On the Semantics of Distributed Compensations with Interruption

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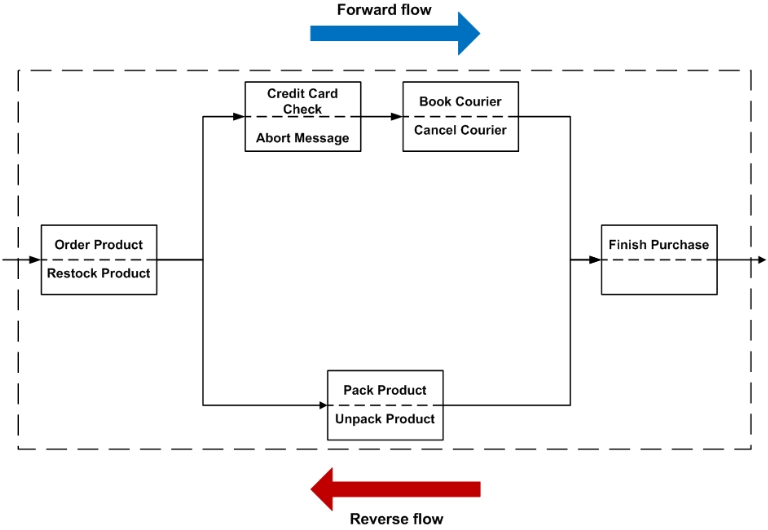
Service-oriented computing

- modular software solutions using services
- services
  - different functionalities, publicly available
  - combined into larger applications
  - loosely coupled
- open environment leads to unreliability
  - different components
  - communication middleware
- importance of reliable systems for the user
- system should be able to handle unexpected events

Long-running transactions

- ACID transactions (as in databases) not suitable for error handling in service oriented computing
- generalization: long-running transactions with "non perfect" rollback
- transaction split into smaller activities
- compensations to ensure consistency ("undoing" action)

Example for a long-running transaction



Formal approach

- different formal models
  - modeling various compensation policies
  - to prove properties of the system
- communication based approach
  - interaction between communication and error-handling
  - extending name passing calculi
  - c-join, webπ, dcπ, ...
- workflow based approach
  - control flow between components
  - cCSP, StAC, Sagas

Sagas / cCSP

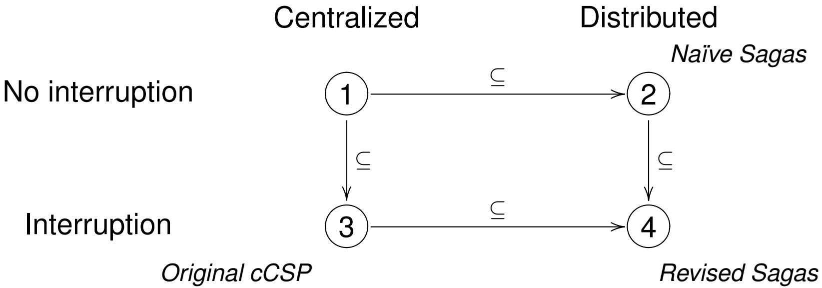
$$
\begin{array}{llcl}
(\textsc{Step}) & X & ::= & A \div B \ \mid \ \mathit{throw} \\
(\textsc{Process}) & P & ::= & X \ \mid \ P;P \ \mid \ P|P \\
(\textsc{Saga}) & S & ::= & \{[P]\} \ \mid \ S;S \ \mid \ S|S
\end{array}
$$

Overview of the semantics

- $A \div B$ (compensation pair): B installed if A is successful, executed in case of a later abort
- compensations of sequential activities are executed in reverse order
- four different policies for the parallel composition

Roberto Bruni, Michael J. Butler, Carla Ferreira, C. A. R. Hoare, Hernán Melgratti, and Ugo Montanari.
Comparing Two Approaches to Compensable Flow Composition.
In *CONCUR'05*, 2005.

Semantics in the literature



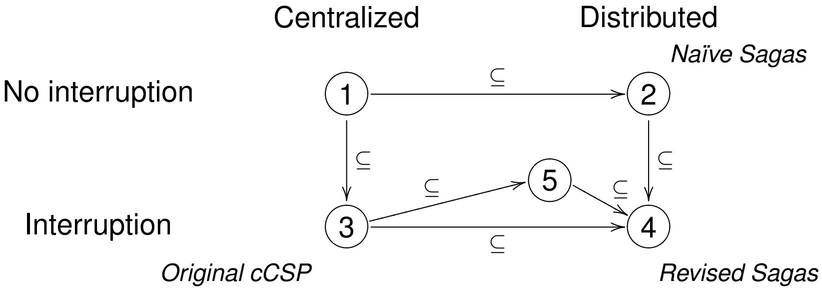
- strategies 1-3 too restrictive
- strategy 4 unrealistic

