y$ is a complex communication;
  $ch.5?x$ and $ch!4!7$ are not complex communications;
- JCSP does not implement communications with more than one field

Complex communications :: Strategy

- Expansion of the possibilities of communication;
- Assignment of the values to the input variables;
- Inference of the next action based on the chosen communication (in the case of an external choice);

Complex communications :: Strategy

$$\{0, 1\} \times \{0, 1, 2, 3\}$$

$$c_1?x?y \rightarrow A_1(x, y) \Box c_2?x?y \rightarrow A_2(x, y)$$

$$\{0 \mapsto \{x \mapsto 0, y \mapsto 0\}, \ldots, 7 \mapsto \{x \mapsto 1, y \mapsto 3\}\}$$

$$\{0 \mapsto 0, \ldots, 7 \mapsto 0, 8 \mapsto 1, \ldots, 15 \mapsto 1\}$$

Figure : Example

Alphabetized Parallelism

- Hoare's parallelism x Alphabetized parallelism
- JCSP: implements Hoare's parallelism;
- Circus: Parallelism is alphabetized;
- Challenge: To force interleaving between occurrences of common events;

Alphabetized Parallelism :: Translation

The strategy uses channel renaming, and consists of the following steps:

- Identification of the parallel branches;
- Construction of the synchronisation sets;
- Defining the renaming of each parallel branch;
- Renaming processing;
- Hiding the renaming from the interface;

