BPEL2oWFN

Translating BPEL Processes into Open Workflow Nets
GNU BPEL2oWFN Version 2.0.2, 15 June 2007

User's Manual

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About this document:

This manual is for GNU BPEL2oWFN, version 2.0.2, a tool translating a BPEL process into an open workflow net (oWFN), last updated 15 June 2007.

This manual does not explain how to setup or install GNU BPEL2oWFN. For this information please read the *Installation Manual* which is part of the distribution, or can be downloaded from the website of GNU BPEL2oWFN, `http://www.gnu.org/software/bpel2owfn`.

GNU BPEL2oWFN was developed during the Tools4BPEL project funded by the German Federal Ministry for Education and Research (BMBF), see `http://www.informatik.hu-berlin.de/top/tools4bpel` for details.

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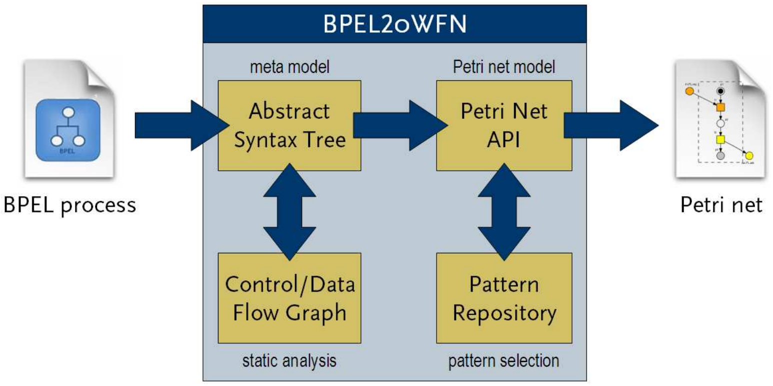
1 Introducing BPEL2oWFN

BPEL2oWFN translates a web service expressed in WS-BPEL (Web Service Business Process Execution Language) into an oWFN (open Workflow Net). This oWFN can be used to:

- check for *controllability* or generate the *operating guideline* using the tool Fiona[1],
- check for deadlocks or any other Petri net property, or
- check any temporal logic formula with a variety of model checking tools.



Furthermore, BPEL2oWFN can translate a BPEL4Chor choreography to a Petri net model. This model can be used to analyze properties of a complete choreography or to synthesize a fitting service for an incomplete choreography.

BPEL2oWFN uses static analysis to make the generated Petri net model as compact as possible to analyze a chosen property. This is called *flexible model generation*. Furthermore, several design flaws can be detected using control and data flow analysis.

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

1.1 Concepts of BPEL2oWFN

Input BPEL Process BPEL2oWFN can read BPEL processes compliant to the WS-BPEL 2.0 or the BPEL4WS 1.1 specification.

Abstract Syntax Tree The AST (abstract syntax tree) is the main data structure of BPEL2oWFN. The AST is annotated with information gained by static analysis.

Control/Data Flow Graph From the abstract syntax tree, a control/data flow graph is built. This graph is used to apply static analysis algorithms to gain information (e.g., dead code) about the process. These algorithms Furthermore, design flaws such as cyclic control links or conflicting receiving activities are detected.

[1] Fiona is available at `http://www.informatik.hu-berlin.de/top/tools4bpel`.

Petri Net API The annotated abstract syntax tree is used to generate a Petri net model of the BPEL process. All Petri net-related functions (adding, removing and merging of nodes; structural reduction) are provided by the Petri net API (application programming interface).

Pattern Repository For each BPEL construct, several patterns with different degrees of abstraction are stored in the pattern repository. Using the information gained by static analysis, the most abstract pattern applicable is used.

Output Petri Net The generated Petri net model can be exported to many file formats, such as PNML, LoLA, Fiona oWFN, INA, APNN, or PEP.

2 Invoking BPEL2oWFN

The standard invocation of BPEL2oWFN is:

```
bpel2owfn -i service.bpel -m petrinet -f owfn -o
```

where '`service.bpel`' is a BPEL process. The option '`-f owfn`' causes BPEL2oWFN to generate an open workflow net (option '`-m petrinet`'). This net is written to a file named '`service.owfn`', because of the option '`-o`'.

BPEL2oWFN can be called without any parameter. In this case, it acts as a simple parser for BPEL processes 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 a BPEL process from file '*`filename`*`.bpel`'. If this parameter is omitted, input is read from standard input (`stdin`). Wildcards such as '`process*.bpel`' are also allowed.

'`--wsdl=`*`filename`*`.wsdl`'
'`-w` *`filename`*`.wsdl`'
Read a WSDL file to support the translation.

'`--topology=`*`filename`*`.xml`'
'`-t` *`filename`*`.xml`'
Read a BPEL4Chor participant topology file to support the translation of BPEL4Chor choreographies. Can only be used with the '`choreography`' mode.

'`--output[=`*`filename`*`]`'
'`-o`' The generated output is 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`).

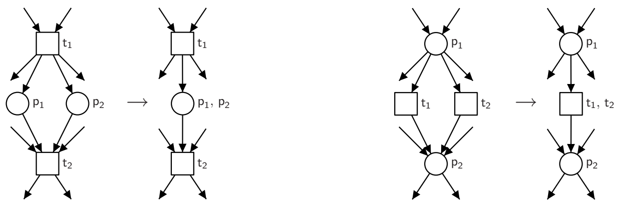
'`--debug=1-4 | flex | bison`'
'`-d 1-4 | flex | bison`'
This option triggers different debug levels, and can enable additional information from Flex and Bison about how the input is lexed and parsed.