Example

- example term $\{[(A \div A'; B \div B')|(C \div C'; \mathit{throw}]\}$

1. no interruption, forward flow followed by compensations, $S_1 \equiv (AB|||C); (B'A'|||C')$
2. no interruption, interleaving of forward flow and compensations, $S_2 \equiv ABB'A'|||CC'$
3. interruption, forward flow followed by compensations, $S_3 \equiv CC' \cup (A|||C); (A'|||C') \cup (AB|||C); (B'A'||C')$
4. interruption, interleaving of forward flow and compensations, $S_4 \equiv CC' \cup AA'|||CC' \cup ABB'A'|||CC'$

Desirable trace

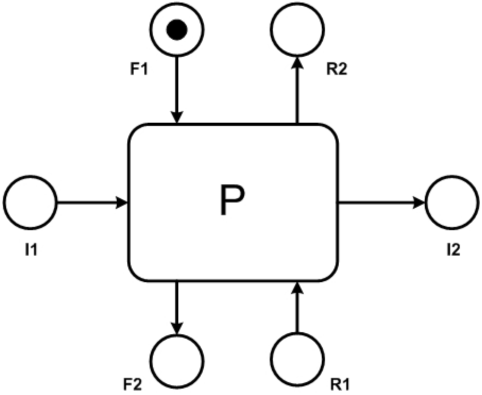


5. interruption, forward flow and compensations are only interleaved after the error occurred, $S \equiv S_3 \cup (CC'AA') \cup (AB|||CC'); B'A'$

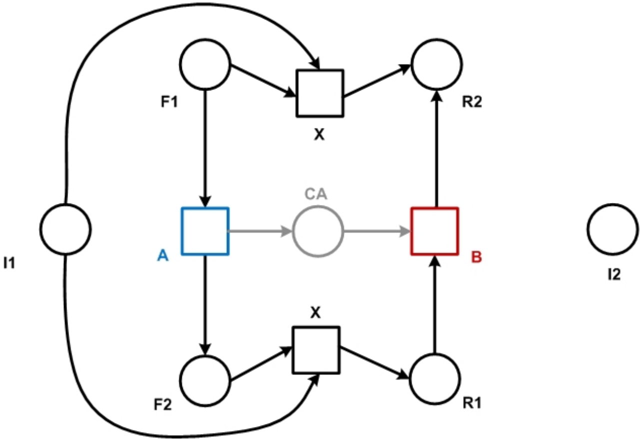
Our contribution

- define a new semantics (5), as liberal as possible but still realistic
- via encoding into Petri nets
- continuation passing style
- tokens to enable activities and send interrupt in case of an abort