Alphabetized Parallelism

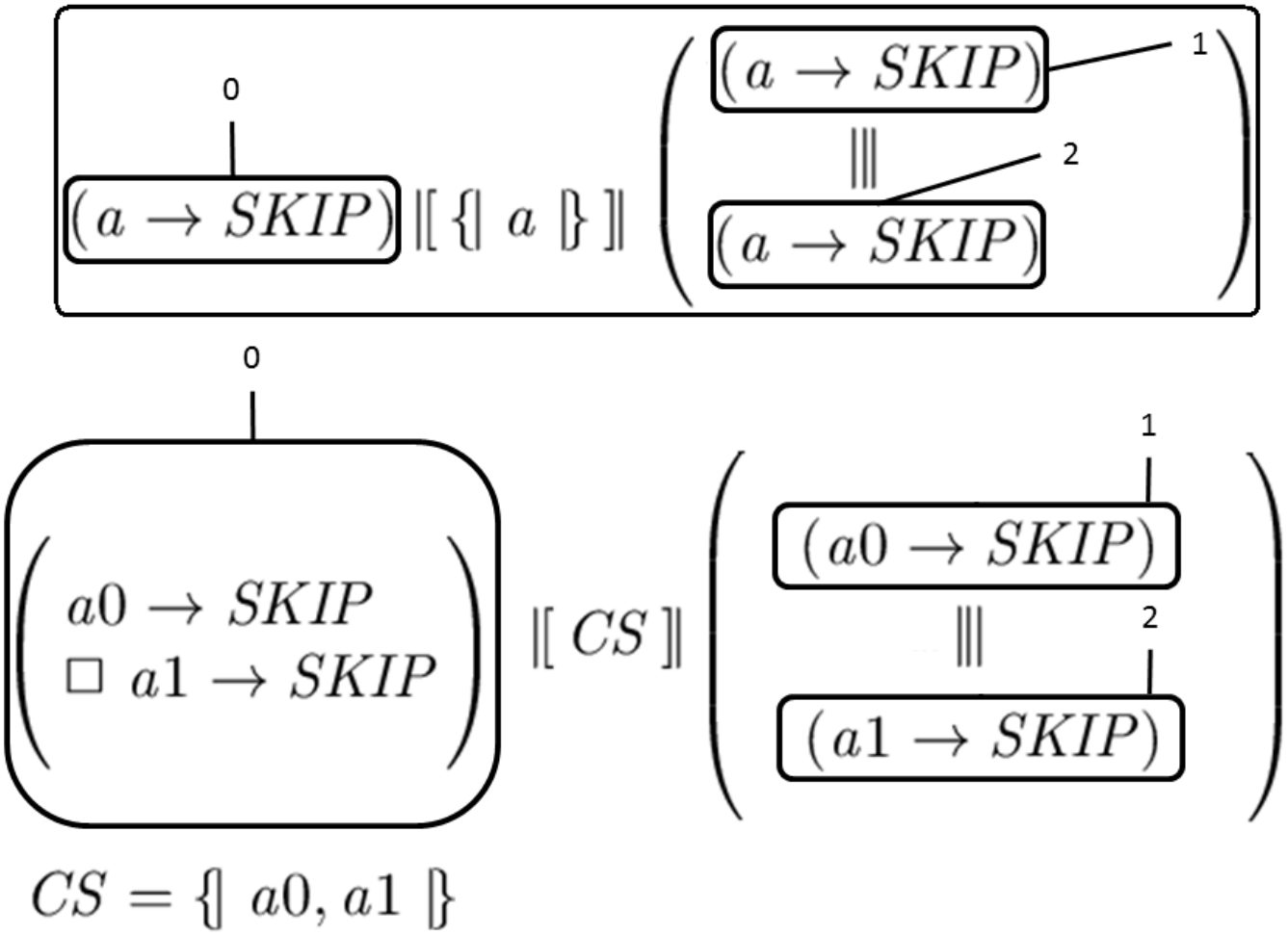


Figure : Example

Deadlock-free GUI

- For each process generated in JCSP, it is generated, also in JCSP, a GUI that interacts with it;
- There was a strategy for generating a GUI in the original version of JCircus, but it was not deadlock-free;

Deadlock-free GUI

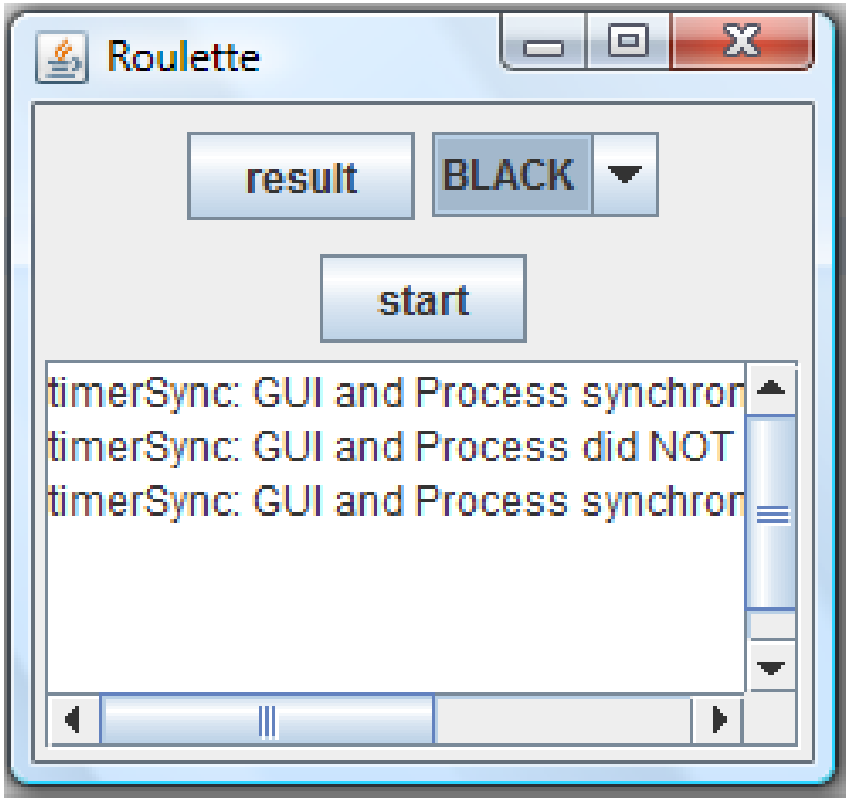


Figure : Example

Integration with CRefine

- CRefine is a tool that automates the application of laws to refine specifications;
- The integration demanded the migration of JCircus to CZT's newest parser of Circus;

