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Business Process Models

We model an “as-is” model using different business process modelling approaches for each of twelve business processes, and the redundancy and complexity of the “as-is” models are measured. The minimal number of change operations needed to transform the “as-is” models to the “to-be” models are measured. The same variant of a family of business processes is used as the “to-be” process variant for the sets of variants in different business process modelling approaches.

Chapter 1 Student Enrolment Process

The student enrolment process is a family of business processes for student enrolment into higher education institutions which is based on the candidate enrolment process in (Subic and Dimitrijevic, 2015). For each of the business process modelling approaches under comparison, an "as-is" model is designed, and its redundancy and complexity is measured. The "to-be" model for the student enrolment process is represented by Figure 1-1a, and the minimal change operations needed to transform the "as-is" models designed in various modelling approaches to the "to-be" process designed in various modelling approaches is measured.

1.1 Multi-Model

Figure 1-1 shows the business process variants of the student enrolment business process modelled individually and separately using the BPMN Standard. The redundancy of activities across the three variants is 10, and the calculation for deriving it is shown in Table 1-1. The complexity across the three variants is 0 because there are no split constructs in any of the three models. The multi-model approach for modelling business processes does not support the transformation of one business process model to another, but rather the modelling of a new separate variant for each new business process variant required. So instead of measuring the minimal number of change operations required to transform an "as-is" model to a "to-be" model, we measure the minimal number of operations required to model the "to-be" from scratch. The minimal number of change operations required to model the first variant in Figure 1-1a is 7 because we need to add seven activities to create the business process model. The results for complexity, redundancy and the minimal number of change operations are shown in Table 1-2.

a. Admission test and Student loan

b. No admission test and self-funded

c. No admission test, transfer candidate and has a scholarship

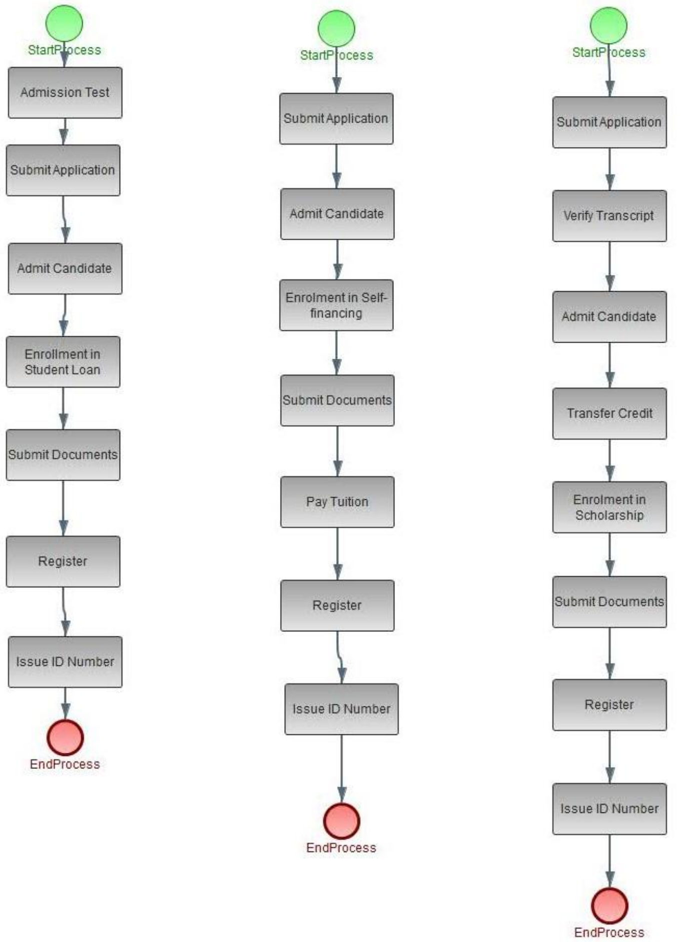


Figure 1-1 Process variants for student enrolment (Subic and Dimitrijevic, 2015)

Table 1-1 Redundancy of activities for Multi-Model student enrolment process

Activity	Occurrences(x)	Duplicates(x-1)
Admission Test	1	0
Submit Application	3	2
Admit Candidate	3	2
Submit Documents	3	2
Register	3	2
Issue ID Number	3	2
Enrolment in Student Loan	1	0
Enrolment in Self-financing	1	0
Pay Tuition	1	0
Verify Transcript	1	0
Transfer Credit	1	0
Enrolment in Scholarship	1	0
Redundancy		10

Table 1-2 Measurements for Multi-model students enrolment models

Metric	Value
Redundancy	10
Complexity	0
Minimal Number of Change Operations	7

1.2 Single Model

The single model is shown in Figure 1-2, and it is modelled using the BPMN standard. Table 1-3 shows the redundancy of activities which totals to 0. The single model in Figure 1-2 has four XOR-splits with two outgoing edges and one XOR-split with three outgoing edges, which makes the Control Flow Complexity (CFC) of all splits in the model to be 11. The minimal number of change operations needed to transform the single model in Figure 1-2 to the "to-be" process variant represented by Figure 1-1a is 5. The results for redundancy, complexity and the minimal number of change operations are summarized in Table 1-4.

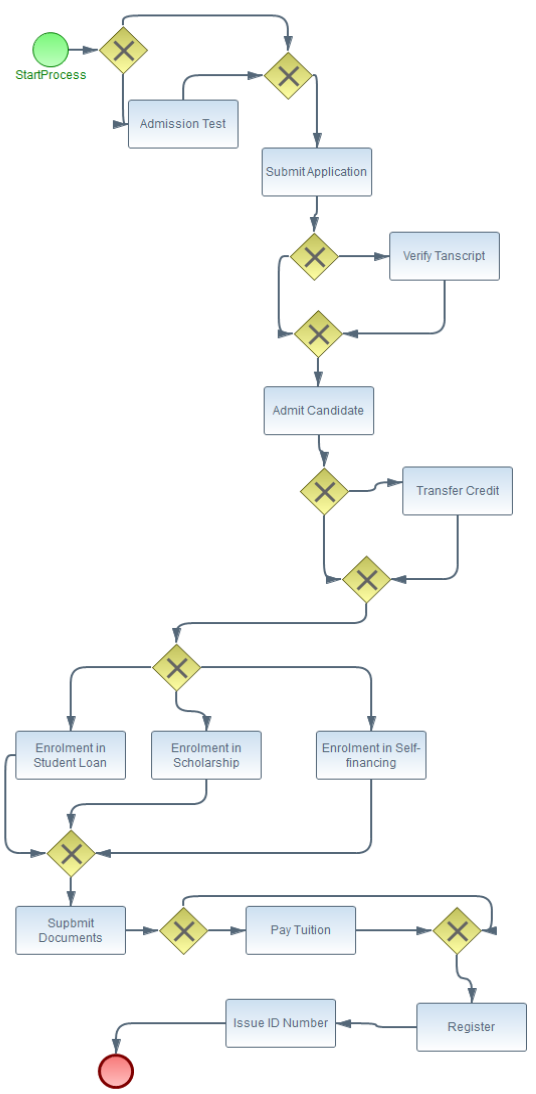


Figure 1-2 Single business process model of the student enrolment process

Table 1-3 Redundancy of activities for Single model student enrolment process

Activity	Occurrences(x)	Duplicates(x-1)
Admission Test	1	0
Submit Application	1	0
Admit Candidate	1	0
Submit Documents	1	0
Register	1	0
Issue ID Number	1	0
Enrolment in Student Loan	1	0
Enrolment in Self-financing	1	0
Pay Tuition	1	0
Verify Transcript	1	0
Transfer Credit	1	0
Enrolment in Scholarship	1	0
Redundancy		0

Table 1-4 Measurements for the single model students enrolment process

Metric	Value
Redundancy	0
Complexity	11
Minimal Number of Change Operations	5

1.3 Provop

The main process model for the student enrolment and related change operations using the provop approach is shown in Figure 1-3, and it is based on the variant in Figure 1-1b. The model has a complexity of 0 and redundancy of 0. The minimal number of change operations needed to transform the main process to the "to-be" variant represented by the process variant model in Figure 1-1a is 4 because four change operations are performed, which are: "Admission Test" is inserted, "Enrolment in Self-financing" is deleted, "Enrolment in Student Loan" is inserted and "Pay Tuition" is deleted. The summary of the results is shown in Table 1-5.