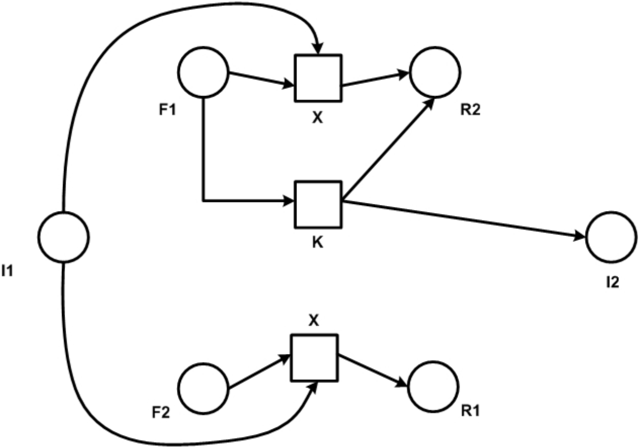
General process



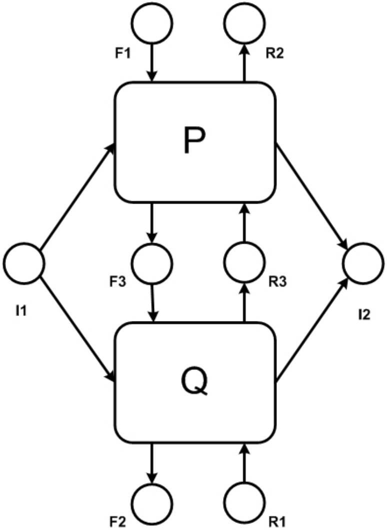
Compensation Pair $A \div B$



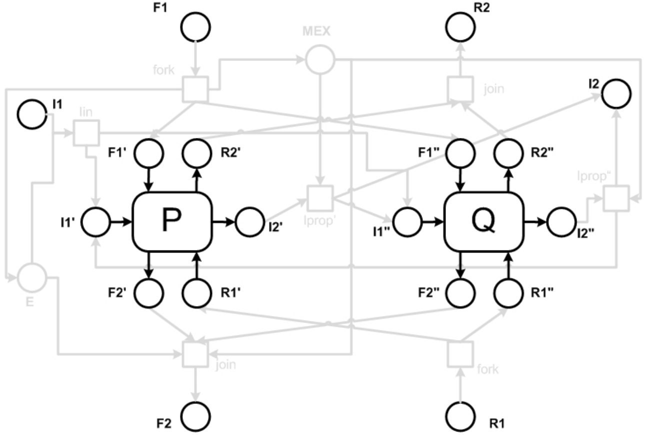
throw



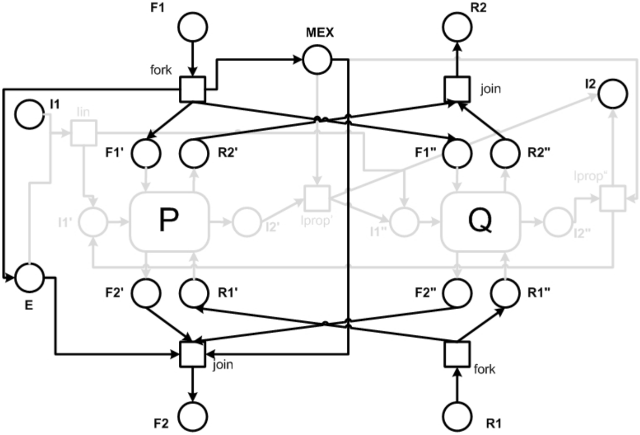
Sequential Composition



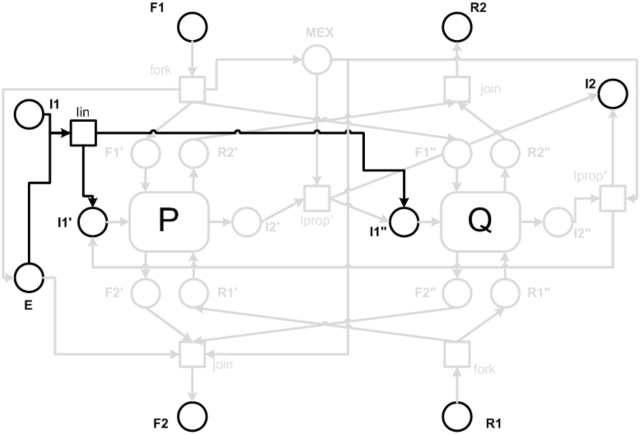
Parallel Composition



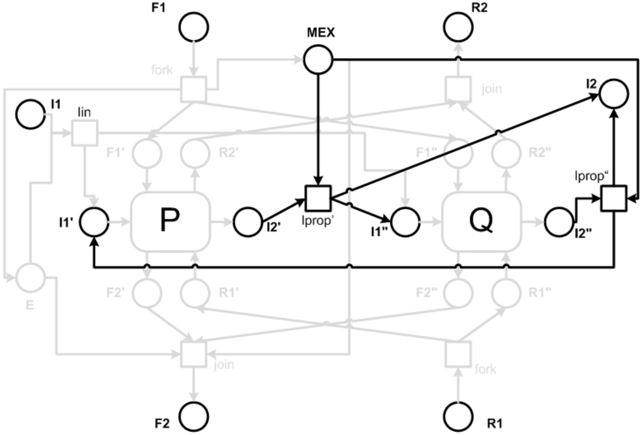
Parallel Composition



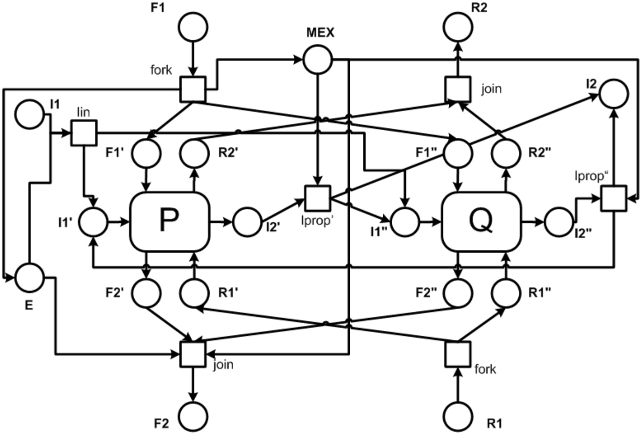
Parallel Composition



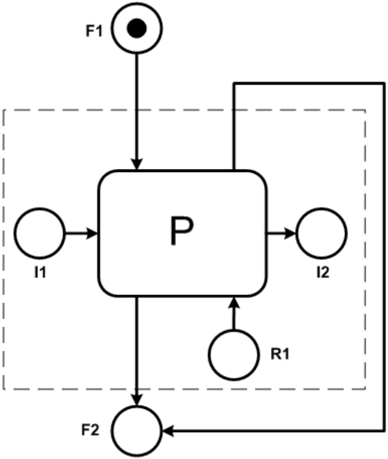
Parallel Composition



Parallel Composition



Transaction scope $\{[P]\}$



Expected Behaviour

- successful computation:
  - providing a token in $F1$ we will issue a token in $F2$
  - providing a token in $R1$ we will issue a token in $R2$
- aborted computation:
  - providing a token in $F1$ we will issue a token in $R2$ and $I2$
- interrupted computation:
  - providing a token in $F1$ and $I1$ we will issue a token in $R2$

Conclusions

- we defined a new realistic semantics for distributed Sagas with interruption
- ongoing and future work
  - denotational semantics and correspondence proof
  - definition in Maude
  - add nested transactions