BPEL2oWFN

Translating BPEL Processes into Open Workflow Nets
GNU BPEL2oWFN Version 2.0, 30 November 2006

User's Manual

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About this document:

This manual is for BPEL2oWFN, Version 2.0, a tool translating a web service described in BPEL into an open workflow net (oWFN), last updated 30 November 2006. This manual does not explain how to setup or install BPEL2oWFN. For this information please read the Installation Manual which is part of the distribution or can be downloaded from the website of BPEL2oWFN (`http://www.informatik.hu-berlin.de/top/tools4bpel/bpel2owfn`).

Tools 4 BPEL

BPEL2oWFN is part of the Tools4BPEL project funded by the Bundesministerium für Bildung und Forschung. See `http://www.informatik.hu-berlin.de/top/tools4bpel` for details.

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1 Overview

1.1 Introduction

BPEL2oWFN is a compiler translating a business processes expressed in BPEL (Business Process Execution Language for Web Services) [ACD+03] into an oWFN (open Workflow Net) [MRS05]. This oWFN can be used to:

- check controllability [Mar03, Wei04] with Fiona [Fiona],
- generate the operating guidelines [MRS05] with Fiona [Fiona],
- check for deadlocks, or
- check any temporal logic formula with several model checking tools [LoLA, MCK].

BPEL2oWFN uses static analysis to make the generated oWFN as compact as possible to analyze a chosen property. This is called *flexible model generation* (see Chapter 7 [Future Work], page 15).

BPEL2oWFN is the successor from BPEL2PN [SHS05], a Java-based compiler generating low-level Petri nets. BPEL2oWFN can be understood as a re-implementation for extensibility and performance issues. Its functionality is a superset of the functionality of BPEL2PN.[1]

BPEL2oWFN was written by Niels Lohmann, Christian Gierds and Dennis Reinert. It is part of the Tools4BPEL project funded by the German Bundesministerium für Bildung und Forschung. See `http://www.informatik.hu-berlin.de/top/tools4bpel` for details.

1.2 Translation Process

The translation process of the BPEL business process is performed in six steps which we describe briefly in this section:

1. **Lexical and syntactical analysis**. BPEL2oWFN parses the input process according to the specification of BPEL4WS version 1.1 [ACD+03]. All information about the process is collected in a symbol table for further use.
2. **Semantic analysis**. The input file is checked against the constraints of the specification, e.g. that each defined link has to be used as source and target exactly once. BPEL processes violating these constraints are rejected.
3. **AST generation**. For further analysis steps the exact syntax (indentation etc.) is not used any more. The input process is represented as an AST (abstract syntax tree). While generating the AST, the implicit transformation rules of BPEL (e.g. the presence of an '`otherwise`'-branch with an empty activity) are applied.
4. **Net generation**. The nodes of the AST are used to create the Petri net using the pattern database by applying 'unparse'-rules (rules associating each node with a pattern).
5. **Net optimization** (optional). To reduce the generated net several structural reduction rules can be applied, e.g. to merge sequences.
6. **Net output**. The generated Petri net can be exported in several file formats.

1.3 Concepts of BPEL2oWFN

In this section we describe the main concepts of BPEL2oWFN used to realize the translation. Reading this section is not necessary for using BPEL2oWFN, yet knowing the underlying algorithms and data structures not only helps to locate bugs, but also helps you to customize BPEL2oWFN or request a feature.

[1] In fact, BPEL2oWFN can simulate the behavior of BPEL2PN with a command-line parameter (see Chapter 2 [Invoking BPEL2oWFN], page 3).

1.3.1 Abstract Syntax Tree

The AST (abstract syntax tree) is an abstraction of the syntax tree generated while parsing the BPEL process: any unnecessary information (e.g. indention, brackets or other “syntax-supporting” elements) is omitted. It is the central data structure of BPEL2oWFN. The nodes of the AST are annotated with pointers to symbol table entries during the analysis steps. These annotations are used to select the most compact Petri net pattern from the pattern database to check a given property.

1.3.2 Pattern Repository

The idea of flexible model generation is to find the most compact model to check a given property. The patterns of the Petri net semantics of [Sta05] are designed to fit in any given context. However when the context is known some behavior modeled in the patterns (i.e. some of the nodes) can be safely removed without changing its semantics. BPEL2oWFN is designed to hold several sets of Petri net patterns each suitable in certain contexts. These patterns are collected in a pattern repository.