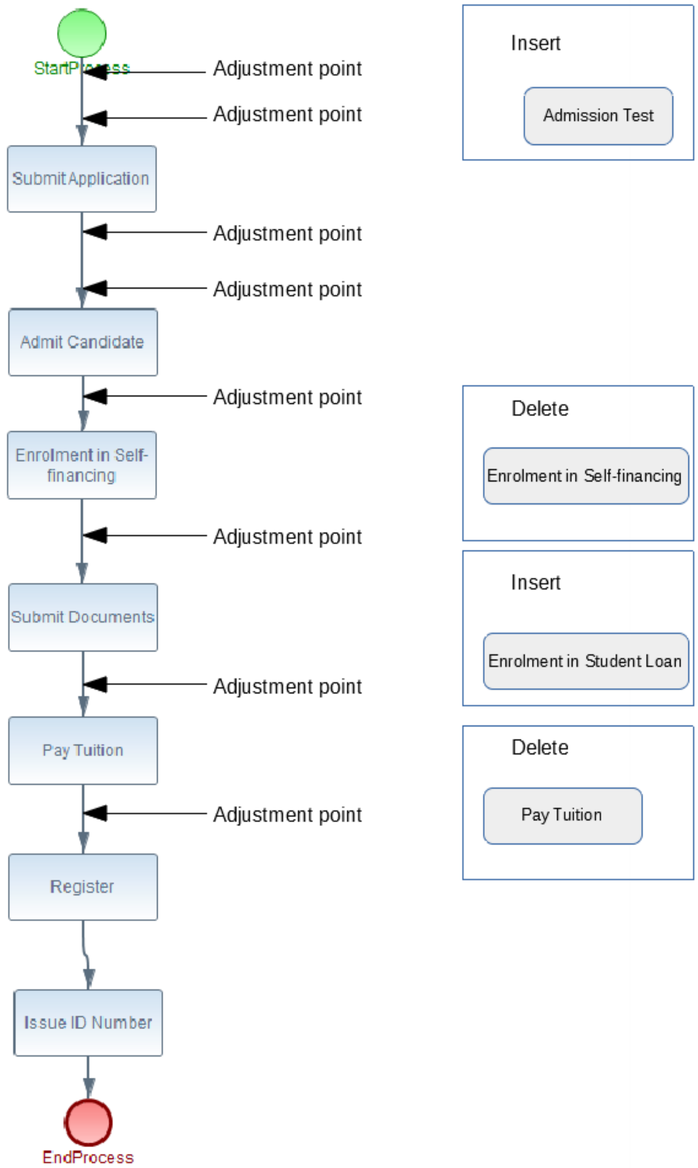


Figure 1-3 Main process model for student enrolment using provop approach

Table 1-5 Measurements for Provop model for the student enrolment process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	4

1.4 PESOA

In PESOA models, the variation points, <<VarPoint>>, function like the XOR-split construct, so in measuring the complexity, the association lines linking with a variation point to the subprocesses are treated as the outgoing lines of an XOR-split. Figure 1-4 shows that the redundancy is 0, the complexity is 7 which is added by the seven association lines in the model and the minimal number of change operations for transforming the model to the variant represented by Figure 1-1a is 5. To achieve this transformation the following five activities will have to be deleted, “Verify Transcript”, “Transfer Credit”, “Enrolment in Self-financing”, “Enrolment in Scholarship”, and “Pay Tuition”. The results for the measurements are shown in Table 1-6.

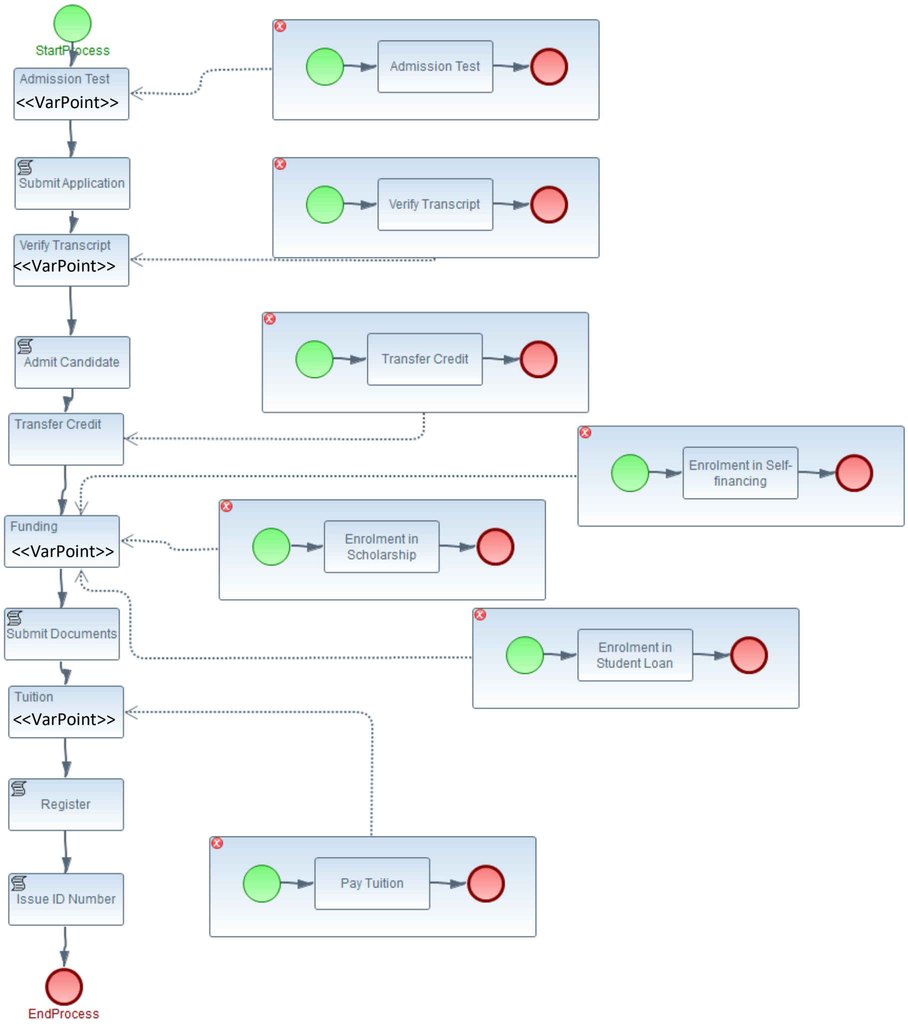


Figure 1-4 Student enrolment model using PESOA

Table 1-6 Measurements for PESOA model for the student enrolment process

Metric	Value
Redundancy	0
Complexity	7
Minimal Number of Change Operations	5

1.5 C-EPC and Configurative Process Modelling

To design the student enrolment process model shown in Figure 1-5 using the Configurable Event-Driven Process Chain (C-EPC) or Configurative Process Modelling, we use the notation for the Event-Driven Process Chain (EPC) modelling language. The redundancy of functions (equivalent to activities) is 0. The model has four XOR-splits with two outgoing edges and one XOR-split with three outgoing edges, making the Control Flow Complexity (CFC) of all splits in the model to be 11. The minimal number of change operations needed to transform the C-EPC or Configurative Process Modelling model in Figure 1-5 to the variant represented in Figure 1-1a is 5 since five functions need to be deleted to achieve the transformation. The functions to be deleted are “Verify transcript”, “Transfer Credit”, “Enrol in Self-financing”, “Enrol in Scholarship”, and “Pay Tuition”. The measurements for complexity, redundancy and minimal change operations are shown in Table 1-7.