Debug level:

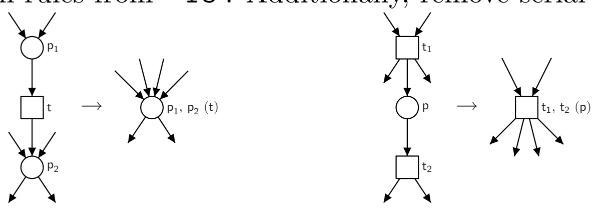
- ‘`0`’ When errors are found, only display the error code and skip additional information.
- ‘`1`’ No debug information, but display warning and error messages. Furthermore, detailled information about syntax errors are displayed.
- ‘`2`’ All messages from ‘`-d1`’. Additionally, information about the current steps is displayed.
- ‘`3`’ All messages from ‘`-d2`’. Additionally, the structure of the process is shown, i.e. when a Petri net is generated...
- ‘`4`’ All messages from ‘`-d3`’. Additionally, a message is displayed each time a function is entered or left.
- ‘`flex`’ Displays messages from Flex. Can be combined with any other debug level.
- ‘`bison`’ Displays messages from Bison. Can be combined with any other debug level.

‘`--reduce=0-5`’
‘`-r 0-5`’ Apply several structural reduction rules to the generated Petri net model (implies mode ‘`petrinet`’ or ‘`choreography`’). The rules preserve deadlocks, livelocks and all deadlock-free communicating partners. The rules are organized in reduction levels:

- ‘`0`’ No rules are applied (standard).
- ‘`1`’ Structural dead nodes are removed; that is, unmarked places with empty preset and transitions with a dead place in its preset are removed.
- ‘`2`’ All reduction rules from ‘`-r1`’. Additionally, unnecessary status places are removed. A status place is considered unnecessary if it has no outgoing arcs.
- ‘`3`’ All reduction rules from ‘`-r2`’. Additionally, identical nodes are merged. Two nodes are considered identical if their presets and postsets are equal:



- ‘`4`’ All reduction rules from ‘`-r3`’. Additionally, remove serial nodes:



- ‘`5`’ All reduction rules from ‘`-r4`’. Additionally, remove self-loop nodes.

2.1.1 Modes

When invoking BPEL2oWFN several modes are possible.

‘`--mode=`*`modus`*’
‘`-m` *`modus`*’
BPEL2oWFN supports different modes for handling input BPEL files: ‘*`modus`*’ can be one of the following:

‘`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. With the CFG, several design flaws of BPEL processes such as cyclic control links or read access to uninitialized variables can be detected statically. Furthermore, faulty constellations such as conflicting receiving activities can be found using the '`cfg`' mode.

'`choreography`'
: The '`choreography`' mode[1] is an extension of the '`petrinet`' mode. In the choreography mode, several BPEL processes can be parsed, and a Petri net model of their composition is generated.

  For examples, check '`test/bpel4chor`' directory. When combined with LoLA file output, an additional '`.task`' file is generated. With the help of this file LoLA can check for weak termination of the composition.

  Note that the choreography mode is only tested with the '`small`' mode. To support the translation of a BPEL4Chor choreography, a participant topology can be additionally parsed using the '`topology`' parameter.

'`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. This option is mostly used for debugging reasons as it shows the implicit transformations and the identifiers of the BPEL constructs.

At most one mode can be selected. If no mode is given, BPEL2oWFN acts like a plain BPEL parser; that is, the input file is read, but no output is generated.

2.1.2 Additional parameters

These options control some Petri net-related options.

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

'`small`'
: With the '`small`' parameter[2], only the communicational behavior of the input BPEL process is modeled. That is, the negative control flow (fault, termination, or compensation handlers, as well as `<exit>`, `<throw>`, `<compensate>`, `<compensateScope>` activities) is not translated to the Petri net model. When combined with '`reduce`', this parameter yields the most compact Petri net model.

'`fhfaults`'
: Confines the '`standardfaults`' parameter: in the negative control flow (in activities in fault handlers), no further BPEL standard faults can occur.

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[1] This mode was formally called '`consinstency`'.

[2] This mode was formally called '`communicationonly`'.

'nointerface'
: When creating a '.dot' file, no interface is printed.

'reduce'
: Apply all implemented structural reduction rules. This parameter is a shortcut for '-r5' and overrides any other defined reduction level.

'standardfaults'
: Model the occurrence of standard faults. When this parameter is ommited, only user-defined faults, that is, faults thrown with <throw> activities, and join failures can occur. With the 'standardfaults' parameter, also the occurrence of other BPEL standard faults is modeled. This parameter yields the most-detailled, and thus biggest Petri net model.

'variables'
: Add places for the variables of the input BPEL process to the Petri net model. As the generated model abstracts from data, that is, a low-level Petri net is generated, the 'variables' parameter also does not introduce data aspects. Thus, this mode is experimental.

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. There are invoked by the following option:

'--format=*fileformat*'
'-f *fileformat*'
: Creates a file in a given ouput file format. Each file format is only available in certain modes. If you want to use more than one output file format you have to add '-f'/ '--format' to each file format. Please note that the underlying modes of the given file formats are the same. You cannot, for example, create XML and LoLA files together since XML requires the mode 'pretty', whereas LoLA requires the mode 'petrinet'.