1.3.3 Petri Net Class

BPEL2oWFN provides many algorithms and data structures to build, represent, modify and simplify Petri nets and open workflow nets, resp. They are the interface between the pattern database and the file output for the model checking tool. The functions are collected in an extensible class allowing to add more output file formats, structural simplification rules (optimized to preserve certain properties such as deadlock freedom or liveness) or abstractions (e.g. abstraction from variables, abstraction from external behavior).

1.3.4 Control Flow Graph

Beside the dynamic analysis of the generated Petri net model with Fiona or classical model checking tools, BPEL2oWFN prototypically implements a control flow graph (CFG) (c.f. [Hei03]). This CFG can be used to check most of the constraints of the specification statically, i.e. without actually deploying and running the BPEL process. For example, the CFG can be used to check if each variable is initialized by an incoming message or an `<assign>` activity.

2 Invoking BPEL2oWFN

The standard invocation of BPEL2oWFN is:

```
bpel2owfn -i inputfile.bpel -f owfn -o
```

where '`inputfile.bpel`' is a BPEL process. The option '`-f owfn`' cause BPEL2oWFN to generate an open workflow net. This net is written to a file named '`inputfile.owfn`', because of the option '`-o`'. For more examples, see [Examples], page 5.

BPEL2oWFN can be called without any parameter. In this case, it acts as a simple parser for BPEL, that reads its input from the standard input (`stdin`).

2.1 Options

BPEL2oWFN supports the following command-line options:

'`--help`'
'`-h`' Print an overview of the command-line options and exit.

'`--version`'
'`-v`' Print version information and exit.

'`--input=`*`filename`*`.bpel`'
'`-i` *`filename`*`.bpel`'
Read BPEL input from file '*`filename`*`.bpel`'. If this parameter is omitted, input is read from standard input (`stdin`).

'`--output[=`*`filename`*`]`'
'`-o`' The generated files are written to a file called *filename*. If the short form is used or the *filename* is omitted, the input file name is taken and extended by the suffix of the chosen file format(s). If this parameter is omitted, the output is passed to the standard output (`stdout`).

'`--log[=`*`filename`*`]`'
'`-l`' All additional information like warnings and processing information are written to a file called *filename*. If the short form is used or the *filename* is omitted, the output file name is taken and extended by the suffix '`.log`'. If this parameter is omitted, the information is passed to the standard error output (`stderr`).

'`--debug=1-4 | flex | bison`'
'`-d 1-4 | flex | bison`'
This option triggers different debug levels, and can enable additional information from Flex and Bison about how the input is lexed and parsed.

'`--bpel2pn`'
This option makes BPEL2oWFN behave like its predecessor, BPEL2PN: it generates a Petri net LoLA format and an information file. The option '`--bpel2pn`' is a shortcut for '`--mode=petrinet --format=lola --format=info --output`'.

2.1.1 Modes

When invoking BPEL2oWFN several modes are possible.

'`--mode=`*`modus`*'
'`-m` *`modus`*'
BPEL2oWFN supports four different modes for handling BPEL, so '*`modus`*' can be one of the following options:

'ast' Outputs the AST (abstract syntax tree) generated while parsing the input file to standard output. This option is mostly used for debugging reasons since it shows the implicit transformations and the phylum names used when generating the Petri net.

'cfg' For control flow analysis (a form of static analysis) a CFG (Control Flow Graph) is generated. It can be printed in graphical (dot) representation. This option is in an early beta-stage and can only check for uninitialzed variables yet. For more information, see Chapter 7 [Future Work], page 15.

'petrinet'
Generates a Petri net representing the semantics of the given process. Other options can be added to simplify or modify that generated Petri net (see below).

'pretty' Outputs the parsed BPEL file in XML representation. Any unnecessary attributes are omitted. This option is mostly used for debugging reasons as it shows the implicit transformations and the identifiers of the BPEL constructs.

Please note that you can only use at most one mode.

2.1.2 Additional parameters

These options control some Petri net-related options. See Chapter 5 [Petri Net-related Functions], page 13 for more details.

