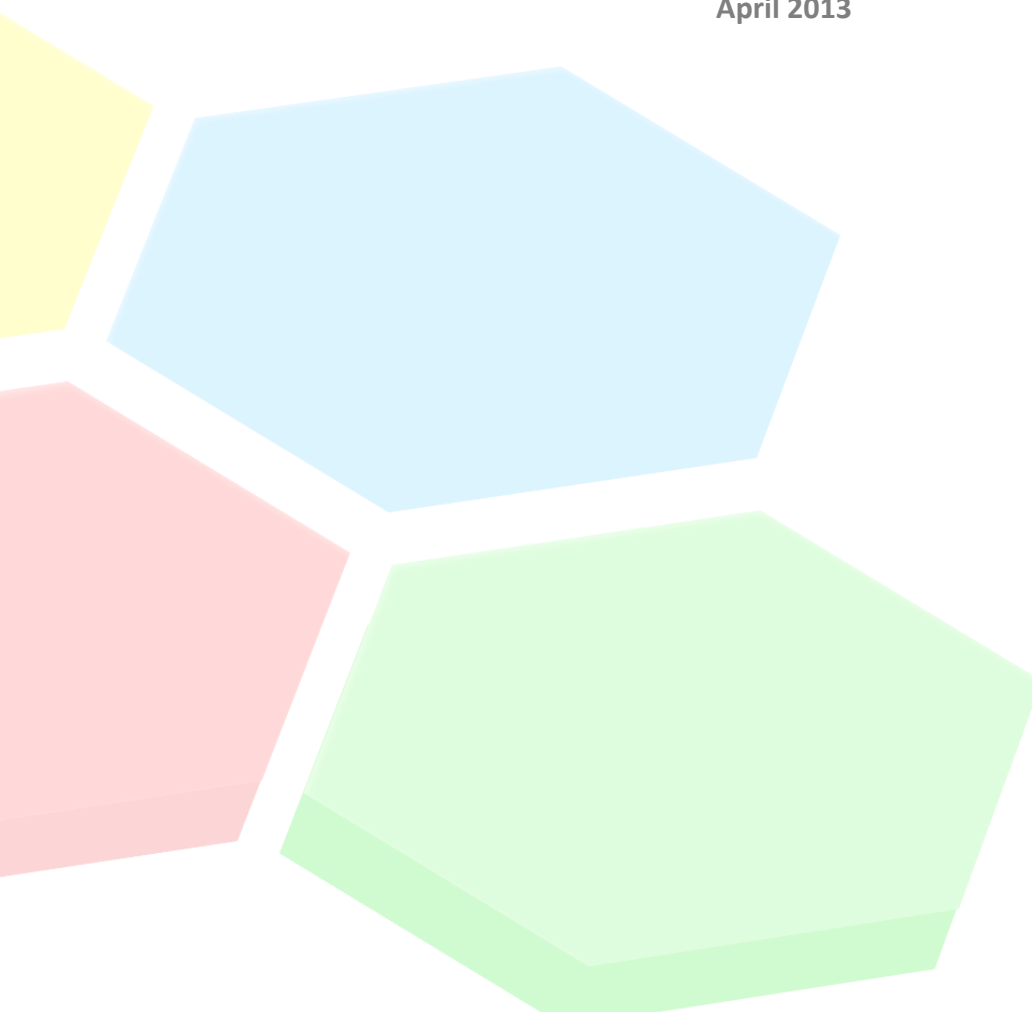


Understanding BPMN Connections

Gregor Polančič
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Introduction

In this whitepaper the syntax and semantics of using different types of BPMN 2.0 connections is explained. Since BPMN is a graph-oriented language, it fundamentally consists of two types of elements: nodes and connections (Figure 1). In BPMN, connections are represented with one of the BPMN connecting objects, where nodes are represented with an element, that belongs to one of the remaining groups of BPMN elements, which are: Flow Objects¹, Data, Swimlanes and Artefacts [1].

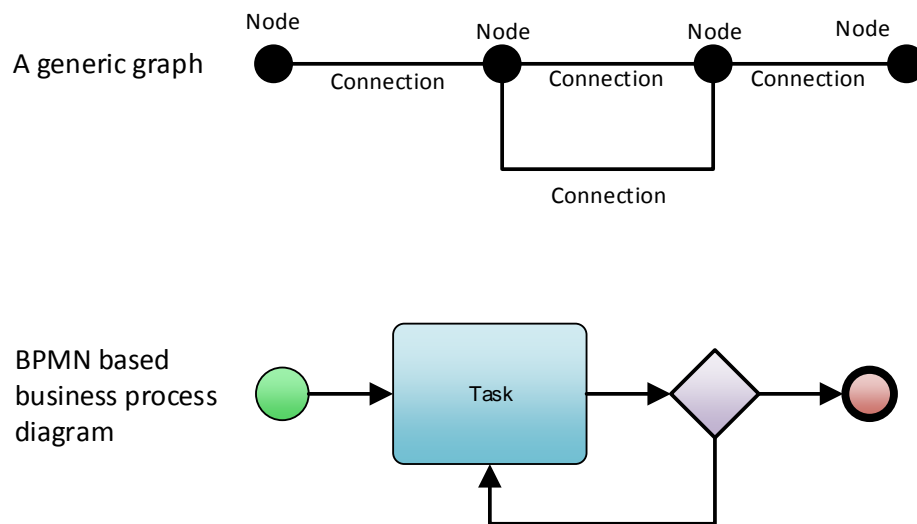


Figure 1: A BPMN based business process diagram is a graph

BPMN 2.0 defines four basic connecting objects: Sequence Flow, Message Flow and two types of Associations. These connecting objects are graphically represented with the following arrows (Figure 2):

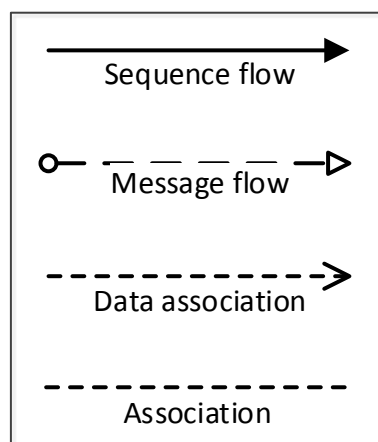


Figure 2: Main BPMN connecting objects

¹ Flow objects are Activities, Gateways and Events.