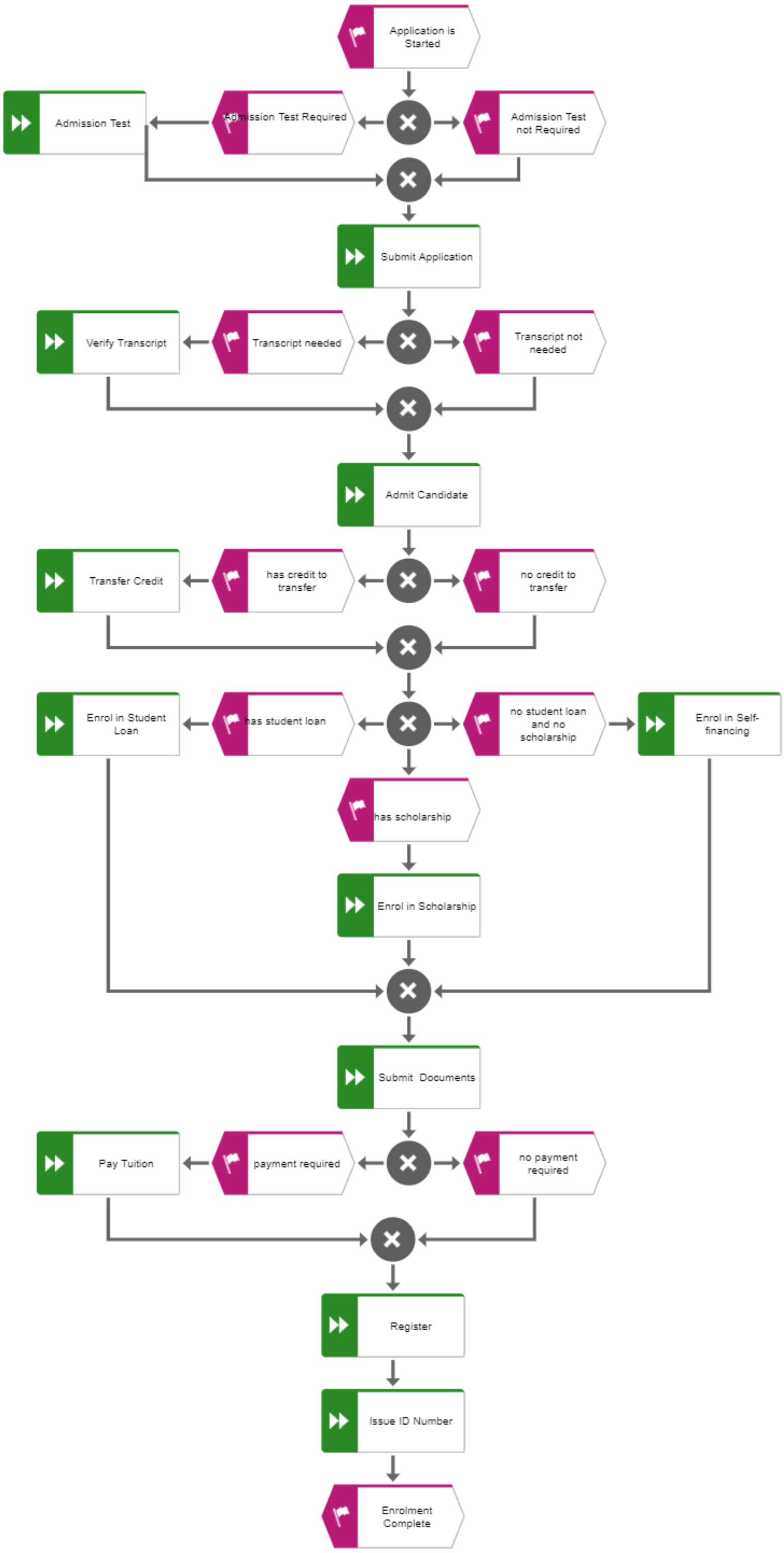


Figure 1-5 C-EPC model for the student enrolment process

Table 1-7 Measurements of C-EPC model for the students' enrolment process

Metric	Value
Redundancy	0
Complexity	11
Minimal Number of Change Operations	5

1.6 proCollab

proCollab is a tree-based modelling approach which provided for only the modelling of activities or tasks as nodes in a tree structure but has not provided for the modelling of split constructs (Mundbrod and Reichert, 2017). Because of the importance of split constructs in modelling alternative paths in business processes, we will incorporate the split constructs as nodes of a tree model the way it is explained in (Kumar and Yao (2009). Figure 1-6 shows a templet for the student enrolment process which is based on the variant in Figure 1-1b, with a complexity of 0 since there are no split construct and redundancy of 0 since there are not duplicate activities. In order to transform the model in Figure 1-6 to a proCollab variant templet which is equivalent to the variant in Figure 1-1a, the following change operations will have to be performed: Insert "Admission Test" and "Enrol in Student Loan"; and Delete "Enrol in Self-financing" and "Pay Tuition"; which bring the minimal number of change operations required to achieve the transformation to 4 as shown in Table 1-8. The summary of the measurements are shown in Table 1-8.

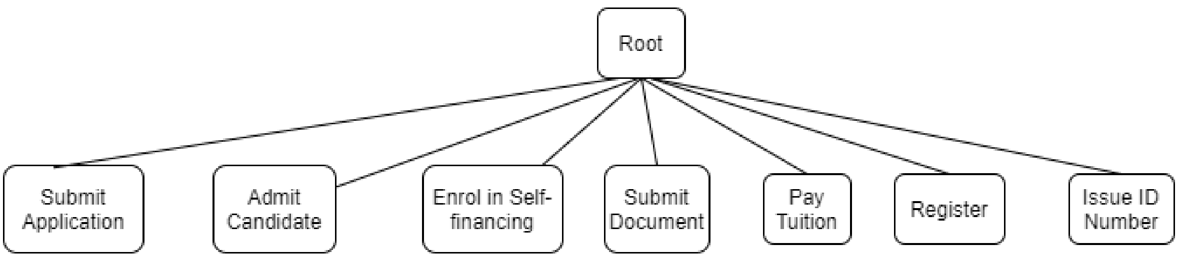


Figure 1-6 proCollab student enrolment process model

Table 1-8 Measurements for the proCollab model for the students' enrolment process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	4

Chapter 2 Airline Booking Process

The business process model in Figure 2-1 represents the "to-be" business process variant that will be derived from the airline booking business process ("as-is" business process model) modelled in different business process modelling approaches. The airline booking process is adapted from the airline booking process models in (Ayora *et al.*, 2015),

2.1 Multi-Model

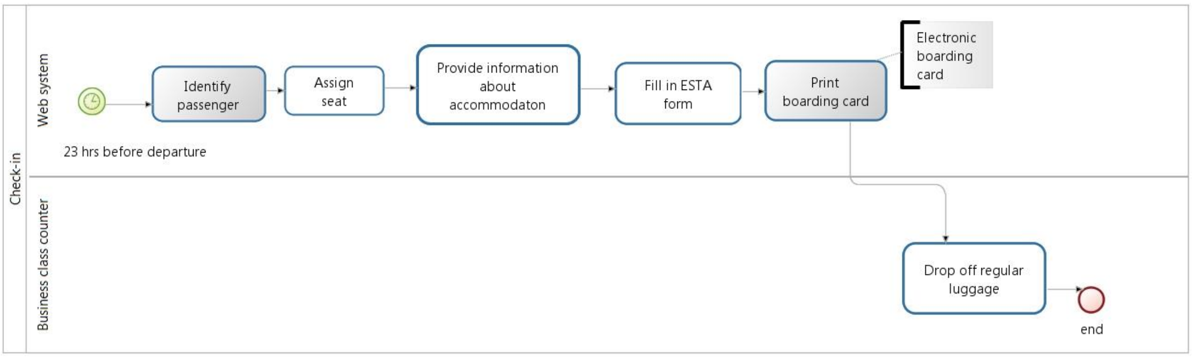


Figure 2-1 Variant 1: Online Check-in of an adult passenger with a business class ticket from EU to the USA (Ayora *et al.*, 2015)

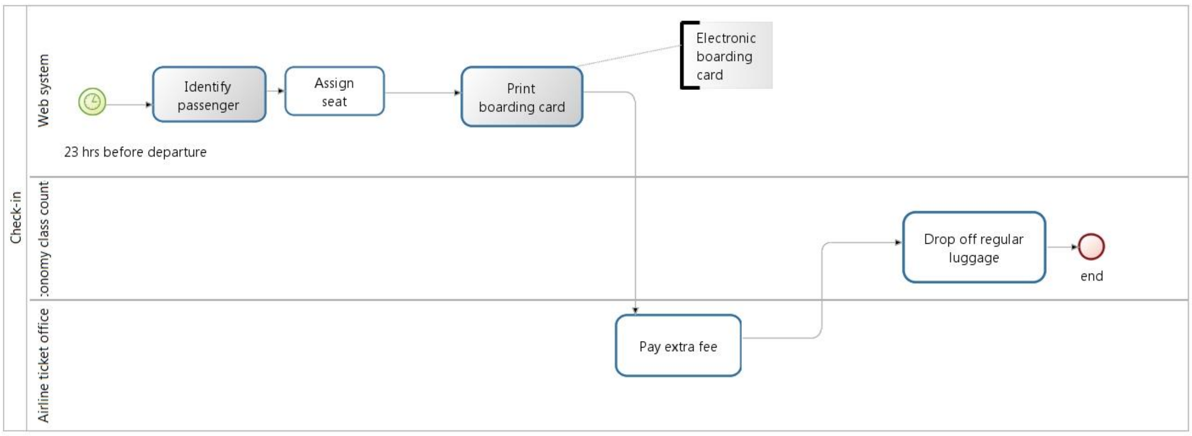


Figure 2-2 Variant 2: Online check-in of an adult passenger with an economy class ticket from EU to EU with overweight luggage (Ayora *et al.*, 2015)