'--parameter=*par*'
'-p *par*'

'cycliceh'
When the parameter is set, the pattern for the message event handler is cyclic as depicted in Fig. 30/31 of [Sta05]. If the parameter is not set (standard case), the pattern is acyclic: the activity embedded in the event handler is executed at most once, depended on the incoming messages.

'cyclicwhile'
When the parameter is set, the pattern for the `<while>` activity is cyclic as depicted in Fig. 18 of [Sta05]. If the parameter is not set (standard case), the pattern is acyclic: the activity embedded in the `<while>` activity is at most executed once, chosen non-deterministically.

'finalloop'
Add an extra loop transition to the final place of the generated Petri net to live-lock the system in order to find deadlocks.

'nofhfaults'
With this parameter, standard faults may not occure in activities directly nested in a fault handler.

'nostandardfaults'
When the parameter is set, only used-defined faults using the `<throw>` activity can occur.

'novariables'
Removes places of the generated Petri net modelling variables as well as the place modelling the system clock.

'simplify'
: Structurally simplify the generated Petri net.

If you want to enable more than one parameter you have to add '-p'/ '--parameter' to each parameter.

2.1.3 Output formats

Especially for the Petri net mode, a variaty of output formats are supported, see Chapter 3 [File Formats], page 8 for more information. There are invoked by the following option:

'--format=*fileformat*'
'-f *fileformat*'

- 'apnn' Create a Petri net in APNN (Abstract Petri Net Notation). Implies the mode 'petrinet'.
- 'dot' Create a dot representation of the structure generated in the current mode which can be any kind of Petri net (mode 'petrinet' or the control flow graph (mode 'cfg').
- 'info' Create an additional information file. Implies the mode 'petrinet'.
- 'lola' Create a LoLA place/transition net. Implies the mode petrinet.
- 'owfn' Create a low-level oWFN in Fiona file format. Implies the mode 'petrinet'.
- 'pep' Create a Petri net in low-level PEP notation. Implies the mode 'petrinet'.
- 'pnml' Create a PNML Petri net. Implies the mode 'petrinet'.
- 'xml' Create an XML (Extensible Markup Lanuage) file. Implies the mode pretty.

If you want to use more than one output file format you have to add '-f'/ '--fileformat' to each file format. Please note that the underlying modes of the given file formats are the same, i.e. you cannot create XML and LoLA files together since XML uses the mode 'pretty' whereas LoLA uses the mode 'petrinet'.

2.2 Examples

In this section we show some examples how BPEL2oWFN can be invoked.

'bpel2owfn -i sample.bpel -flola -finfo -o -p simplify'
: Reads the file 'sample.bpel', generates a structural simplified low-level Petri net and saves it in a LoLA file 'sample.lola'. For further information a file 'sample.info' is generated.

'bpel2owfn -i sample.bpel -fowfn -d3 -o'
: Reads the file 'sample.bpel', generates a low-level open workflow net and saves it in an oWFN file 'sample.owfn'. For further information a file 'sample.info' is generated. During the conversion several debug messages are printed to standard output.

'*prog* | bpel2owfn -fdot -m petrinet | dot -Tpng -osample.png'
: Runs the program *prog* and reads its output as BPEL process, generates a Petri net and outputs its Dot representation. This stream is read by Dot which layouts the Petri net and creates an output PNG (Portable Network Graphic) file 'sample.png'.

'bpel2owfn -i sample.bpel -m ast'
: Reads the file 'sample.bpel' and prints the abstract syntax tree (AST) to standard output.

2.3 Exit Values

When BPEL2oWFN is invoked and run without any error, the exit value is 0.

0 **No error.** The input file could be correctly opened, parsed and the output file(s) could be generated without any error.

1 **Lexical or syntax error.** This error occurs while lexing or parsing the input file. It is thrown by the lexer or the parser, resp. Usually the 'source' of the error (i.e. the filename and line number) is indicated together with the unexpected (last read) and expected token.

An example:

```
Error while parsing

syntax error, unexpected X_SLASH, expecting X_OPEN
Error in 'example.bpel' in line 12:
  token/text last read was '/'
```

Please note that the indicated position (i.e. the line number) may be fuzzy — it should be understood as a hint to the erroneous line.

2 **'File not found' exception.** The given input file was not found resp. could not be opened.

An example:

```
An error has occurred while parsing "example.bpel"!

Exception #2 occurred!

   File 'example.bpel' not found.
```

3 **'File could not be opened' exception.** An output file could not be opened for write access. You may check the appropriate for the target directory or the file if it already exists.