In BPMN, different connecting objects are necessary to represent different types of flows:

- A **Sequence Flow** is used to represent the order of Flow elements in process and choreography models.
- A **Message Flow** is used to show the flow of messages between two participants that are able to send and receive them. In BPMN, two separate Pools in a Collaboration Diagram will represent the two Participants.
- A **Data Association** is used to show the flow of information between Activities in a business process.
- An **Association** is used to link Artefacts with other BPMN (graphical) elements.

The following business process diagram demonstrates the basic usage of different BPMN connecting elements.

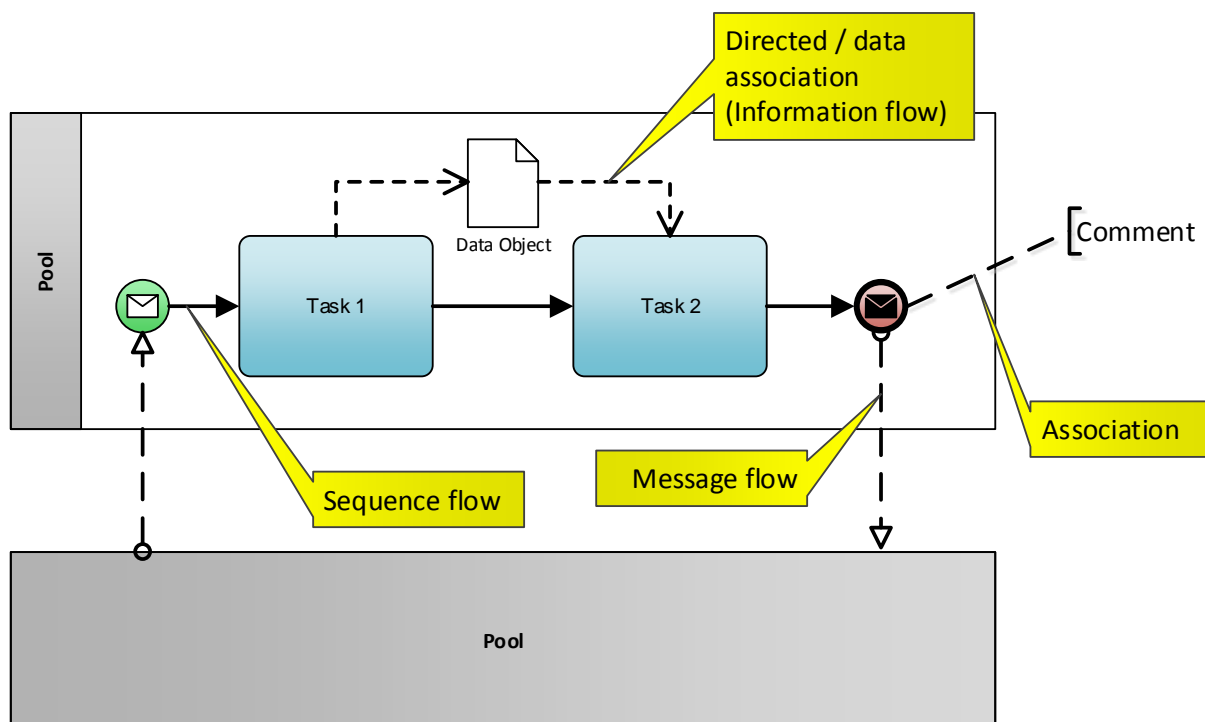


Figure 3: BPMN connecting objects in a business process diagram

The following chapters will present details of using different types of connecting objects, common mistakes and best practices.

Sequence Flows

As already stated, a Sequence Flow is used to show the order of Flow elements in a business process diagram. When connecting Flow elements with Sequence Flows, certain rules need to be followed as presented on the next table (Figure 4), obtained from the BPMN 2.0 specification [1].

	Start Event	Task	Exclusive Gateway	Inclusive Gateway	Intermediate Event	End Event
Start Event		→	→	→	→	→
Task			→	→	→	→
Exclusive Gateway		→		→	→	→
Inclusive Gateway		→	→		→	→
Intermediate Event		→	→	→		→
End Event						

Figure 4: Basic Sequence Flow rules [1]

Figure 4 illustrates regular Sequence Flows. The empty column and the empty row indicate the following:

- No Sequence Flows are allowed to flow into a Start Event. This is represented by the empty first column in Figure 4.
- No Sequence Flows are allowed to flow out of an End Event. This is represented by the empty last row in Figure 4.