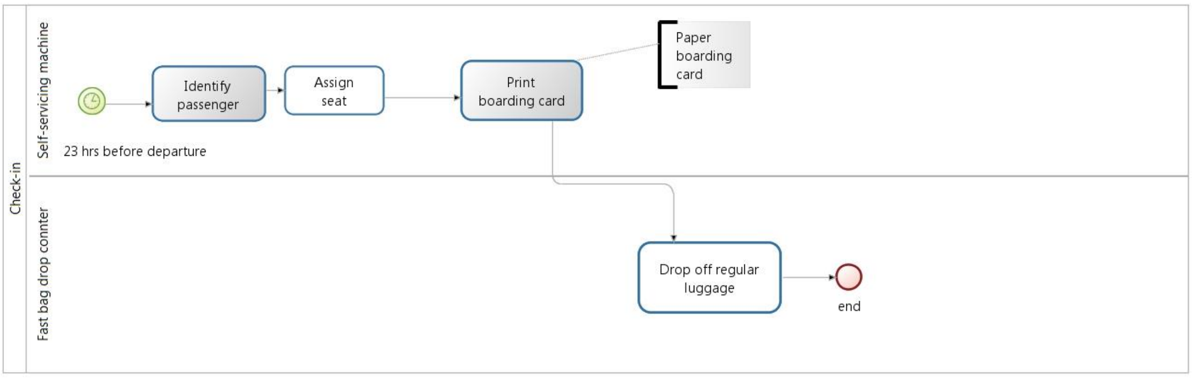


Figure 2-3 Variant 3: Check-in at the self-servicing machine for an adult passenger with an economy class ticket from EU to EU (Ayora *et al.*, 2015)

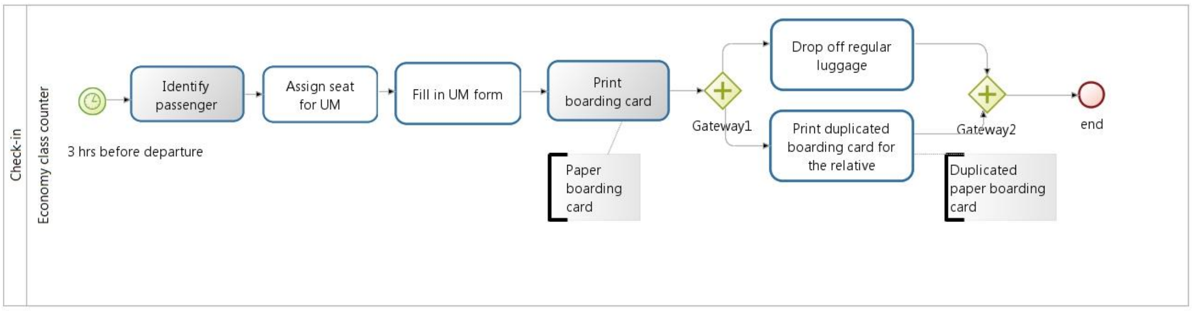


Figure 2-4 Variant 4: Check-in for an unaccompanied minor (UM) passenger with an economy class ticket from EU to EU with a relative accompanying him until the boarding gate (Ayora *et al.*, 2015)

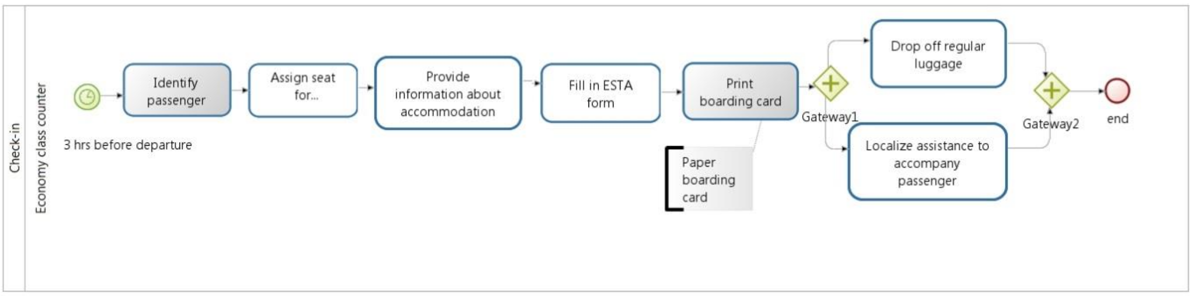


Figure 2-5 Variant 5 Check-in for a disabled passenger with an economy class ticket from EU to the USA (Ayora *et al.*, 2015)

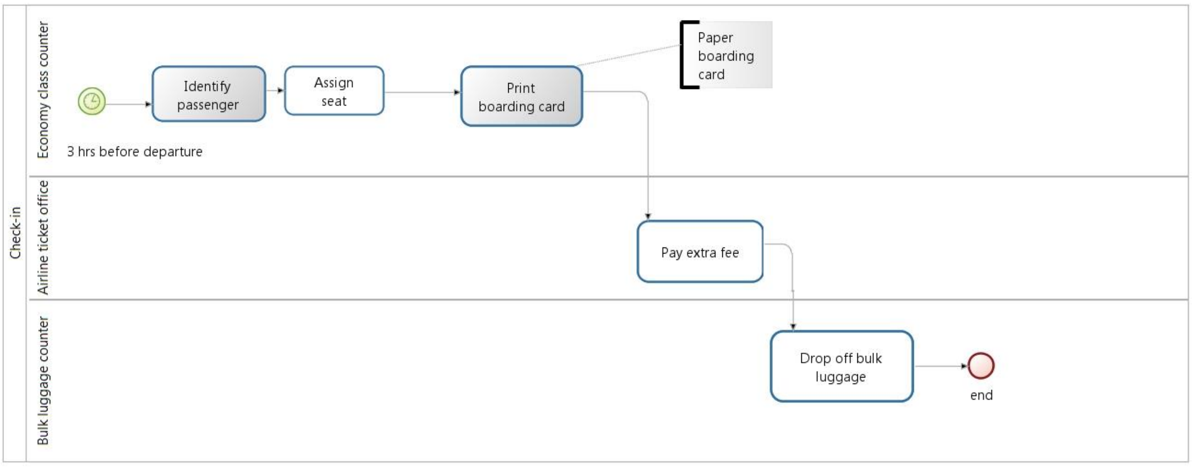


Figure 2-6 Variant 6: Check-in for an adult passenger with an economy class ticket from EU to EU with bulk luggage (Ayora *et al.*, 2015)

Figure 2-1to Figure 2-6 shows the business process variants, which are modelled individually using the BPMN modelling language. The variant shown in Figure 2-4 has one AND-split which results to the complexity of 1 and the variant shown in Figure 2-5 has one AND-split which results to a complexity of 1 making the total complexity across all variants to be 2. The redundancy across variants is 19, and Table 2-1 shows how the redundancy of activities across the variant model in Figure 2-1 to Figure 2-6 is derived. The minimal change operations are the number of activities added to create an entirely new variant model in Figure 2-1, which is 6.

Table 2-1 Redundancy of activities for Multi-model of the airline booking process

Activity	Occurrences(x)	Duplicates(x-1)
Identify passenger	6	5
Assign seat	4	2
Assign seat for UM	1	0
Provide information about accommodation	2	1
Fill in ESTA form	2	1
Print boarding card	6	5
Drop off regular luggage	5	4
Fill in UM form	1	0
Print duplicate boarding card for the relative	1	0
Assign seat for handicapped passenger	1	0
localize assistance to accompany passenger	1	0
Pay extra fee	2	1
Drop off bulk luggage	1	0
Redundancy		19

Table 2-2 Result of measurements of Multi-Model airline booking processes

Metric	Value
Redundancy	19
Complexity	2
Minimal Number of Change Operations	6

2.2 Single Model

The single model for the airline booking process is shown in Figure 2-7, and it is modelled using the BPMN standard. The model has a redundancy of 0. The model has four XOR-splits with two outgoing edges (CFC is 8), two XOR-split with three outgoing edges (CFC is 6), and one AND-split with two outgoing edges (CFC is 1) which makes the Control Flow Complexity (CFC) of all splits in the model to be 15. The minimal number of change operations needed to transform the single model to the “to-be” represented by the variant in Figure 2-1 is 7. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 2-3.