An example:

```
An error has occured while parsing "example.bpel"!

Exception #3 occured!

   File "example.dot" could not be opened for writing access!
```

10 **Option mismatch.** The given command-line options cannot be processed together.

An example:

```
An error has occurred while parsing "example.bpel"!
An error has occured while parsing "<STDIN>"!

Exception #10 occured!

   Choose only one mode

 Additional information:
   Type ./bpel2owfn -h for more information.
```

30 **'Dynamic cast error' exception.** While building an internal scope tree an unexpected error has occurred.

40 **Node not found.**

41 **'Node already defined' exception.** While generating the Petri net a node was found having a history entry covered by another node before.

An example:

```
An error has occurred while parsing "example.bpel"!

Exception #41 occurred!

   Place with role '1.internal.final' already defined.
```

42 **'Merging error' exception.** While generating the Petri net an error occurred while merging two nodes. It happens either when one of the nodes was not found or one of the nodes is a guarded transition—the merging of guarded transitions is not yet supported.

43 **'Arc error' exception.** While generating the Petri net an error occurred while adding an arc to the net. It happens either on type errors — i.e. an arc between two transitions (or two places, resp.) should be drawn — or when the source or target node of an arc was not found.

Please report the occurrence of any exception with numbers 30–50 since it indicates a bug in BPEL2oWFN we would like to fix immediately (see [Reporting Bugs], page 14).

3 File Formats

BPEL2oWFN can generate several file formats:

3.1 Petri Net File Formats

These file formats output the generated Petri net model to various Petri net file formats to support as much model checking and analysis tools as possible. The nodes of the Petri net are named using the internal (numeric) names generated by BPEL2oWFN. For more information on the node naming conventions of BPEL2oWFN, see [Naming Conventions], page 8.

In all file formats, the inital place of the process, the process clock and all variable places are initially marked.

LoLA place/transition net
: A (low-level) place/transition net as described in [LoLA]. The first entry of the history of each node is added as a comment.

oWFN in Fiona format
: An open workflow net is a Petri net with an *interface*, i.e. two sets of places: *input places* and *output places*. Additionally an open workflow net has a set of final markings. To represent oWFNs the LoLA format was extended to implement this categorization.

Petri Net Markup Language (PNML)
: A (low-level) place/transition net in Petri Net Markup Language as described in [WK02]. An '*arcname*' value is just added to meet the syntactic requirements and is just an enumeration of the arcs ('a1', 'a2', . . .).

Abstract Petri Net Notation (APNN)
: A (low-level) place/transition net in Abstract Petri Net Notation as described in [BKK95]. An '*arcname*' value is just added to meet the syntactic requirements and is just an enumeration of the arcs ('a1', 'a2', . . .).

Low-level PEP Notation
: A (low-level) place/transition net in low-level PEP (Programming Environment based on Petri Nets) notation as described in [PEP].

3.2 Info-files

The Info-files are generated when any command-line option is used which imply Petri net-generation. When reading from a file '`process.bpel`' a file '`process.info`' is generated. This file sums up all places and transitions together with their internal (numeric) name and their complete history:

```
PLACES:
ID  TYPE        ROLES
a list of places

TRANSITIONS:
ID      ROLES
a list of transitions
```

These files are generated to document the connection between the generated output file and the chosen Petri net patterns. In future distributions of BPEL2oWFN the Info-files will be used to annotate witness and counter-example paths, resp. and to "re-translate" Petri net properties (e.g. a dead transition) to the input BPEL process.

3.2.1 Naming Conventions

BPEL2oWFN generates the output Petri net by creating and merging parameterized patterns of the Petri net semantics defined in [Sta05]. Due to merging and simplifying the Petri net nodes "belong" to more than one pattern. For example, in a sequence the initial place of the sequence and the initial place of its first activity are merged so that the final Petri net contains one place with two *roles*.

The roles of each place are collected during the Petri net generation. They form the *history* of the node. It is used to locate errors of the modeled business process: If, for example, BPEL2oWFN generates a Petri net of a business process and the model checker LoLA finds a dead transition, its history helps to find which BPEL constructs are affected and in this case will never be executed.