For example, the rounded arrow (red ellipse) in row 2, column 3 in Figure 4 indicates that a Sequence Flow can connect the two elements in the following order (Figure 5):

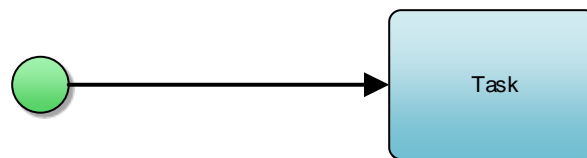


Figure 5: Regular Sequence Flow

Figure 4 is very useful since it clearly represents regular Sequence Flows. However, when applying it to business process diagrams, the corresponding text in the BPMN specification should also be considered [1]. This text clearly states that Figure 4 is incomplete in case of representing irregular Sequence Flows as presented on the next example (Figure 6).

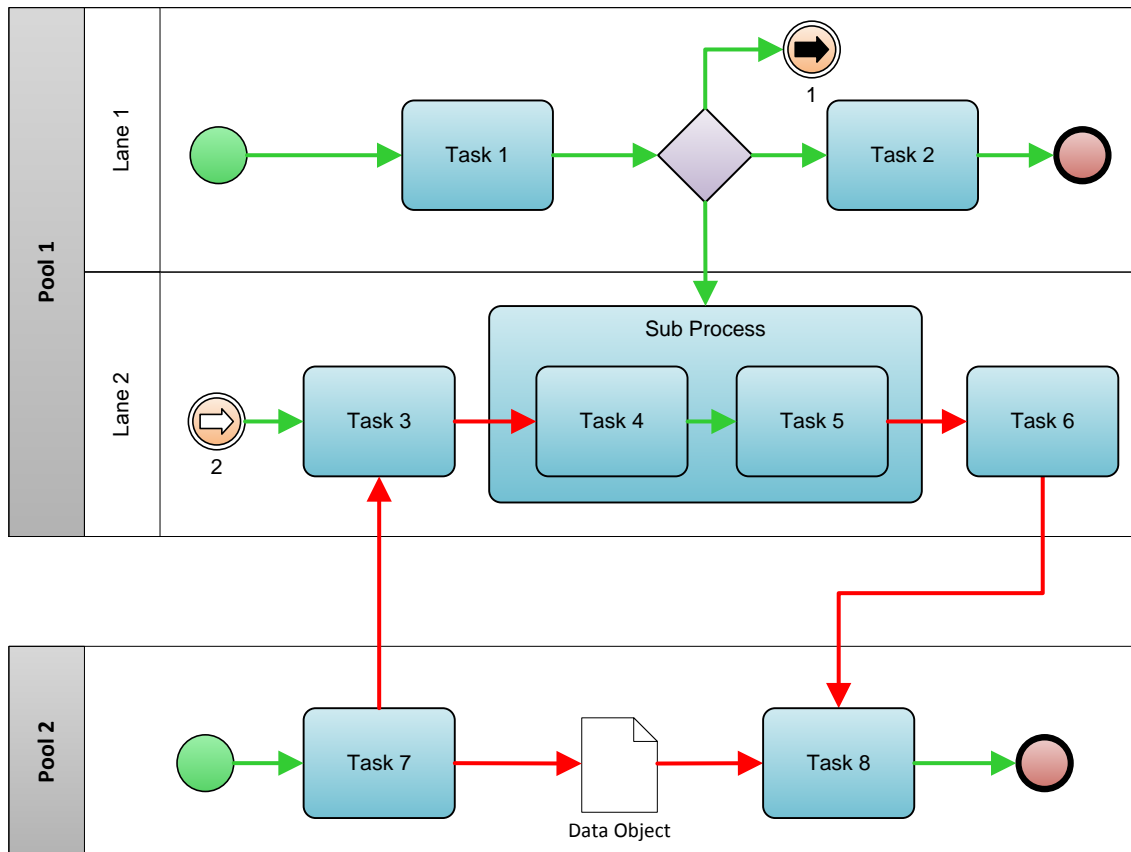


Figure 6: Business process diagram example with correct (green) and incorrect (red) Sequence Flows

Figure 6 represents a business process diagram example, with semantically correct (green arrows) and incorrect (red arrows) Sequence Flows. Note that non-permitted Sequence Flows are not listed on Figure 4, so there are some additional rules to take into account. For example:

- Figure 4 clearly illustrates that two Tasks can be connected with a Sequence Flow; however it doesn't state that it is wrong to directly connect two Tasks between a process and a sub-process (see connection between Task 3 and Task 4 and connection between Task 5 and Task 6 on Figure 6).
- On Figure 4 there is no rule highlighting connection of any objects between Pools using Sequence Flows (see connection between Task 7 and Task 3 and connection between Task 6 and Task 8 on Figure 6). This means that Sequence Flows are allowed only within a Pool. In the case of cross-Pool interaction, Message Flows should be used.
- On Figure 4 artefacts are not listed within the connection rules (see both connections between Task 7 and Task 8 on Figure 6). However, this should be assumed - and in this case Associations should be used.
- According to connection rules on Figure 4, the regularity of the use of the Intermediate Link Events ("1" and "2" on Figure 6) is also unclear, since an incoming or outgoing flow is missing. However, a Link event is also an exception to the rule, since it replaces a Sequence Flow (between Link events "1" and "2" on Figure 6). Still, be aware that a Link event "replaces" a Sequence Flow, meaning that it is allowed to use them only within a Pool (Figure 7).