Petri net file formats (imply mode 'petrinet' or 'choreography'):

'apnn'
: Outputs the inner of the generated open workflow net in APNN (Abstract Petri Net Notation). When the parameter '-o' is used, a file with the suffix '.apnn' is created.

'ina'
: Outputs the inner of the generated open workflow net as untimed low-level Petri net in INA (Integrated Net Analyzer) format. When the parameter '-o' is used, a file with the suffix '.pnt' is created.

'lola'
: Outputs the inner of the generated open workflow net as low-level Petri net in LoLA (Low-Level Analyzer) file format. When the parameter '-o' is used, a file with the suffix '.lola' is created.

'owfn'
: Outputs the generated open workflow net in Fiona file format. Note that the Fiona file format is — together with the PNML file format — the only Petri net output format that outputs the complete open workflow net, that is, also

the interface is exported. When the parameter '-o' is used, a file with the suffix '.owfn' is created.

'pep' Outputs the inner of the generated open workflow net as low-level Petri net in low-level PEP notation. When the parameter '-o' is used, a file with the suffix '.llnet' is created.

'pnml' Outputs the generated open workflow net in PNML (Petri Net Markup Language). Note that the PNML file format is — together with the Fiona file format — the only Petri net output format that outputs the complete open workflow net, that is, also the interface is exported. Currently, the interface places are annotated using a `<type>` tag which is only supported by Yasper[3]. When the parameter '-o' is used, a file with the suffix '.pnml' is created.

'spin' Outputs the inner of the generated open workflow net as low-level Petri net in Promela (Process Meta Language) for the model checker SPIN. When the parameter '-o' is used, a file with the suffix '.spin' is created.

Other file formats (note the required mode):

'dot' When mode 'petrinet' is used, the generated open workflow net is printed in Graphviz dot representation. When mode 'ast' is used, the AST (abstract syntax tree) is printed in Graphviz dot representation. When mode 'cfg' is used, the CFG (control flow graph) is printed in Graphviz dot representation.

In any case, when the tool dot is found in the search path during configuration of BPEL2oWFN and the parameter '-o' is used, dot is used to generate a PNG (Portable Network Image) file. In this case, two files with the suffixes '.dot' and '.png' are created. Note that when the 'ast' mode is used with the 'dot' file format, the '-o' parameter has to be used.

'info' When mode 'petrinet' is used, information about the places and transitions of the generated net in a proprietary ASCII-based format. For each place and transition, all roles, that is, inscriptions of the Petri net patterns, are listed. The information can be used to correlate the generated Petri net model with the input BPEL process. When the parameter '-o' is used, a file with the suffix '.info' is created.

'xml' When the mode 'pretty' is used, the pretty-printed input BPEL process — with the implicit transformation rules applied – exported in XML (Extensible Markup Lanuage). When the parameter '-o' is used, a file with the suffix '.xml' is created.

2.2 Exit Values

0 No error occurred.

[3] Yasper is available at http://www.yasper.org.

1 A critical error occured; that is, a fault was detected that makes further processing impossible.

2 An input file could not be opened.

3 A syntax error in the input BPEL occurred. The input file cannot be further processed.

4 Any other error.

2.3 Examples

In this section we show some examples how BPEL2oWFN can be invoked. See Chapter 4 [File Formats], page 17 for more examples.

'`bpel2owfn -i sample.bpel -m petrinet -f lola -f info -o -p reduce`'
: Reads the file '`sample.bpel`', generates a structural reduced 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 -mpetrinet -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 -Tps -osample.ps`'
: Runs the program *prog* and reads its output as BPEL process, generates a Petri net and outputs its Graphviz dot representation. This stream is read by `dot` which layouts the Petri net and creates an output PostScript file '`sample.ps`'.

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

'`bpel2owfn -m choreography -i service1.bpel -i service2.bpel -f lola -o`'
: Reads the files '`service1.bpel`' and '`service2.bpel`' and creates a Petri net model of their composition. The result is written to the LoLA file '`service1_service2.lola`'. Furthermore, an analysis file '`service1_service2.task`' is written that can be processed by LoLA.

Further examples for invocations of BPEL2oWFN can be found in the '`tests`' directory of the source distribution.

3 Warnings and Error Messages

BPEL2oWFN performs several analysis steps on the input BPEL process. These messages are displayed during parsing and postprocessing of the process, and can be classified as follows:

- **Notices** do not report errors, but just give information about the translation process.
- **Syntax error messages** report problems during the lexical or syntactical analysis of the process. See Chapter 5 [FAQ and Known Bugs], page 21 for information about handling syntax errors.
- **Static analysis messages** occur when a test described in the WS-BPEL specification detects an error in the process. When such an error is found, a WS-BPEL processor must reject the process. If the process is an abstract process, the static analysis errors can be considered as warnings as abstract processes are not meant to be executed.
- **Warnings** report potential problems in the input process. The warned problem should be corrected to assure executability of the input process.
- **Errors** report problems that are explicitly mentioned in the WS-BPEL specification. They should be corrected to avoid runtime errors. Furthermore, problems can arise during the generation of a Petri net model.
- **Critical errors** make a further processing of the input process impossible and terminate GNU BPEL2oWFN immediately.