The roles are named using the following conventions:

- Each BPEL activity has been assigned an identifier during the syntactic analysis of the input process. Each node added to the Petri net from the Petri net pattern of that activity begins with that identifier.

  For example, BPEL's activity process has the identifier '`1`', so that all nodes of the process pattern begin with '`1.`'. To find out the identifiers of a given process use the '`--xml`' command-line option which prints the id of each activity as an XML attribute.
- In most cases each BPEL activity can be source or target of links. The semantics defined in [Sta05] organizes this link concept by several wrappers. For an activity with the identifier *id* the nodes of the wrapper begin with '*`id.`*' whereas the nodes of the actual activity begin with '*`id`*`.internal.`'.
- The roles of nodes of the stop pattern of a process or scope with identifier '*`id`*' begin with '*`id`*`.internal.stop.`'.

  The same schema is used for fault handlers ('*`id`*`.internal.faultHandler.`'), compensation handlers ('*`id`*`.internal.compensationHandler.`') and event handlers ('*`id`*`.internal.eventHandler.`'), resp.
- Labels (e.g. '`initial`') in a figure of [Sta05] are appended to the id string (e.g. '*`id`*`.internal.initial`'). If both numeric (e.g. '`p1`') and textual (e.g. '`initial`') labels are depicted in a figure, the latter is used.
- The labels of fault-throwing transitions also contain the last place of the positive control flow: If, for example, a reply activity throws a fault, the fault-throwing transition reads from the place labeled '*`id`*`.internal.running`' and is labeled '*`id`*`.internal.throwFault.running`'.
- In parameterized patterns (e.g. an assign activity or all structured activities) the labels of the figures of [Sta05] are trailed by an numeration (e.g. '*`id`*`.internal.copy.`*`number`*`.running`').

3.3 Dot Graphics

To bugfix[1] the implemented Petri net patterns BPEL2oWFN implements a graph representation of the generate Petri net. Furthermore, the CFG can be printed as dot output.

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[1] The Petri nets usually have a large number of nodes so that the graphical representation of a 'real world' process would not be suitable to process, read or understand. That is why the Dot output shall be seen as a means to debug small patterns.

4 Petri Net Patterns

In version 2.0 of BPEL2oWFN the following Petri net patterns are implemented:

4.1 Petri net semantics from [Sta05]

The Petri net semantics for BPEL4WS from Christian Stahl (Humboldt-Universität zu Berlin) published in [Sta05].

4.1.1 Overview

Feature complete semantics covering both positive control flow with event handling and negative control flow (fault and compensation handling).

4.1.2 Limitations of the semantics

- Only one instance of a BPEL process can be transformed into a Petri net.
- The semantics abstracts from the connection of a BPEL process to its partner processes. The interface of a BPEL process is transformed into a set of message channels, i.e. places in the Petri net.
- In our Petri net patterns we model data, but we abstract from the definition of the functions which edit the data. Furthermore, we did not specify the transition guards and so we did not specify which circumstances are necessary that a specific fault can occur.
- Every activity is limited to one correlation set (except the synchronous invoke which is limited to two correlation sets).

4.1.3 Changes and Modulation

We tried to stick as close to the Petri net patterns of [Sta05] as possible. However, the implemented patterns in the pattern database sometimes differ to the given patterns due to discovery of bugs or implementation decisions. In this subsection we sum up these changes to help you understand the generated Petri net model.

- **Fault model**. At most one error can occur in the positive control flow of each scope or process. Yet this confines the possible runs of the process it is only a little change of the semantics, since — according to the specification — only the first fault is handled anyway. While further faults occurring before the positive control flow is stopped are ignored in the original semantics of [Sta05] (in fact, the faults are collected on place '`fault_in`' and then consumed by a reset arc) they are prevented in the implemented semantics. In our model, exactly the *first* occurring fault is handled, whereas in [Sta05] one fault is chosen non-deterministically.

  Furthermore, all '`failed`' places of the activities were removed. In the original Petri net semantics, all faults of a scope were collected on the '`fault_in`' of the stop-pattern and then classified as being the first fault of the scope, a following fault, a fault from the fault handler, a fault from the compensation handler, or a fault from a child scope. In our implementation, new places ('`fh_fault_in`' and '`ch_fault_in`') were introduced and each activity throws its faults to the "correct" place automatically.