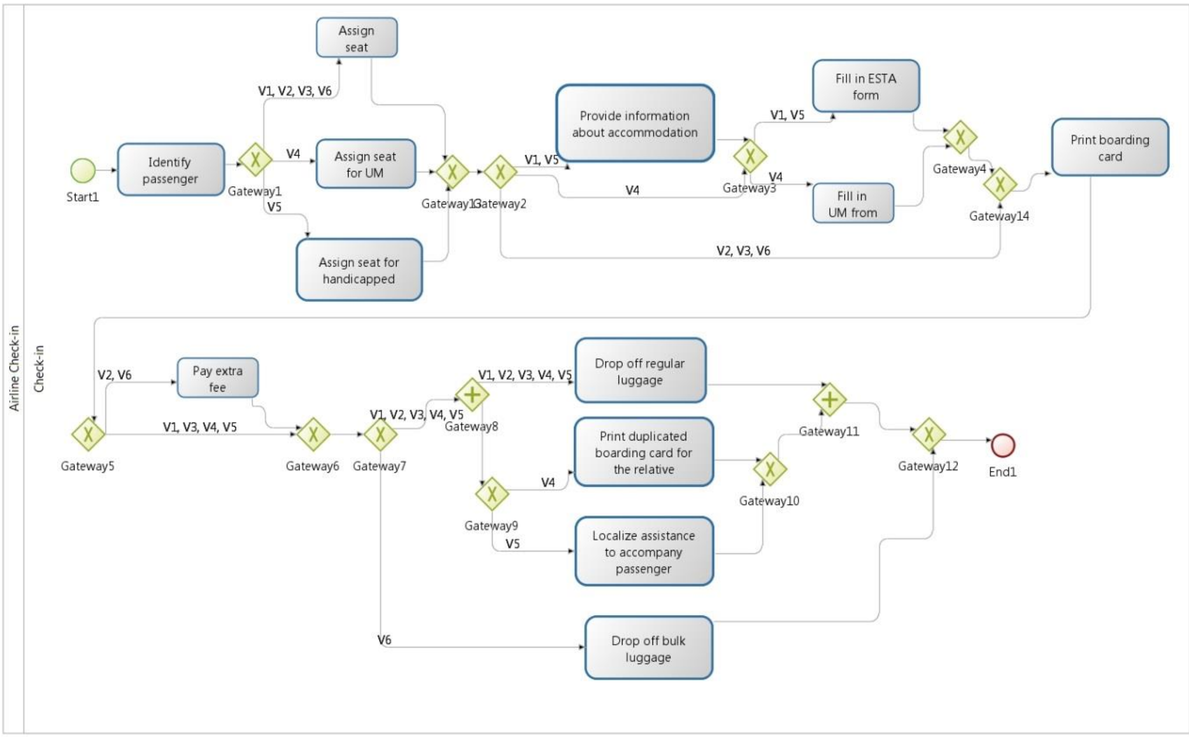


Figure 2-7 All-in-one check-in model

Table 2-3 Result of measurements for Single model of the airline booking process

Metric	Value
Redundancy	0
Complexity	15
Minimal Number of Change Operations	7

2.3 Provop

The main process model, which is based on the variant model shown in Figure 2-3 with related change operations for the airline booking process using the provop approach, is shown in Figure 2-8. The model has a complexity of 0 and redundancy of 0. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 2-1 is 2 because two change operations are performed, “Provide information about accommodation”, and “Fill in ESTA form” are inserted.

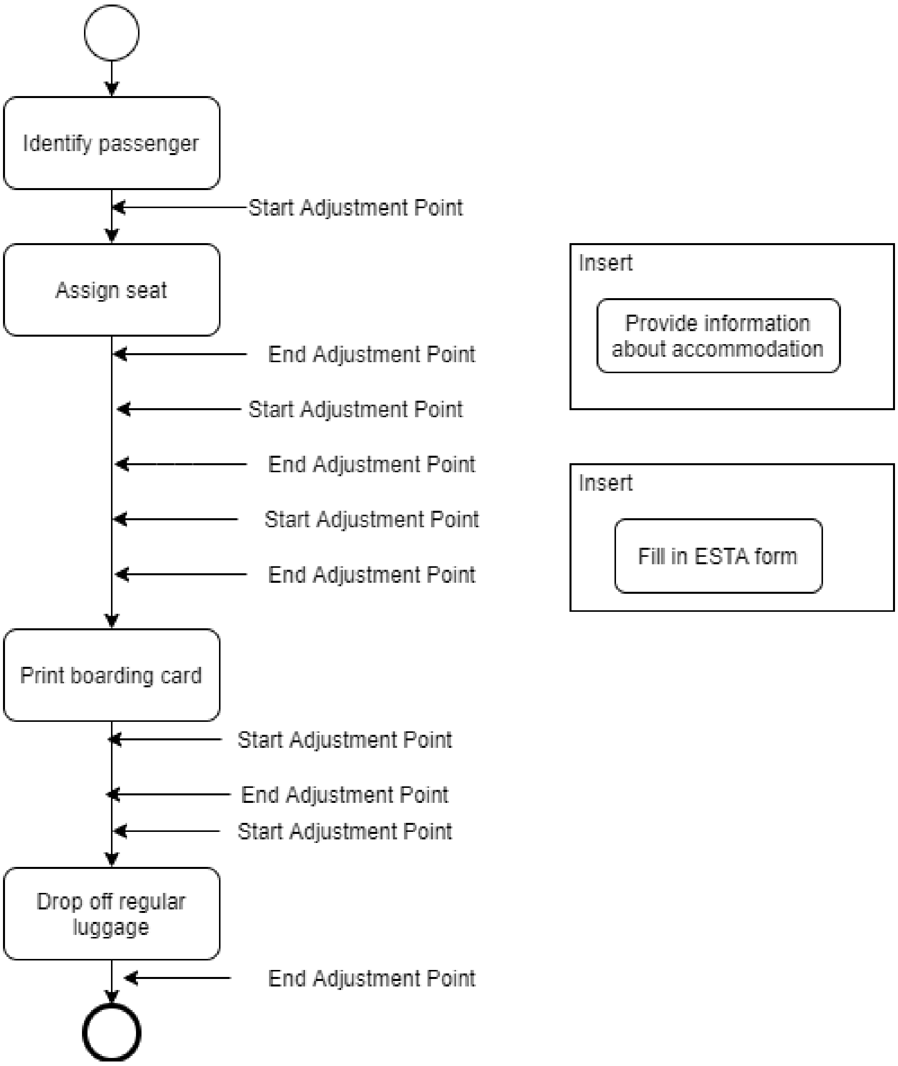


Figure 2-8 Main model for airline booking using Provop

Table 2-4 Measurements for the Provop model for the airline booking process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	2

2.4 PESOA

Figure 2-9 shows that the redundancy is 2 because "Drop off regular luggage" activity occurs three times in the model, the complexity is 12 because each of two fragments has an AND-split which adds a complexity of 2 and the ten association lines add a complexity of 10 which makes a total of 12. The minimal number of change operations for transforming the model in Figure 2-9 to the "to-be" variant represented by the model in Figure 2-1 is 7. In order to achieve this transformation, seven subprocesses will need to be deleted. The measurements for redundancy, complexity, and the minimal number of change operations are summarized in Table 2-5.