Integration with CRefine

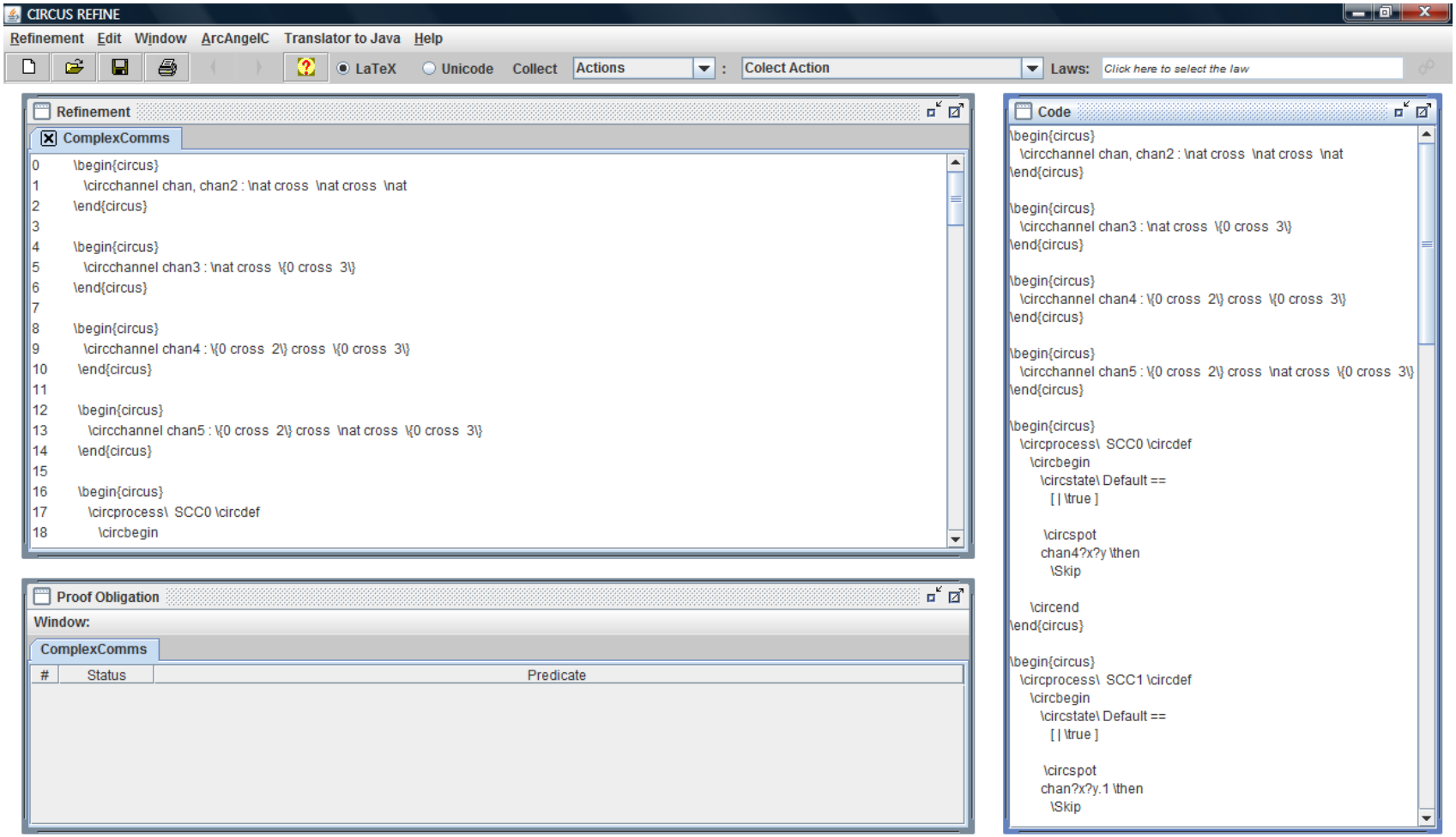


Figure : Example

Multi-synchronisation

Number of Processes	Translation (ms)		Execution (ms)		Memory (KB)	
	Protocol	Barriers	Protocol	Barriers	Protocol	Barriers