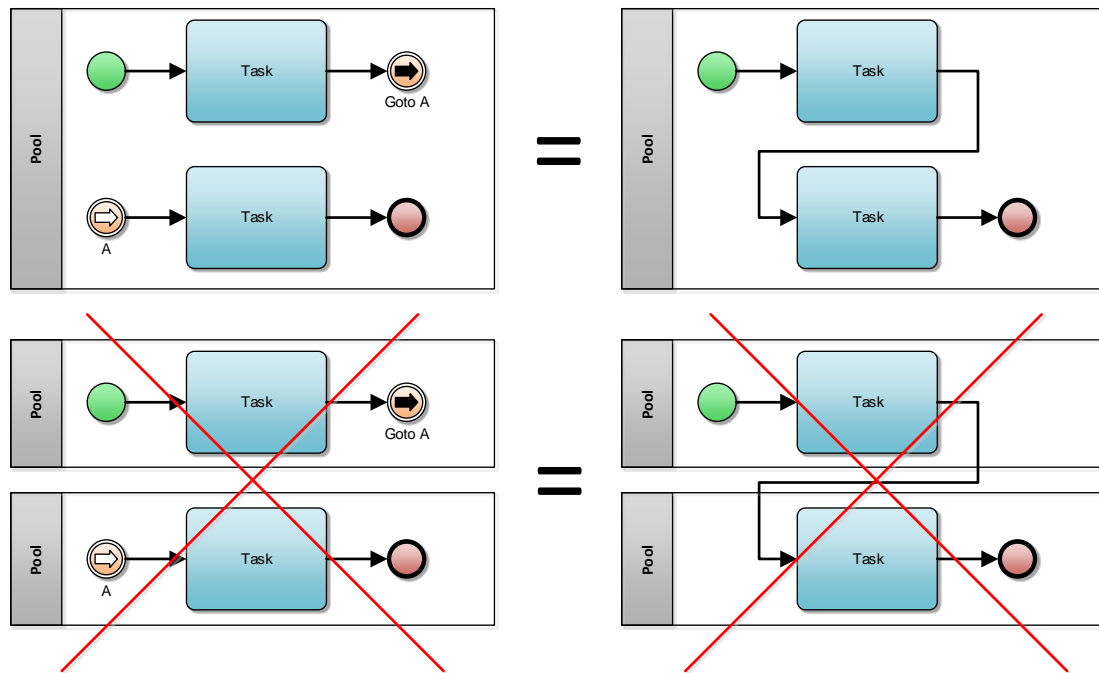


Figure 7: RIGHT and WRONG use of link events

The correct version of the business process diagram example on Figure 6 is presented in Figure 8.

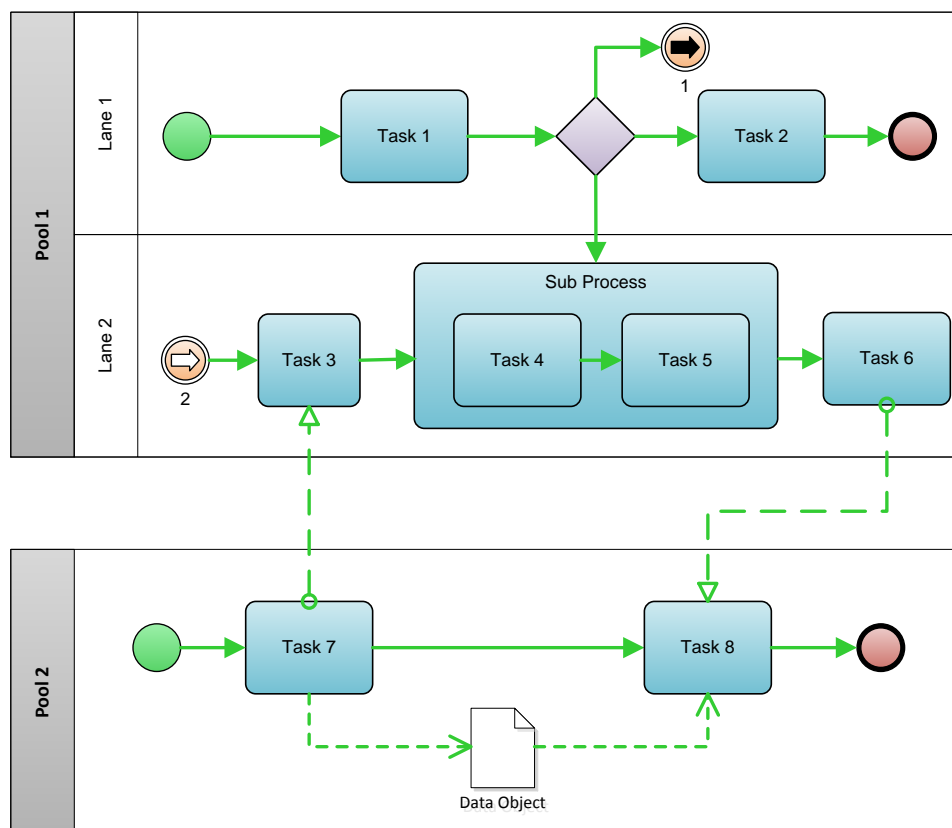


Figure 8: Business process diagram example with regular connections

A Sequence Flow can optionally define a condition², when connecting from an Exclusive or Inclusive Gateway or an Activity. When a condition is used on the outgoing Sequence Flow of an Activity, it is called a Conditional Sequence Flow, which is graphically represented with a mini-diamond.

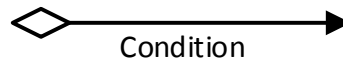


Figure 9: Conditional Sequence Flow

When using conditional Sequence Flows, a modeler should always ensure that the combination of conditions represented in an outgoing Sequence Flow leads to at least one of them activating for every performance of the Activity. One way to do that is to add a default Sequence Flow, which is graphically represented in Figure 10.

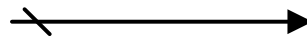


Figure 10: Default Sequence Flow

An example of using combination of conditional and default Sequence Flows is presented in Figure 11.