An example for a message is this:

```
CubeManagement.bpel:566 - [W00114]
variable 'waitResponse' used as 'variable' in <from> might be uninitialized
```

The first line contains the filename of the input process '`CubeManagement.bpel`' and the line number '`566`' of the displayed issue. The line number might be imprecise; that is, it might deviate up or down a few lines. After the line number, the error code is displayed. '`W00114`' stands for a warning with code 114. The detailed description of the messages can be suppressed with option '`-d0`'.

Further details can be taken from the table below.

Code	**Type**	**Description**
2	static analysis	A WS-BPEL processor MUST reject any WSDL portType definition that includes overloaded operation names.[1]
3	static analysis	If the value of `exitOnStandardFault` of a `<scope>` or `<process>` is set to `"yes"`, then a fault handler that explicitly targets the WS-BPEL standard faults MUST NOT be used in that scope.
6	static analysis	The `<rethrow>` activity MUST only be used within a faultHandler (i.e. `<catch>` and `<catchAll>` elements).
5	static analysis	If the `portType` attribute is included for readability, in a `<receive>`, `<reply>`, `<invoke>`, `<onEvent>` or `<onMessage>` element, the value of the `portType` attribute MUST match the `portType` value implied by the combination of the specified `partnerLink` and the role implicitly specified by the activity.

[1] The descriptions for static analysis messages are taken from Appendix B of the WS-BPEL specification.

7	static analysis	The `<compensateScope>` activity MUST only be used from within a `faultHandler`, another `compensationHandler`, or a `terminationHandler`.
8	static analysis	The `<compensate>` activity MUST only be used from within a `faultHandler`, another `compensationHandler`, or a `terminationHandler`.
15	static analysis	To be instantiated, an executable business process MUST contain at least one `<receive>` or `<pick>` activity annotated with a `createInstance="yes"` attribute.
16	static analysis	A `partnerLink` MUST specify the `myRole` or the `partnerRole`, or both.
17	static analysis	The `initializePartnerRole` attribute MUST NOT be used on a partnerLink that does not have a partner role.
18	static analysis	The name of a `partnerLink` MUST be unique among the names of all partnerLinks defined within the same immediately enclosing scope.
23	static analysis	The name of a variable MUST be unique among the names of all variables defined within the same immediately enclosing scope.
24	static analysis	Variable names are `BPELVariableNames`, that is, NCNames (as defined in XML Schema specification) but in addition they MUST NOT contain the '`.`' character.
25	static analysis	The `messageType`, type or `element` attributes are used to specify the type of a variable. Exactly one of these attributes MUST be used.
32	static analysis	For `<assign>`, the `<from>` and `<to>` element MUST be one of the specified variants.[2]
35	static analysis	In the from-spec of the partnerLink variant of `<assign>` the value `"myRole"` for attribute `endpointReference` is only permitted when the partnerLink specifies the attribute `myRole`.
36	static analysis	In the from-spec of the partnerLink variant of `<assign>` the value `"partnerRole"` for attribute `endpointReference` is only permitted when the partnerLink specifies the attribute `partnerRole`.
37	static analysis	In the to-spec of the partnerLink variant of `<assign>` only partnerLinks are permitted which specify the attribute `partnerRole`.
44	static analysis	The name of a `<correlationSet>` MUST be unique among the names of all `<correlationSet>` defined within the same immediately enclosing scope.

[2] The specification describes all allowed combinations of elements and attributes in from- and to-specifications.

51	static analysis	The `inputVariable` attribute MUST NOT be used on an `Invoke` activity that contains `<toPart>` elements.
52	static analysis	The `outputVariable` attribute MUST NOT be used on an `Invoke` activity that contains `<toPart>` elements.
55	static analysis	For `<receive>`, if `<fromPart>` elements are used on a `<receive>` activity then the variable attribute MUST NOT be used on the same activity.
56	static analysis	A "start activity" is a `<receive>` or `<pick>` activity that is annotated with a `createInstance="yes"` attribute. Activities other than the following: start activities, `<scope>`, `<flow>` and `<sequence>` MUST NOT be performed prior to or simultaneously with start activities.
57	static analysis	If a process has multiple start activities with correlation sets then all such activities MUST share at least one common correlationSet and all common correlationSets defined on all the activities MUST have the value of the `initiate` attribute be set to `"join"`.
59	static analysis	For `<reply>`, if `<toPart>` elements are used on a `<reply>` activity then the `variable` attribute MUST NOT be used on the same activity.
62	static analysis	If `<pick>` has a `createInstance` attribute with a value of '`yes`', the events in the `<pick>` MUST all be `<onMessage>` events.
63	static analysis	The semantics of the `<onMessage>` event are identical to a `<receive>` activity regarding the optional nature of the `variable` attribute or `<fromPart>` elements, if `<fromPart>` elements on an activity then the variable attribute MUST NOT be used on the same activity (see SA00055).
64	static analysis	For `<flow>`, a declared link's name MUST be unique among all `<link>` names defined within the same immediately enclosing `<flow>`.
65	static analysis	The value of the `linkName` attribute of `<source>` or `<target>` MUST be the name of a `<link>` declared in an enclosing `<flow>` activity.
66	static analysis	Every link declared within a `<flow>` activity MUST have exactly one activity within the `<flow>` as its source and exactly one activity within the `<flow>` as its target.
67	static analysis	Two different links MUST NOT share the same source and target activities; that is, at most one link may be used to connect two activities.
68	static analysis	An activity MAY declare itself to be the source of one or more links by including one or more `<source>` elements. Each `<source>` element MUST use a distinct link name.