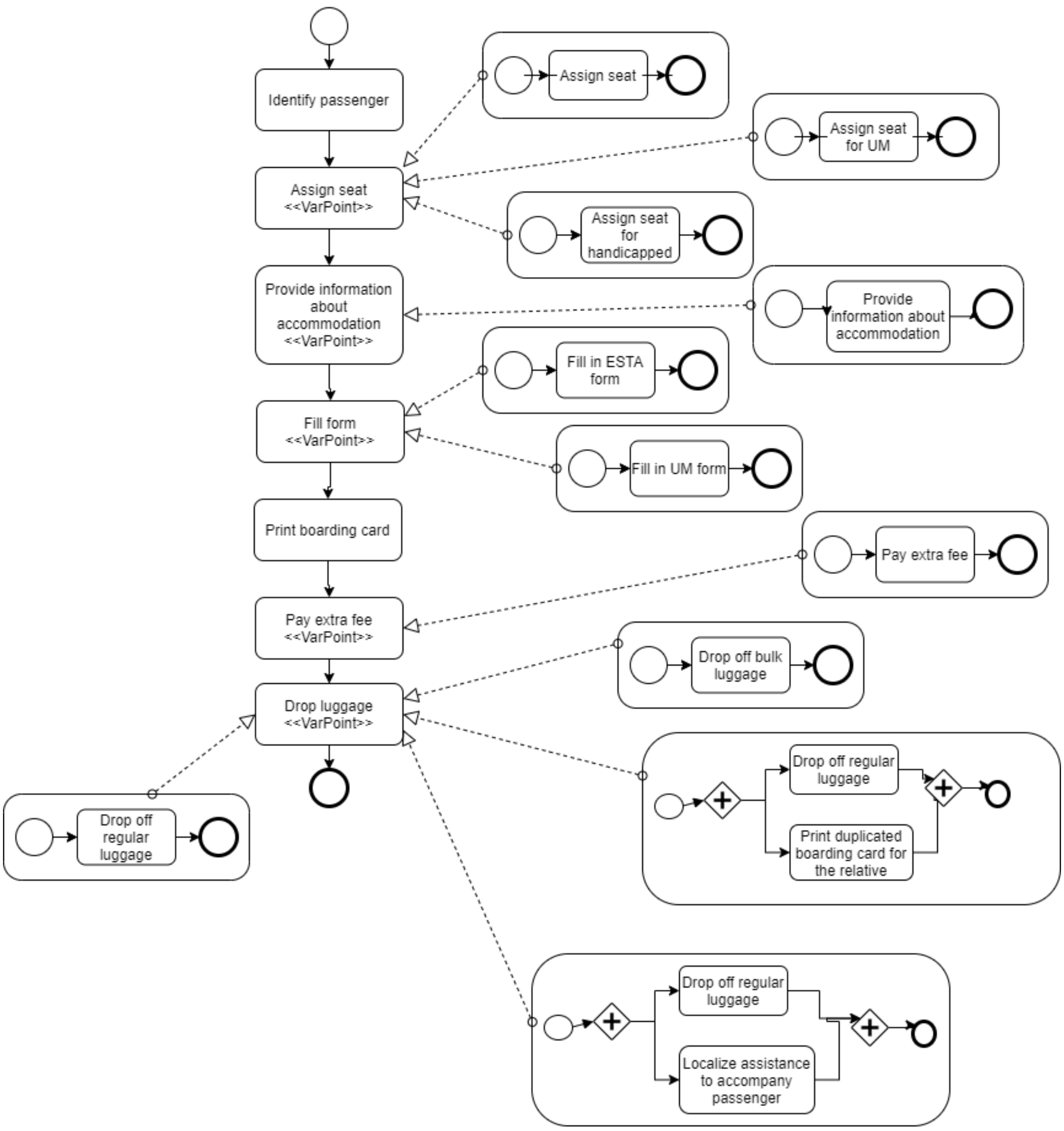


Figure 2-9 PESOA model for the airline booking process

Table 2-5 Measurements for the PESOA model for the airline booking process

Metric	Value
Redundancy	2
Complexity	12
Minimal Number of Change Operations	7

2.5 C-EPC and Configurative Process Modelling

Figure 2-10 shows the EPC model for the airline booking process with the redundancy of functions equals 0. The functions with tick outline such as “Provide information about accommodation” can be included or skipped depending on whether the destination requires accommodation information. The model has five XOR-splits with two outgoing edges, one XOR-split with three outgoing edges and one AND-split with two outgoing edges, making the Control Flow Complexity (CFC) of all splits in the model to be 14. The minimal number of change operations needed to transform the C-EPC model in Figure 2-10 to a variant represented by the model in Figure 2-1 is 7 since seven functions need to be deleted to achieve the transformation. The functions to be deleted are “Assign seat for UM”, “Assign seat for handicapped”, “Fill in UM form”, “Pay extra fee”, “Drop off bulk luggage”, “Print duplicated boarding card for relative” and “Localize assistance to accompany passenger”. The measurements for complexity, redundancy and minimal change operations are summarized in Table 2-6.

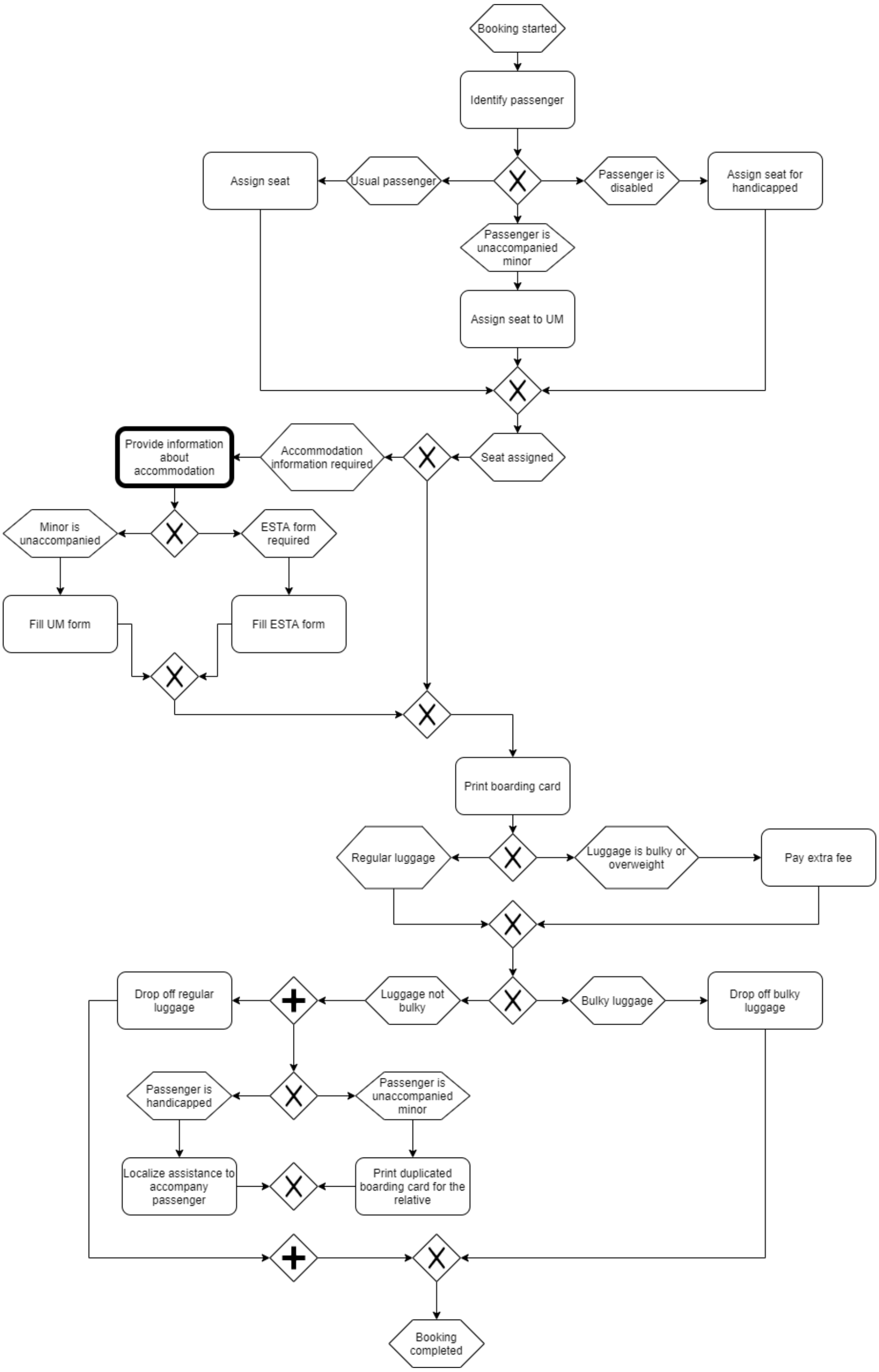


Figure 2-10 C-EPC model for the airline booking process

Table 2-6 Measurements for EPC model for airline booking process students

Metric	Value
Redundancy	0
Complexity	14
Minimal Number of Change Operations	7

2.6 proCollab

Figure 2-11 shows a templet for the airline booking process which is based on the variant in Figure 2-3, with a complexity of 0 since there are no split construct and redundancy of 0 since there are not duplicate activities. To transform the model in Figure 2-11 to a proCollab variant templet which is equivalent to the variant in Figure 2-1 the following change operations will have to be performed: insert “Provide information about accommodation”, and insert “Fill in ESTA form”, which bring the minimal number of change operations required to achieve the transformation to 2. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 2-7.