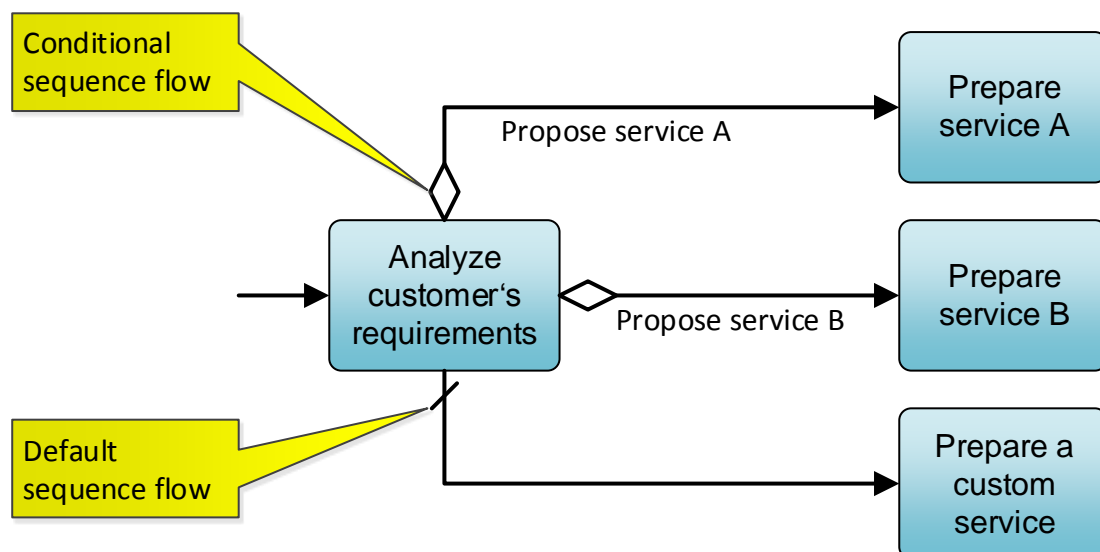


Figure 11: Complementary use of conditional and default Sequence Flows

² BPMN attributes are generally not shown graphically. In this case they do have a graphical representation (a mini-diamond attached to the arrow)

Message Flows

A Message Flow represents the flow of a message in a business process diagram. The BPMN 2.0 specification defines a Message Flow as follows [1]: “A Message Flow is used to show the flow of Messages between two Participants that are prepared to send and receive them /.../. In BPMN, two separate Pools in a Collaboration Diagram will represent the two Participants /.../.”

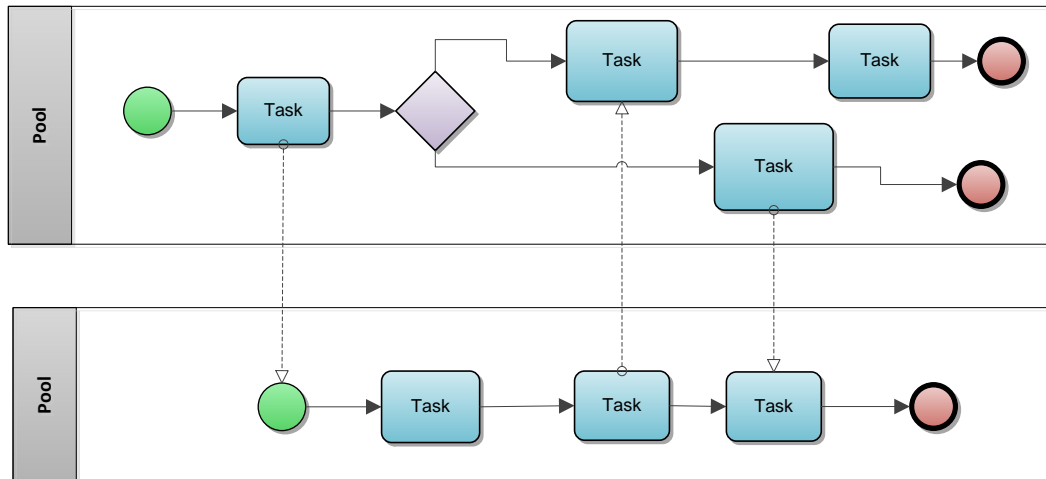


Figure 12: An example of BPMN collaboration diagram

As evident from Figure 12, Message Flows are used to represent interactions in BPMN collaboration diagrams. Message Flows can be optionally extended with a Message object, which explicitly represents the content of a communication between two participants (Figure 13).

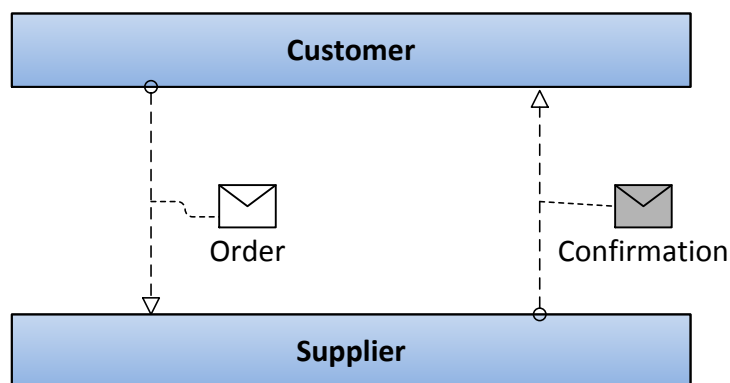


Figure 13: Message association overlapping Message Flows

As evident from Figure 13, two types of messages exist: an initiating message (painted white) and a non-initiating message (painted grey). In general, Message Flows can be used only for between-Pools interactions (collaborations). Several rules need to be considered when applying Message Flows to business process diagrams, as summarized in the following table (Figure 14).






