69	static analysis	An activity MAY declare itself to be the target of one or more links by including one or more <target> elements. Each <target> element associated with a given activity MUST use a link name distinct from all other <target> elements at that activity.
70	static analysis	A link MUST NOT cross the boundary of a repeatable construct or the <compensationHandler> element. This means, a link used within a repeatable construct (<while>, <repeatUntil>, <forEach>, <eventHandlers>) or a <compensationHandler> MUST be declared in a <flow> that is itself nested inside the repeatable construct or <compensationHandler>.
71	static analysis	A link that crosses a <catch>, <catchAll> or <terminationHandler> element boundary MUST be outbound only, that is, it MUST have its source activity within the <faultHandlers> or <terminationHandler>, and its target activity outside of the scope associated with the handler.
72	static analysis	A <link> declared in a <flow> MUST NOT create a control cycle, that is, the source activity must not have the target activity as a logically preceding activity.[3]
73	static analysis	The expression for a join condition MUST be constructed using only Boolean operators and the activity's incoming links' status values.
74	static analysis	The expressions in <startCounterValue> and <finalCounterValue> MUST return a TII (meaning they contain at least one character) that can be validated as a xsd:unsignedInt. Static analysis MAY be used to detect this erroneous situation at design time when possible (for example, when the expression is a constant).
75	static analysis	For the <forEach> activity, <branches> is an integer value expression. Static analysis MAY be used to detect if the integer value is larger than the number of directly enclosed activities of <forEach> at design time when possible (for example, when the branches expression is a constant).
76	static analysis	For <forEach> the enclosed scope MUST NOT declare a variable with the same name as specified in the counterName attribute of <forEach>.
77	static analysis	The value of the target attribute on a <compensateScope> activity MUST refer to the name of an immediately enclosed scope of the scope containing the FCT-handler with the <compensateScope> activity. This includes immediately enclosed scopes of an event handler (<onEvent> or <onAlarm>) associated with the same scope.
78	static analysis	The target attribute of a <compensateScope> activity MUST refer to a scope or an invoke activity with a fault handler or compensation handler.

[3] This fault can only be detected in mode mode 'cfg'.

79	static analysis	The root `scope` inside a FCT-handler MUST not have a compensation handler.
80	static analysis	There MUST be at least one `<catch>` or `<catchAll>` element within a `<faultHandlers>` element.
81	static analysis	For the `<catch>` construct; to have a defined type associated with the fault variable, the `faultVariable` attribute MUST only be used if either the `faultMessageType` or `faultElement` attributes, but not both, accompany it. The `faultMessageType` and `faultElement` attributes MUST NOT be used unless accompanied by `faultVariable` attribute.
82	static analysis	The peer-scope dependency relation MUST NOT include cycles. In other words, WS-BPEL forbids a process in which there are peer scopes S1 and S2 such that S1 has a peer-scope dependency on S2 and S2 has a peer-scope dependency on S1.[4]
83	static analysis	An event handler MUST contain at least one `<onEvent>` or `<onAlarm>` element.
84	static analysis	The `partnerLink` reference of `<onEvent>` MUST resolve to a partner link declared in the process in the following order: the associated scope first and then the ancestor scopes.
88	static analysis	For `<onEvent>`, the resolution order of the `correlation set`(s) referenced by `<correlation>` MUST be first the associated scope and then the ancestor scopes.
91	static analysis	A scope with the `isolated` attribute set to `"yes"` is called an isolated scope. Isolated scopes MUST NOT contain other isolated scopes.
92	static analysis	Within a scope, the name of all named immediately enclosed scopes MUST be unique.
93	static analysis	Identical `<catch>` constructs MUST NOT exist within a `<faultHandlers>` element.
100	notice	Either a non-standard element[5] was parsed or a BPEL activity was considered as misplaced. In the first case, a non-standard element was parsed when the parser expected a BPEL standard activity. Then, a syntax error is printed and the whole element is ignored. The parse error and this message can usually be ignored, as non-standard elements would neither we translated to a Petri net model nor are constrained by the WS-BPEL specification. In the second case, a syntactically correct BPEL was skipped, because it was misplaced. As an example, consider two activities embedded in a `<while>` activity without an enclosing `<sequence>` activity. In this case, the second activity triggers this message.

[4] This fault can only be detected in mode mode '`cfg`'.

[5] All elements that are not explicitly defined in the WS-BPEL specification (e.g., elements from other namespaces) are considered as "non-standard".