  To ensure that at most one error can occur (i.e. at most one token is produced on any fault place) the fault places are guarded by state places: To throw a fault from an activity enclosed in a scope, the state of that scope has to be '`Active`'. The first thrown fault changes the state to '`!Active`' thus preventing more faults to occur. The places '`fh_fault_in`' and '`ch_fault_in`', resp. are guarded by '`!FHFaulted`'/'`FHFaulted`' and '`!CHFaulted`'/'`CHFaulted`', resp.

  Moreover, the generated Petri nets have less nodes than those generated by BPEL2PN [SHS05] since an unfolding of the reset arcs in not necessary any more.

- **Standard faults**. The "throw-fault" and "stop" transitions are generated using parametrized functions. With the command-line parameter '`--parameter=nostandardfaults`' all BPEL standard faults that can occur in the activites (i.e. all faults except user-defined faults in a throw activity or join failures) are suppressed. The generated models have a smaller state space and allow the analysis for controllability which is impossible without the assumption that messages can always be sent faultlessly.

  In order not to suppress standard faults at all, the command-line parameter '`--parameter=nofhfaults`' can be used to allow standard faults outside fault handlers, i.e. to create models that allow the occurrence of one standard fault in each scope yet disallow to occurrence of further faults.
- **1-safety**. The new modeling of the fault management yields to 1-safe Petri nets (i.e. any reachable state of the Petri net model puts at most one token on each place of the net).

  Beside performance (e.g. only 1 bit is needed to store the marking of a place) and compatibility issues (e.g. 1-safety is a prerequisite to use the Model-Checking Kit [MCK]), features not supported by the Petri net semantics can be discovered since the generated net will most likely violate 1-safety when an unsupported BPEL feature is used. If, for example, a scope is enclosed in a while loop (which would model instantiation which is not supported by the Petri net semantics [Limitations of the semantics], page 10), the state places of that scope would not be 1-safe.
- **Assign activity**. All copy branches of an assign activity are modeled in a single pattern (i.e. Fig. 6 and Fig. 7 are merged). Furthermore, when an error (outside that activity) occurs, an active assign-activity is not stopped until all copy branches have finished. This is described in [ACD+03] as:

  > The assign activities are sufficiently short-lived that they are allowed to complete rather than being interrupted when termination is forced.

  This change fixes a bug in the Petri net semantics.
- **While activity**. Since the original semantics does not support instances of the BPEL process, while activities were poorly supported and usually produced non 1-safe Petri nets or deadlocks as links embedded in the while activity were evaluated incorrectly. In the implementation the while activity is acyclic: the embedded activity is now executed at most once (whether or not it is executed is decided non-deterministically).

  The "original" behavior can be restored with the command-line parameter '`--parameter=cyclicwhile`'.
- **Event handlers**. There is one pattern for both alarm and message event handlers (i.e. Fig. 29 and Fig. 30 are merged). When no event handler is specified, an "implicit" event handler is installed which is just a stub and does not change the semantics. The message event handlers are acyclic by default to create acyclic Petri net models. However, the "original" behavior can be restored with the command-line parameter '`--parameter=cycliceh`'.
- **Deadlocks**. A transition named '`1.internal.finalloop`' can be added to livelock the process upon completion using the command-line parameter '`--parameter=finalloop`'. This leads to deadlock-free Petri nets in case of processes with "reasonable" control flow and helps to find unwanted deadlocks occurring due wrong modeling. If, for example, the links of a process model are cyclic the generated Petri net will deadlock.

  In future versions of BPEL2oWFN these found deadlocks shall be mapped back into the BPEL code to highlight the "unreasonable" activities (i.e. a cycle-closing link).
- **Unfoldings of high-level places**. Due to the abstraction (high-level to low-level) of the patterns some places were unfolded: the place '`compScope`' of Fig. 42–44 usually holding a token with a name of a scope is unfolded to '`compScope.`*`scopename`*' and only merged with the '`ch_in`'-place of that respective scope. In all other cases the places are "converted" to low-level places so the generated model completely abstracts from data.

- **Link semantics**. The generated Petri net model always generates '`negLink`' places for structured activities independently of the presence of links. Anyway, the semantics is not changed since the resulting subnets are dead in this case.
- **Correlation sets**. Correlation sets are not implemented and are simply ignored during parsing.