						
						
						
						
						
						
						

Figure 14: Basic Message Flow rules [1]

Similar to Figure 4, several preconditions should be considered when using the basic Message Flow rules table (Figure 14) [1]:

- Message Flows cannot connect to objects that are within the same Pool.
- Only those objects that can have incoming and/or outgoing Message Flows are shown in the table. Thus, Lane, Gateway, Data Object, Group, and Text Annotation are not listed in the table.

Considering these Message Flow rules, the following presents an example of regular and irregular Message Flows (Figure 15)[2]:

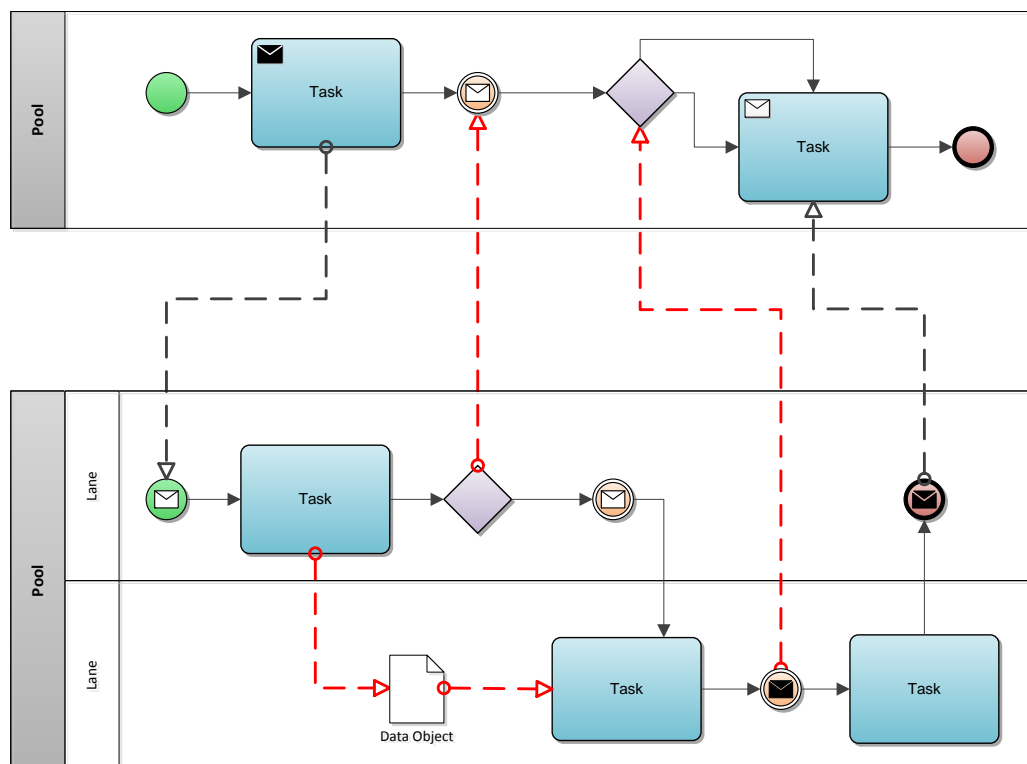


Figure 15: Regular and irregular (painted red) Message Flows

When comparing basic Message Flow rules (Figure 14) with basic Sequence Flow rules (Figure 4) some commonalities can be identified. For example, the tables have the opposite in terms of empty rows and columns, meaning following is apparent (note though not illustrated below, when using message flows with End Events, the type should be 'message' event):

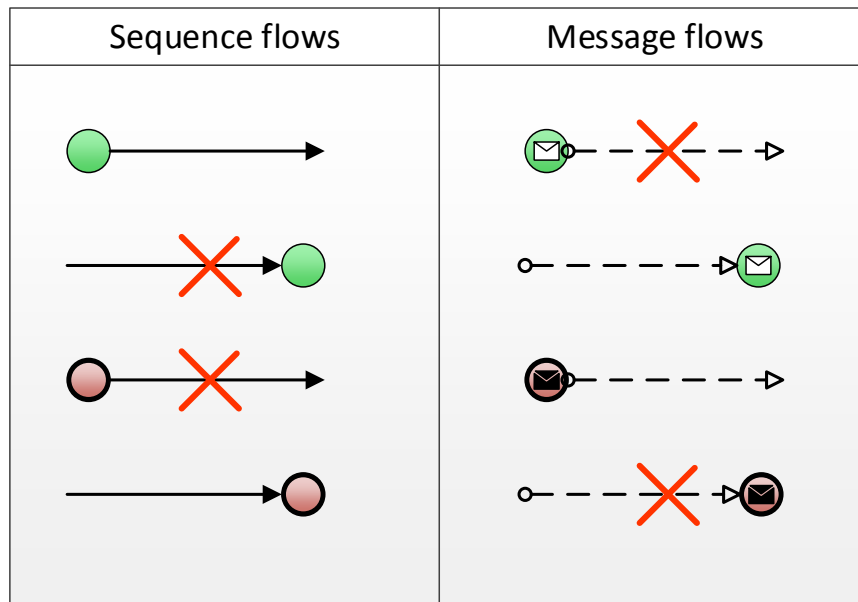


Figure 16: Comparing Sequence Flow rules and Message Flow rules

In the case of the set of BPMN 2.0 elements within analytical process models, Message Flows are associated with specific subtypes of BPMN elements. Figure 17 presents these Message Flow related elements with relating connections.