101	notice	The `<partners>` construct (only supported by BPEL4WS 1.1) is skipped due to a syntax error.
102	notice	The `<to>` or `<from>` construct is skipped due to a syntax error.
103	notice	The `<condition>` construct is skipped due to a syntax error.
104	critical	When a syntax error occurs, BPEL2oWFN tries to recover and continues parsing the input file after skipping the faulty or unknown element. Sometimes, however, the skipping of activities yields to situations where a further analysis of the BPEL process is impossible. In this case, the syntax of the process has to be fixed or non-standard elements have to be removed or out-commented.
105	notice	When a syntax error occurs, BPEL2oWFN tries to recover and continues parsing the input file after skipping the faulty or unknown element. If it is possible to continue, the analysis results might be faulty. In this case, the syntax of the process has to be fixed or non-standard elements have to be removed or out-commented.
106	warning	CFG analysis detected two receiving activities (i.e., `<receive>`, `<onEvent>`, `<onMessage>`, synchronous `<invoke>`) that might be activated concurrently and share the same partner link, port type, operation, and correlation set. When a message is sent to the process, these activities are in *conflict*; that is, it is not defined which activity will receive an inbound message. At runtime, the standard fault '`bpel:conflictingReceive`' would be thrown.[6]
107	warning	A mandatory attribute of an activity was not defined. Especially for communicating activities, the absence of `partnerLink` and `operation` might hamper the subsequent analysis and Petri net generation.
108	syntax	An attribute was set to a value that violates the attribute's given type. Only the types `tBoolean`, `tInitiate`, `tRoles`, and `tPattern` are checked.
109	warning	A variable referenced in an activity was not defined before; that is, no matching `<variable>` definition was found in a parent scope.
110	warning	A partner link referenced in an activity was not defined before; that is, no matching `<partnerLink>` definition was found in the process.
111	warning	A correlation set referenced in an activity was not defined before; that is, no matching `<correlationSet>` definition was found in a parent scope.
112	notice	The `<literal>` construct is skipped due to a syntax error.

[6] This fault can only be detected in mode mode '`cfg`'.

113	syntax	A UTF-8 character was read in the input file. As BPEL2oWFN's scanner does not support Unicode, all UTF-8 characters are ignored. This message is only displayed when the first UTF-8 character is read.
114	warning	CFG analysis detected a read access to a variable that was not initialized before. At runtime, the standard fault '`bpel:uninitializedVariable`' would be thrown.[7]
115	notice	The process definition defines an abstract process profile, and thus allows several "opaque" constructs. When processing and analyzing an abstract process, BPEL2oWFN might report error messages that where designed for executable processes, for example missing attributes. Static analysis errors detected in an abstract process are reported as warnings.
116	notice	An `<opaqueActivity>` of an abstract process is modeled by an `<empty>` activity.
117	notice	When using the parameter '`small`', the occurrence of join failures is not modeled. Thus, any activity is treated as if the attribute '`suppressJoinFailure`' is set to '`yes`'.[8]
118	notice	A user-defined transition condition is ignored and modeled as "n-out-of-n" ('`true`') instead.
119	notice	A user-defined transition condition is ignored and modeled as "1-out-of-n" (XOR) instead.
120	notice	When using the parameter '`small`', the FTC (fault, termination, and compensation) handlers are not modeled.
121	notice	When using the parameter '`small`', activities of the negative control flow (`<exit>`, `<throw>`, `<compensate>`, and `<compensateScope>`) are replaced by an `<empty>` activity.
122	notice	A syntax error in the BPEL4Chor chorography file occurred.
123	notice	A syntax error in the WSDL input file occurred.
124	notice	An XML Schema element nested in a WSDL <types> element was ignored. This is usually no problem, as WSDL `<types>` are not evaluated in subsequent analysis or translation.
125	notice	A variable property element was ignored while parsing the input WSDL file.
126	warning	A WSDL `<message>` referenced in a WSDL `<operation>` was not found.
127	warning	A WSDL `<portType>` referenced in a WSDL `<role>` was not found.

[7] This fault can only be detected in mode mode '`cfg`'.

[8] If the attribute '`suppressJoinFailure`' is not explicitly defined for an activity, the value is inherited by the parent activity.

128	warning	A WSDL `<operation>` referenced in a BPEL activity was not specified in the input WSDL file.
129	warning	A WSDL `<role>` of a `partnerLinkType` referenced by a `<partnerLink>` was not defined in the specified `<partnerLinkType>` in the input WSDL file.
130	warning	A WSDL `<partnerLinkType>` referenced by a `<partnerLink>` was not specified in the input WSDL file.
131	error	An activity has neither a `name` or `id` attribute and thus can not be linked with a BPEL4Chor `<messageLink>`.
132	error	An activity has neither could not be linked with a BPEL4Chor `<messageLink>` using the activity's `name` or `id` attribute.
133	notice	An `<extensionActivity>` is replaced by an `<opaqueActivity>` (cf. notice 116).
134	warning	A BPEL4Chor `<participantType>` was defined twice.
135	warning	The `<participantType>` referenced by a BPEL4Chor `<participant>` was not found.
136	error	The value of a `<forEach>`'s attribute `id` or `name` does not reference a BPEL4Chor `<participant>` or `<participantSet>`. Thus, the `<forEach>` activity is not grounded to the BPEL4Chor topology.
137	error	In a BPEL4Chor topology, no XML namespace was defined for a `<participant>`. In a WS-BPEL file, the attribute `targetNamespace` could not to be grounded to a BPEL4Chor `<participant>`.
138	notice	In a BPEL4Chor topology, a partner link specified for an activity was not found. Instead, the name of the specified id is used as a partner link.