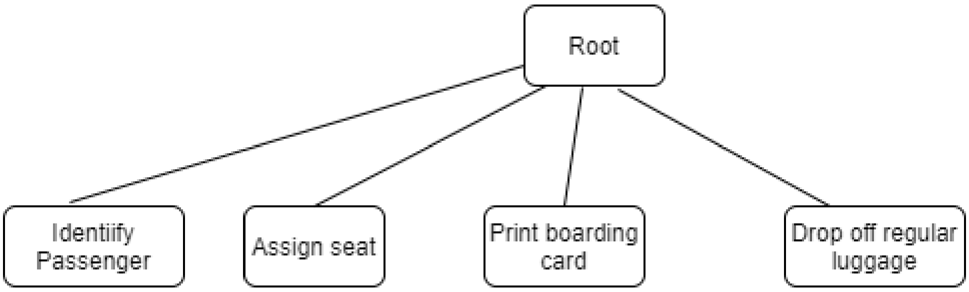


Figure 2-11 proCollab model for the airline booking process

Table 2-7 Measurements for proCollab model for the airline booking process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	2

Chapter 3 Invoice Verification Process

The business process model in Figure 3-1a represent the "to-be" invoice verification process variant that will be derived from the invoice business process ("as-is" business process model) modelled in different business process modelling approaches. The invoice verification process is adapted from (Rosemann and van der Aalst, 2007).

3.1 Multi-Model

Figure 3-1 shows the business process variant of the invoice verification process modelled separately in a multi-model approach using the BPMN modelling language. None of the variants has any split construct, which results in a complexity of 0 across the variants. The redundancy across variants is 2, as shown in Table 3-1. The minimal change operations are the number of activities added to create an entirely new variant model in Figure 3-1a, which is 2. The results of the measurements are summarized in Table 3-2.

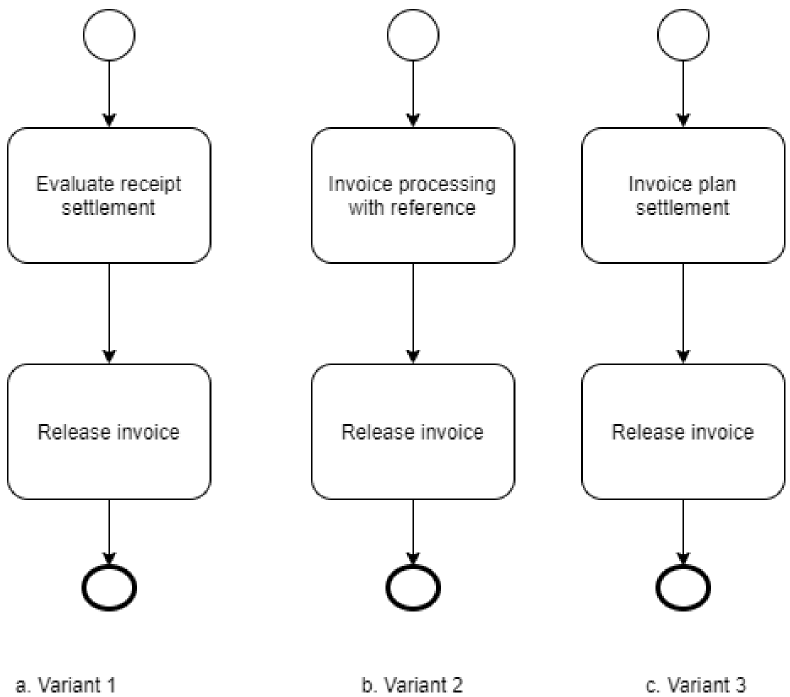


Figure 3-1 Multi-model for invoice verification process

Table 3-1 Redundancy of activities in Multi-model for invoice verification process

Activity	Occurrences(x)	Duplicates(x-1)
Release invoice	3	2
Redundancy		2

Table 3-2 Measurements for Multi-model for invoice verification process

Metric	Value
Redundancy	2
Complexity	0
Minimal Number of Change Operations	2

3.2 Single Model

The single model for the invoice verification process is shown in Figure 3-2, and it is modelled using the BPMN standard. The single model has a redundancy of 0. The model has one XOR-split with three outgoing edges (CFC is 3) which makes the Control Flow Complexity (CFC) of all splits in the model to be 3. The minimal number of change operations needed to transform the single model to the “to-be” represented by the variant in Figure 3-1a is 2. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 3-3.

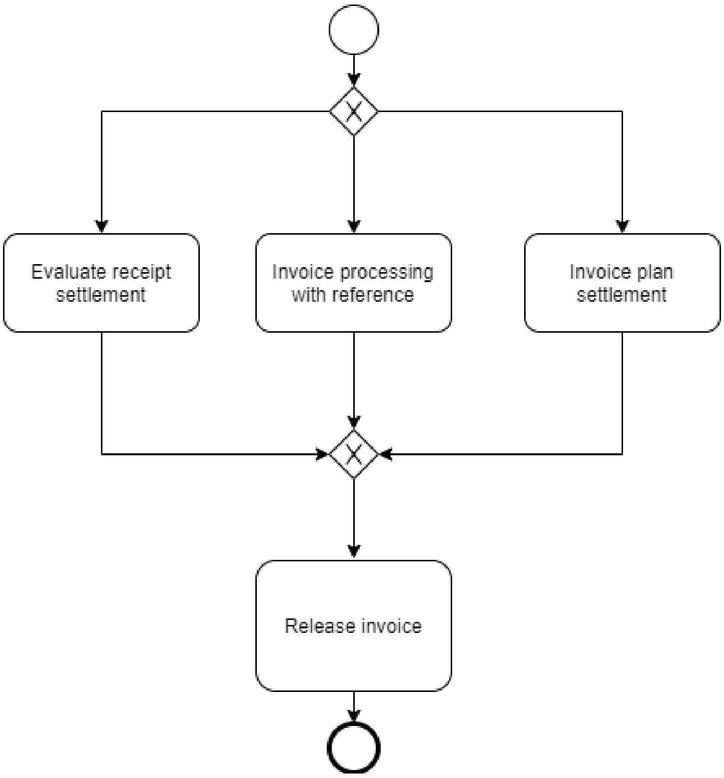


Figure 3-2 Single model for invoice verification process

Table 3-3 Measurements from Single model for invoice verification process

Metric	Value
Redundancy	0
Complexity	3
Minimal Number of Change Operations	2

3.3 Provop

The Provop model for the invoice verification process is shown in Figure 3-3 with the main process model based on the variant model shown in Figure 3-1c, and with related change operations. The model has a complexity of 0 and redundancy of 0. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 3-1a is 2 because two change operations are performed, “Invoice plan settlement” is deleted, and “Evaluate receipt settlement” is inserted. The measurements are summarized in Table 3-4.

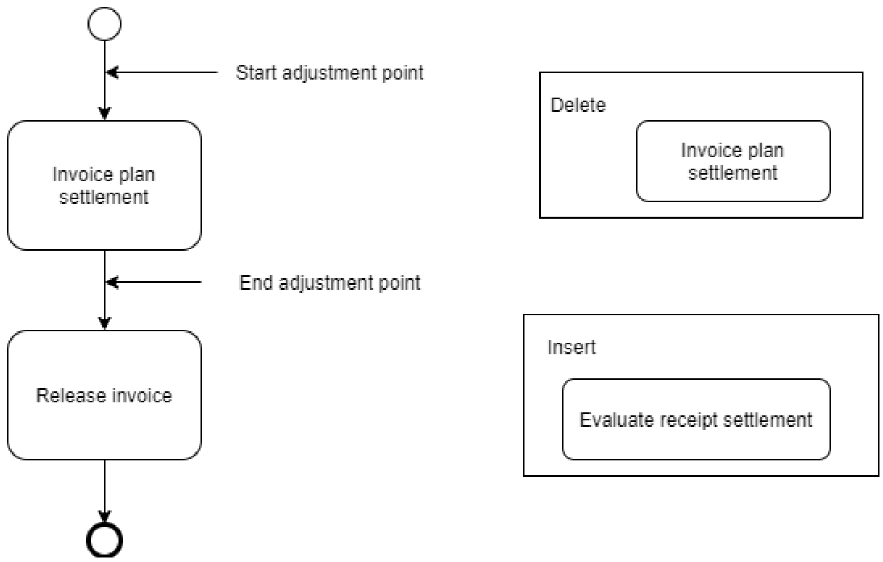


Figure 3-3 Provop model for invoice verification process

Table 3-4 Measurements from Provop model for invoice verification process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	2

3.4 PESOA

The PESOA model for the invoice verification process in Figure 3-4 shows that the redundancy is 0; the complexity is 3 because the three association lines add the complexity of 3. The minimal number of change operations for transforming the model in Figure 3-4 to the "to-be" variant represented by the model in Figure 3-1a is 2 because two subprocesses will need to be deleted to achieve the transformation. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 3-5.