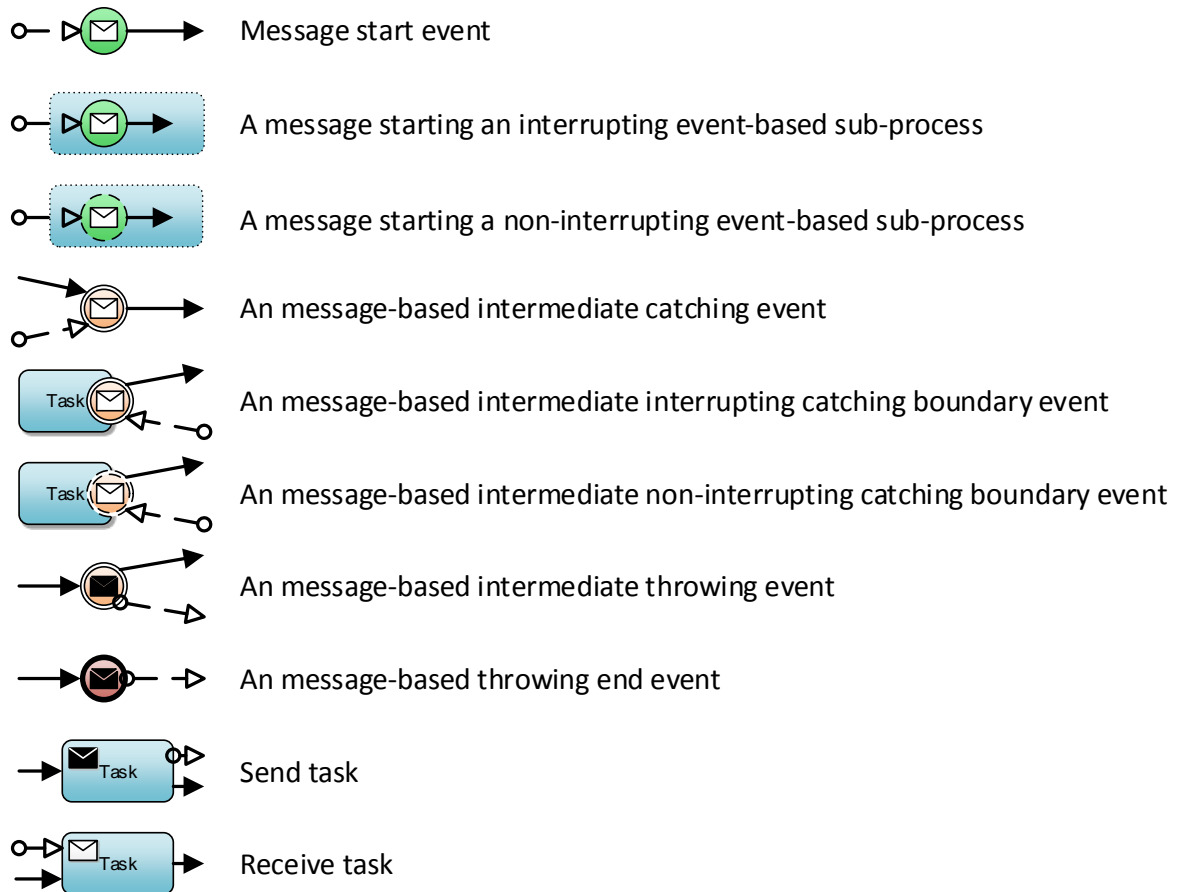


Figure 17: BPMN 2.0 Message Flow related elements

Associations

In BPMN 2.0, process data flows are represented with Data Associations, which are graphically represented as directional associations (Figure 18).

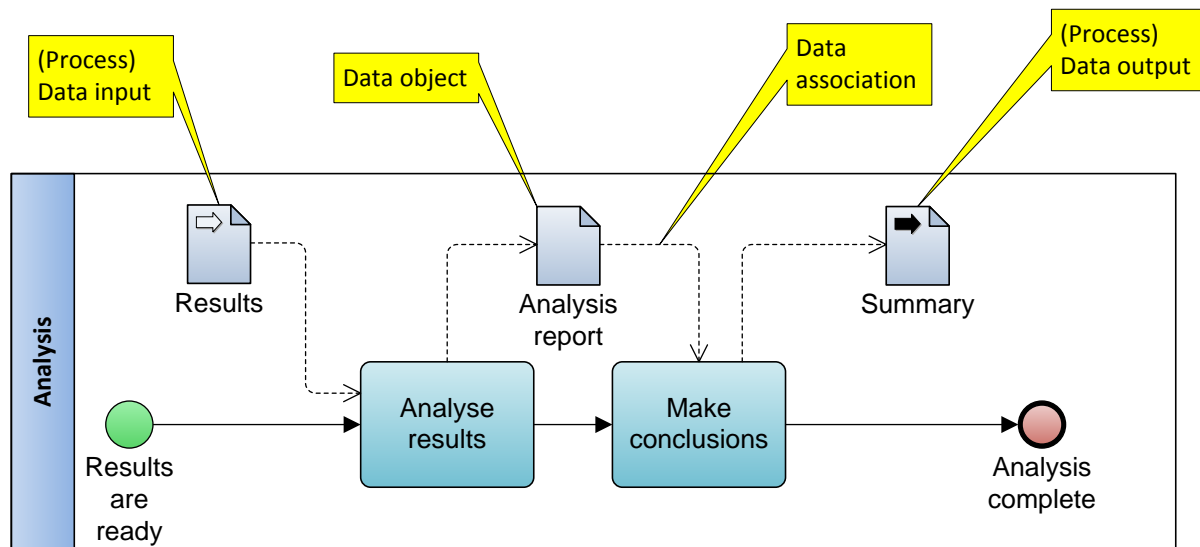


Figure 18: Data flow, represented with Data Associations and data objects

Data Associations are used to move data between:

- Data Objects (visual data elements), Data Stores and
- Inputs and outputs of Activities (also Data Objects), Processes, and Global Tasks.