4 File Formats

In this chapter, we show how a BPEL process can be translated to a Petri net model an then exported to several output file formats. Consider the following simple BPEL process 'example.bpel':

```
<process name="exampleprocess" targetNamespace="www.gnu.org/software/bpel2owfn">
  <partnerLinks>
    <partnerLink name="PL" partnerLinkType="PLT"
      myrole="exampleprocess" partnerRole="exampleuser" />
  </partnerLinks>

  <sequence>
    <receive partnerLink="PL" operation="req" createInstance="yes" />
    <reply partnerLink="PL" operation="ack" />
  </sequence>
</process>
```

This process just waits for a message 'req' on partner link 'PL' and replies to this message with 'ack' on the same partner link. To parse this BPEL process, BPEL2oWFN has to be invoked with

```
bpel2owfn -i example.bpel
```

which responds with the output:

```
===============================================================================
GNU BPEL2oWFN 2.0.1 reading from file 'example.bpel'
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
3 activities (2 basic, 1 structured, 0 scopes) + 3 implicit activities
0 handlers (0 FH, 0 TH, 0 CH, 0 EH) + 1 implicit handlers
0 links, 0 variables

[SYNTAX ANALYSIS] No syntax errors found.
[STATIC ANALYSIS] No errors found checking 44 statics analysis requirements.
[OTHER ANALYSIS]  No other errors found.
-------------------------------------------------------------------------------
```

This means, the process consists of three activities (two basic activities and one structured activities), no handlers, no links and no variables. On the bottom the analysis results are summarized: no syntactic, static, or other error was found.

Furthermore, three "implicit" activities are counted: The WS-BPEL specification describes several implicit transformations of the input process, as well as standard fault, termination and compensation handlers. In the considered BPEL process, no fault handlers are specified. Thus, a standard fault handler is added by BPEL2oWFN:

```
<faultHandlers>
  <catchAll>
    <sequence>
      <compensate />
      <rethrow />
    </sequence>
  </catchAll>
</faultHandlers>
```

To see how the BPEL process looks like after applying the transformation rules and adding the standard handlers, BPEL2oWFN output the manipulated process using its pretty-printer:

```
bpel2owfn -i example.bpel -m pretty
```

The manipulated process looks like this:

```
<process id="1" abstractProcess="no" exitOnStandardFault="no" name="exampleprocess"
 suppressJoinFailure="no" targetNamespace="www.gnu.org/software/bpel2owfn">
  <partnerLinks>
    <partnerLink id="3" myrole="exampleprocess"
       name="PL" partnerLinkType="PLT" partnerRole="exampleuser" />
  </partnerLinks>
  <faultHandlers id="4">
    <catchAll id="13">
      <sequence id="12" suppressJoinFailure="no">
        <compensate id="11" suppressJoinFailure="no">
        </compensate>
        <rethrow id="10">
        </rethrow>
      </sequence>
    </catchAll>
  </faultHandlers>
  <sequence id="7" suppressJoinFailure="no">
    <receive id="8" createInstance="yes" operation="req"
       partnerLink="PL" suppressJoinFailure="no">
    </receive>
    <reply id="9" operation="ack" partnerLink="PL" suppressJoinFailure="no">
    </reply>
  </sequence>
</process>
```

Each activity is printed together with its attributes. Note that the standard values of several attributes (e.g., '`abstractProcess`' or '`suppressJoinFailure`') are added. Furthermore, an identifier (attribute '`id`') was added to every activity.

We now want to create a compact Petri net model of the BPEL process, using the '`petrinet`' mode and the '`small`' parameter:

```
bpel2owfn -i example.bpel -m petrinet -p small
```

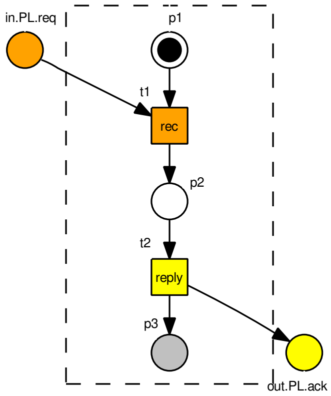
BPEL2oWFN now also displays statistics of the generated Petri net model:

```
|P|=5, |P_in|= 1, |P_out|= 1, |T|=2, |F|=6
```

The generated Petri net model consists of five places, including one input and one output place, two transitions and six arcs. To create a graphical representation, invoke BPEL2oWFN with the following options:

```
bpel2owfn -i example.bpel -m petrinet -p small -f dot -o
```

This command creates a file '`example.dot`', containing a Graphviz dot representation of the Petri net, and—if the `dot` tool was found in the search path—a PNG (Portable Network Graphics) an image file '`example.png`'. The latter looks like this:



Petri net generated from example.bpel

The graphic depicts the generated open workflow net. The inner of the net, that is, all nodes except the interface places, are depicted inside the dashed box, whereas the interface is depicted outside the frame. Input places and all connected transitions are colored orange. Similarly, output places and connected transitions are colored yellow. Gray places belong to the final marking, that is, the marking [**p3**] is the final marking of the oWFN.

To reach this final marking, the environment has to send a message **in.PL.req**, followed by receiving a message **out.PL.ack**. The name of the communication places is composed by the communication direction ("in" or "out"), the partner link's name ('PL') and the operations name ('req' or 'ack').