5 Petri Net-related Functions

Currently implemented Petri net-specific functions:

5.1 Structural Simplification

- If two transitions t_1 and t_2 have the same preset and postset, one of them can be removed.
- If a transition has a singleton preset and postset, the transition can be removed (sequence) and the preset and postset can be merged.
- All places with empty preset and postset (isolated places) are removed.

These structural reduction rules are implemented in the command-line option '`--parameter=simplify`', see Chapter 2 [Invoking BPEL2oWFN], page 3. To acheive a better reduction, combine the parameter with '`--parameter=novarialbles`'.

5.2 Abstractions

- To obtain a place/transition Petri net from an open workflow net the communication places are removed. This abstraction from communicational behavior is used in all Petri net output formats except oWFN ('`--format=owfn`').
- The original Petri net semantics [Sta05] consists of high-level Petri net patterns. However, the models generated from BPEL2oWFN abstract from data. Therefore all transition guards, arc inscriptions and arc types were "converted" to low-level constructs: all transition guards and arc inscriptions were removed (decisions are now made non-deterministically) and read arcs are "unfolded" to loops. Due to a new fault management (see [Changes and Modulation], page 10) the patterns do not contain any reset arcs and is 1-safe.

5.3 Markings

The following places are initially marked to ensure a deadlock-free model of processes with "reasonable" control-flow (e.g. with an acyclic link structure):

- the initial place of the process ('`1.internal.initial`'),
- the variable places ('`variable.`*`variablename`*'), and
- the clock ('`1.internal.clock`') if the process embeds an alarm event handler or a `<wait>` activity.

6 Limitations and Bugs

6.1 Known Bugs

As this is the first public version of BPEL2oWFN the translation from a BPEL process to an open workflow net might be unstable or incorrect in some few scenarios:

- **Problem:** The original semantics of [Sta05] was created to support executable BPEL processes. Therefore the translation of abstract BPEL processes (business protocols) might throw an exception or even crash.

  Solution: Each communicating activity (i.e. `invoke`, `receive`, `reply`) should be defined with (input/output) variables.
- **Problem:** The parser of BPEL2oWFN is not capable of skipping XML elements originating other namespaces than '`bpws`'. Processes using these elements are rejected with a syntax error message.

  Solution: Try removing or commenting these elements.
- **Problem:** LoLA does not accept the generated files and reports parse errors in the first line.

  Solution: This problem occurs using a pre-compiled windows version of BPEL2oWFN. The generated files are in Windows format, yet LoLA only supports files in Unix format. To overcome this limitation of LoLA, use a tool like '`dos2unix`' or change the file format in an editor like vi.

6.2 Reporting Bugs

If you find a bug in BPEL2oWFN, please first check that it is not a known bug listed in 'Known Bugs'. Otherwise please send us an electronic mail to `nlohmann@informatik.hu-berlin.de`. Include the version number which you can find by running '`bpel2owfn --version`'. Also include in your message the input BPEL process and the output that the program produced. We will try to answer your mail within a week.

If you have other questions, comments or suggestions about BPEL2oWFN, contact us via electronic mail to `nlohmann@informatik.hu-berlin.de`.

6.3 Contact Person

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7 Future Work

For future releases of BPEL2oWFN the following features are planned:

- **Add data aspects**. In the implemented patterns we abstract from data and do not evaluate join or transition conditions. Instead all decisions are made non-deterministically. With static analysis it is possible to find the relevant ranges of values that allow a replacement of non-deterministic choices with choices made evaulating data. This technique (called *abstract interpretation*) might help to reduce the modelled behavior of the process yet being more precise.
- **Control flow analysis**. In [Hei03] a control flow graph for BPEL was introduced. This control flow graph (currently implemented prototypic) is the base for more sophisticated analysis, e.g. finding unreachable activities, uninitialized variables or other problems that can occur during runtime.
- **Detailed info-files**. The generated info-files currently just list the nodes of the generated net. To help the retranslation of Petri net-specific properties to the input process the generated files have to be more detailed. The integration of a symbol table is currently in pre-beta state and should be finished in the next version of BPEL2oWFN.
- **Support for WS-BPEL**. The specification of WS-BPEL (Web Service Business Process Execution Language) version 2.0 is in its final phase. As soon as the standardization is completed, WS-BPEL can be supported by BPEL2oWFN by overworking the grammar and adding appropriate patterns to the pattern database.

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