3	257	115	157,8	106,4	11276	14732
4	314	130	170,8	98	11232	14568
5	254	143	152,8	97,8	11208	14520
30	1764	344	307,3	136,6	11228	15636
100	7052	17949	548,6	378	11692	19680

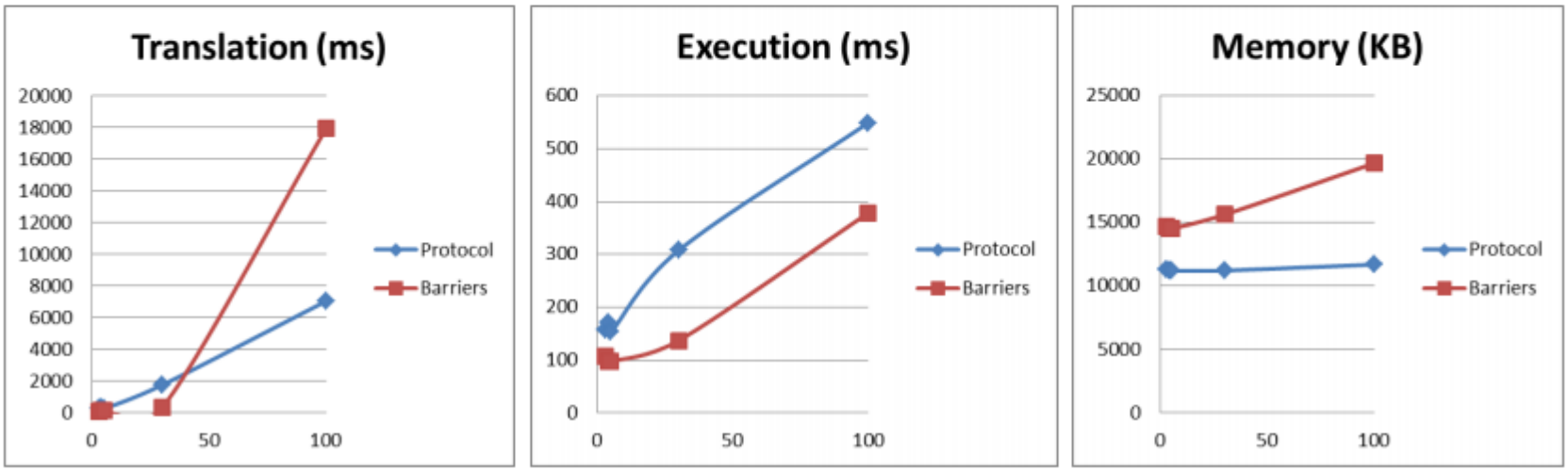
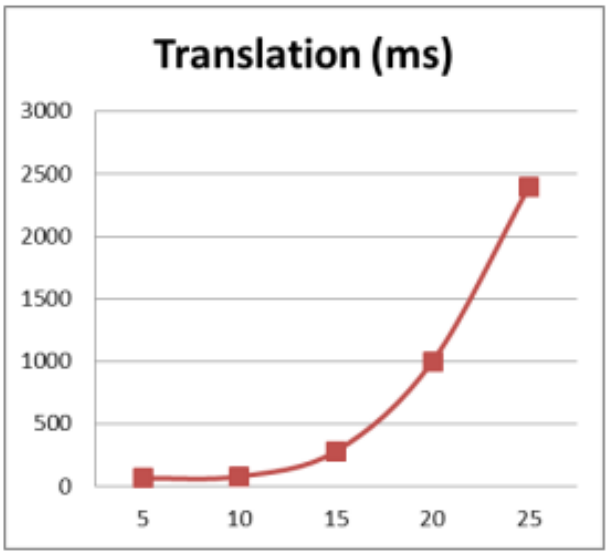