For this very small process, it is easy to validate the generated Petri net model, that is, to compare the intended semantics by the actually modeled semantics. Especially the correlation between the nodes of the Petri net and the activities of the input BPEL process is not obvious for larger processes. To this end,

```
bpel2owfn -i example.bpel -m petrinet -p small -f info
```

displays an information file, consisting of all the Petri net nodes' roles.

```
PLACES:
ID      TYPE            ROLES
p1      internal        1.internal.initial
                        7.initial
                        7.internal.initial
                        8.initial
                        8.internal.initial
p2      internal        8.final
                        8.internal.final
                        9.initial
                        9.internal.initial
p3      internal        1.internal.final
                        7.final
                        7.internal.final
                        9.final
                        9.internal.final
in.PL.req       input           in.PL.req
out.PL.ack      output          out.PL.ack

TRANSITIONS:
ID      ROLES
t1      8.internal.receive
t2      9.internal.reply
```

This file has to be read as follows: the place 'p1' has the type internal (i.e., is not connected with an interface place) and has the roles '1.internal.initial', '7.initial', '7.internal.initial', '8.initial', and '8.internal.initial'. While the prefix of each role is the identifier of an activity ('1' for the <process>, '7' for the <sequence>, and '8' for the <receive>), the suffix specifies the role inside the respective pattern. Without going too much into details, '1.internal.initial' is the role of the initial place of the pattern for the <process>, whereas, for example '7.internal.final' is the final place of the <sequence>'s pattern. Similarly, roles of transitions are specified. Multiple roles of a single place arise due to the merging of distinct places during the composition of the several patterns.

Now that we have convinced ourselves that the generated net reflects the intended behavior of the BPEL process, we can export the Petri net model to an output file to process it by analysis tools. In this case, we want to create a Fiona open workflow net executing

```
bpel2owfn -i example.bpel -m petrinet -p small -f owfn -o
```

which creates a file 'example.owfn':

```
{
  generated by: BPEL2oWFN 2.0.1
  input file:   'example.bpel' (process 'exampleprocess')
  invocation:   'bpel2owfn -i example.bpel -m petrinet -p small -f owfn'
  net size:     |P|=5, |P_in|= 1, |P_out|= 1, |T|=2, |F|=6
}

PLACE
  INTERNAL
    p1, p2, p3;

  INPUT
    in.PL.req {$ MAX_OCCURRENCES = 1 $};

  OUTPUT
    out.PL.ack {$ MAX_OCCURRENCES = 1 $};


INITIALMARKING
  p1:    1 {initial place};

FINALMARKING
  p3 {final place};


TRANSITION t1 { input }
  CONSUME in.PL.req, p1;
  PRODUCE p2;

TRANSITION t2 { output }
  CONSUME p2;
  PRODUCE out.PL.ack, p3;


{ END OF FILE 'example.owfn' }
```

This is finally the oWFN model of the BPEL process that can be analyzed by Fiona[1].

[1] Fiona is available at http://www.informatik.hu-berlin.de/top/tools4bpel.

5 FAQ and Known Bugs

5.1 Frequently Asked Questions

- **Why does the parser reject my BPEL file?**

  BPEL2oWFN uses Flex and Bison to implement the parser. We decided do not use an off-the-shelf XML parser generator as we did not found a suitable platform-independent parser generator whose license was "compatible" to the GNU GPL (General Public License). Furthermore, we use the term generator Kimwitu++ to describe and process the AST (abstract syntax tree), and the trio Flex/Bison/Kimwitu++ integrates seamlessly. Though the grammar has to be defined manually, the generated parser is very flexible as it allows to process BPEL4WS 1.1, WS-BPEL 2.0, and to some extend BPEL4WS 1.0 processes.

  However, the parser does not support XML namespaces. BPEL2oWFN will ignore namespace prefixes and skip all elements that are not explicitly covered by the WS-BPEL 2.0, BPEL4WS 1.2 or WSDL 1.1 specification, respectively. Nevertheless, skipping elements are reported as syntax error message (cf. warning message [W00104]).

  As a solution, try removing or commenting non-standard elements.

- **I validated my process using an XML validator. Why does BPEL2oWFN still reports syntax errors?**

  Well, because there *are* such errors. Many BPEL editors generate invalid BPEL. Even the official WS-BPEL 2.0 specification contains processes with syntax errors. Furthermore, a lot of syntax errors cannot be covered with XSD (XML Schema Definition) validation. Even if the considered process run on existing engines, BPEL2oWFN might reject it, as it stubbornly follows the WS-BPEL specification.

- **Why LoLA does not accept the generated files and reports parse errors in the first line?**

  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`'.

5.2 Known Bugs

Though this is the second major release version of BPEL2oWFN, it might still contain poorly tested, inefficient code.

- **Problem:** BPEL2oWFN crashes during the translation of an abstract BPEL process.

  Diagnosis: The implemented semantics of was mainly created to support executable BPEL processes. Therefore, the translation of abstract BPEL processes (formerly called *business protocols*) might be buggy. In particular, the allowed absence of implementation details hampers the analysis of the process and the generation of a formal model.

  Solution: To avoid errors, at least each communicating activity should be defined with `partnerLink` and `operation` attribute, and `<invoke>` activities should be defined with `inputVariable` and/or `outputVariable` to distinguish the respective asynchronous and synchronous occurrence.

5.3 Reporting Bugs

If you find a bug in BPEL2oWFN or have a question, please first check that it is not a known bug or a frequently asked question listed in above. Otherwise, please send us an email to `bug-bpel2owfn@gnu.org`. 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`.

5.4 Contact Person

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5.5 Help BPEL2oWFN

BPEL2oWFN is now developed for one and a half year, and grown to a quite big program. Since November 2006, BPEL2oWFN is a GNU package, and the development is organized at Savannah (`https://savannah.gnu.org/projects/bpel2owfn`). We are always looking for developers and testers that can help us improving BPEL2oWFN.

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