In contrast to Sequence Flows, “tokens”³ do not flow along a Data Association, and as a result they have no direct effect on the flow of the Process.

The purpose of retrieving data from Data Objects or Process Data Inputs is to fill the Activities inputs and later push the output values from the execution of the Activity back into Data Objects or Process Data Outputs (see Figure 18).

The core concepts of a Data Association are that they have a source, a target, and an optional transformation. When a Data Association is “executed,” data is copied to the target. What is copied depends on if there is a transformation defined or not. If there is no transformation defined or referenced, then only one source must be defined, and the contents of this source will be copied into the target [1].

Alternatively, Data Objects may be directly associated with a Sequence Flow connector to represent the same input/output relationships (Figure 19).

³ BPMN 2.0 specification defines tokens as a theoretical concept that is used as an aid to define the behaviour of a Process that is being performed. The behaviour of Process elements can be defined by describing how they interact with a token as it “traverses” the structure of the Process. For example, a token will pass through an Exclusive Gateway, but continue down only one of the Gateway's outgoing Sequence Flow.

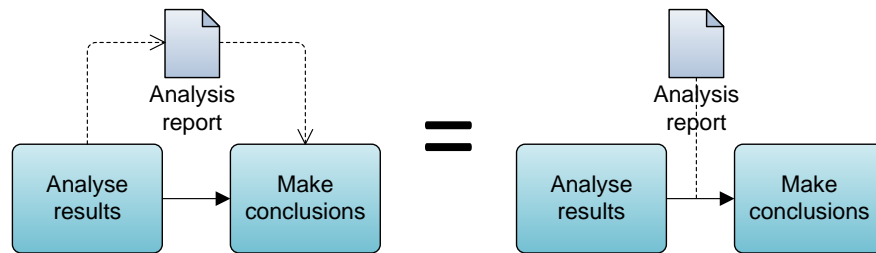


Figure 19: Equal representations of data flows

While it is possible to associate a Data Object to a Sequence Flow that connects to a Gateway (Figure 20), this is not recommended, because it can quickly become difficult to understand how the inputs and outputs are applied to Activities on both sides of a Gateway [3].

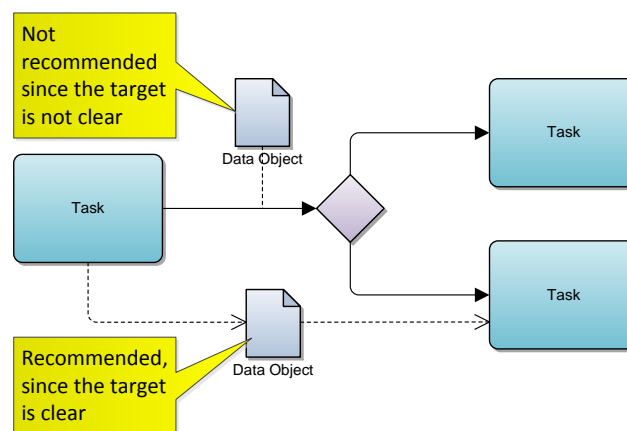


Figure 20: Recommended and not recommended use of data flows

If there is a reason to put directionality on the Association then a line arrowhead may be added to the Association line⁴. The directionality of the Association can be in one direction or in both directions (Figure 21). If the association is directional it is a data association.

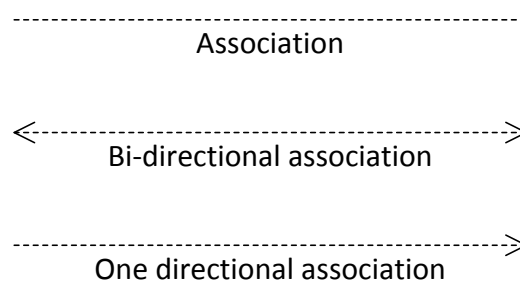


Figure 21: Variations of associations

⁴ Note that directional Associations were used in BPMN 1.2 to show how Data objects were inputs or outputs to Activities. In BPMN 2.0, a Data Association connector is used to show inputs and outputs. A Data Association uses the same notation as a directed Association.

Conclusions

This whitepaper focused on representing the syntax and semantics of using different types of BPMN 2.0 connections. Basically there are four main types of BPMN connections. The most common are Sequence Flows, which represent the sequence of execution of activities in a business process diagram. The flow of data in a business process diagram is represented with Data Associations. In case of collaborative processes, Message Flows need to be used to synchronize two participants and show the flow of messages between them. And finally Associations are used to associate Artefacts with other BPMN graphical elements.

References

- [1] OMG, "Business Process Model and Notation version 2.0," 03-Jan-2011. [Online]. Available: <http://www.omg.org/spec/BPMN/2.0/>. [Accessed: 15-Mar-2011].
- [2] J. Freund, *Praxishandbuch BPMN : [inklusive BPMN 2.0]*. München [u.a.]: Hanser, 2010.
- [3] *BPMN Modeling and Reference Guide*. Future Strategies Inc., Lighthouse Pt, FL, 2008.

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