Figure : Example

Complex Communications

Type Size	Translation (ms)	Memory (KB)
5	68	0,78
10	83	0,94
15	285	1,09
20	1004	1,25
25	2403	1,38



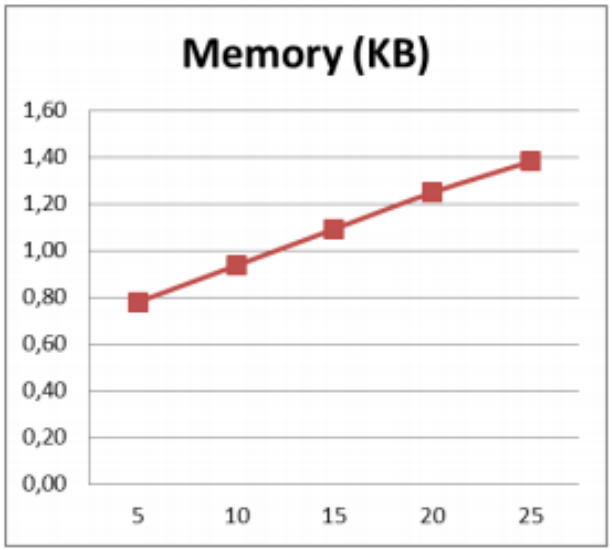
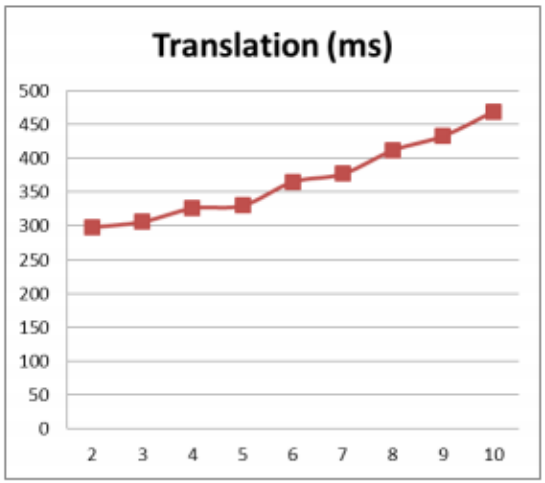


Figure : Example

Alphabetized Parallelism

Number of Processes	Translation (ms)	Execution (ms)	Memory (KB)
2	298	23	0,98
3	306	22	1,25
4	326	21	1,52
5	330	26	1,78
6	365	25	2,05
7	377	26	2,31
8	412	28	2,58
9	433	25	2,84
10	469	29	3,11



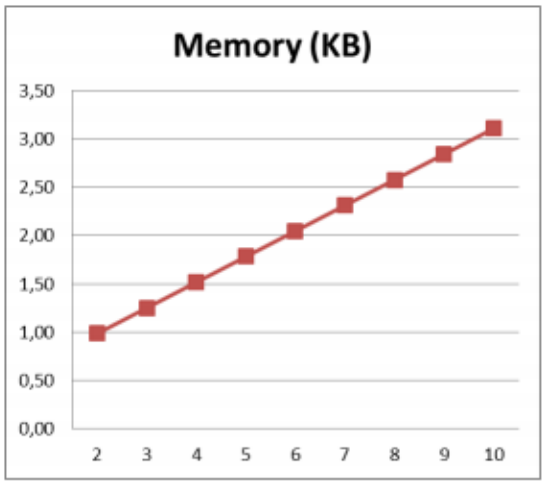


Figure : Example

Conclusions and Future Work

- Translation of Hiding;
- Translation of Schema types;
- Optimization of complex communications;

Questions?