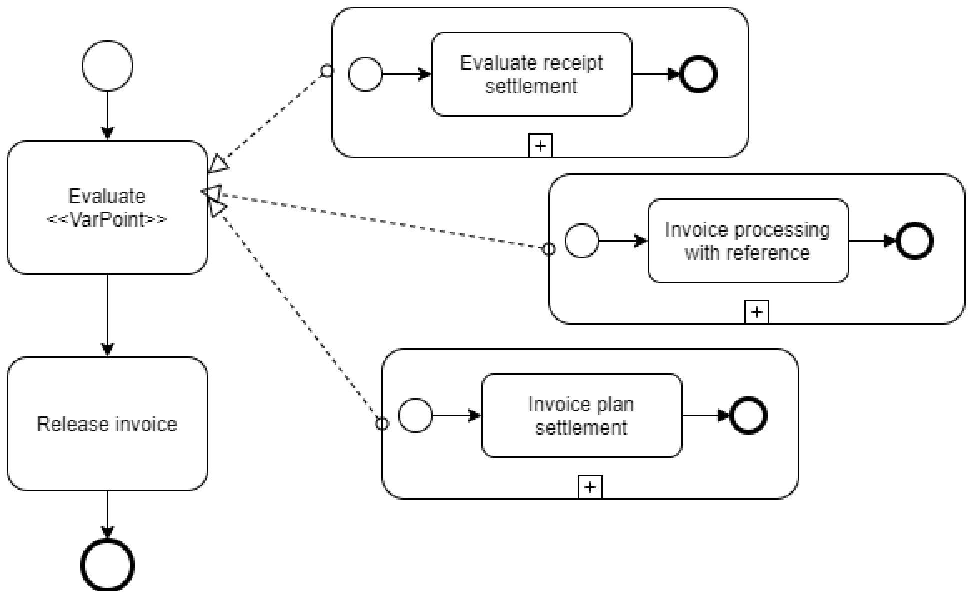


Figure 3-4 PESOA model for invoice verification process

Table 3-5 Measurements from PESOA model for invoice verification process

Metric	Value
Redundancy	0
Complexity	3
Minimal Number of Change Operations	2

3.5 C-EPC and Configurative Process Modelling

The C-EPC model for invoice verification process in Figure 3-5 shows that the redundancy of functions equal 0. The model has one XOR-splits with three outgoing edges, making the Control Flow Complexity (CFC) of all splits in the model to be 3. The minimal number of change operations needed to transform the C-EPC model in Figure 3-5 to a variant represented by the model in Figure 3-1a is 2 since two functions need to be deleted to achieve the transformation. The functions to be deleted are “Invoice Processing with Reference”, and “Invoice Plan Settlement”. The measurements for complexity, redundancy and the minimal number change operations are summarized in Table 3-6.

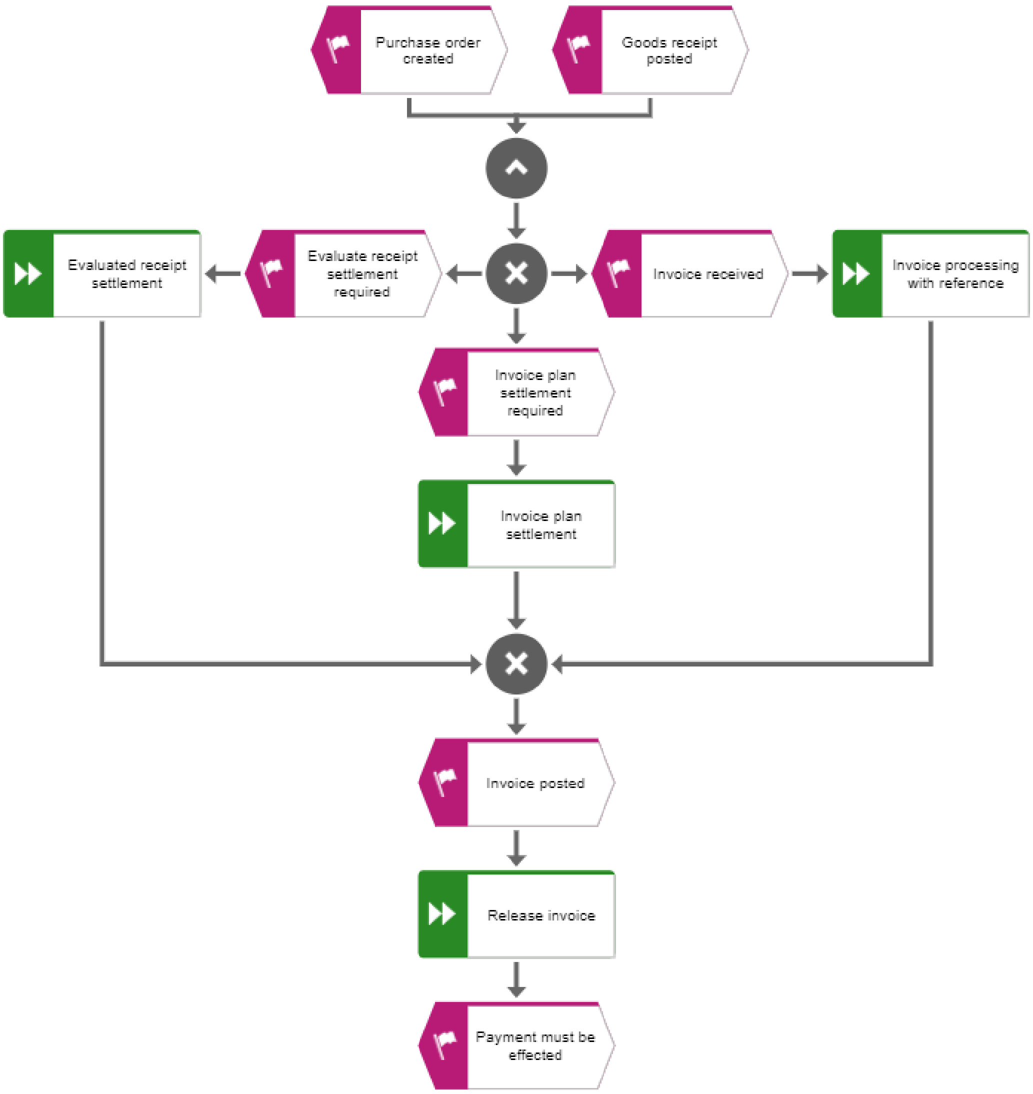


Figure 3-5 C-EPC model for invoice verification process (Rosemann and van der Aalst, 2007)

Table 3-6 Measurements from C-EPC model for invoice verification process

Metric	Value
Redundancy	0
Complexity	3
Minimal Number of Change Operations	2

3.6 proCollab

Figure 3-6 shows a templet for the invoice verification process which is based on the variant in Figure 3-1c, with a complexity of 0 since there are no split construct and redundancy of 0 since there are no duplicate activities. To transform the model in Figure 3-6 to a proCollab variant templet which is equivalent to the variant in Figure 3-1c the following change operations will have to be performed: delete “Invoice plan settlement”, and insert “Evaluate receipt settlement”, which bring the minimal number of change operations required to achieve the transformation to 2. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 3-7.

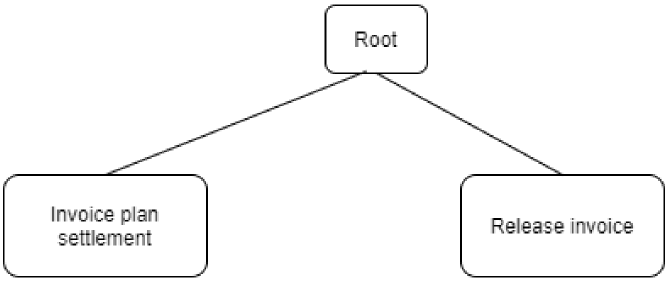


Figure 3-6 proCollab model for invoice verification process

Table 3-7 Measurements from proCollab model for invoice verification process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	2

Chapter 4 Picture Postproduction Process

The business process model in Figure 4-1a represents the "to-be" business process variant that will be derived from the picture postproduction business process ("as-is" business process model) modelled in different business process modelling approaches. We will use the picture postproduction business process presented in (Rosa *et al.*, 2017).

4.1 Multi-Model

Figure 4-1 shows the model for business variants for the picture postproduction process, which are modelled separately using the BPMN modelling language. The variant shown in Figure 4-1d has two AND-splits with two outgoing edges, which results in a complexity of 2. The variant shown in Figure 4-1e has one XOR-split with two outgoing edges, which adds a complexity of 2, and the variant in Figure 4-1f has one XOR-split with two outgoing edges which adds a complexity of 2. The total complexity across the variants is 6 when the complexities for all variants are added together. The redundancy of all the variants is 27 as can be seen from Table 4-1. The minimal number of change operations is the number of activities added to create an entirely new variant model in Figure 4-1a, which is 5.

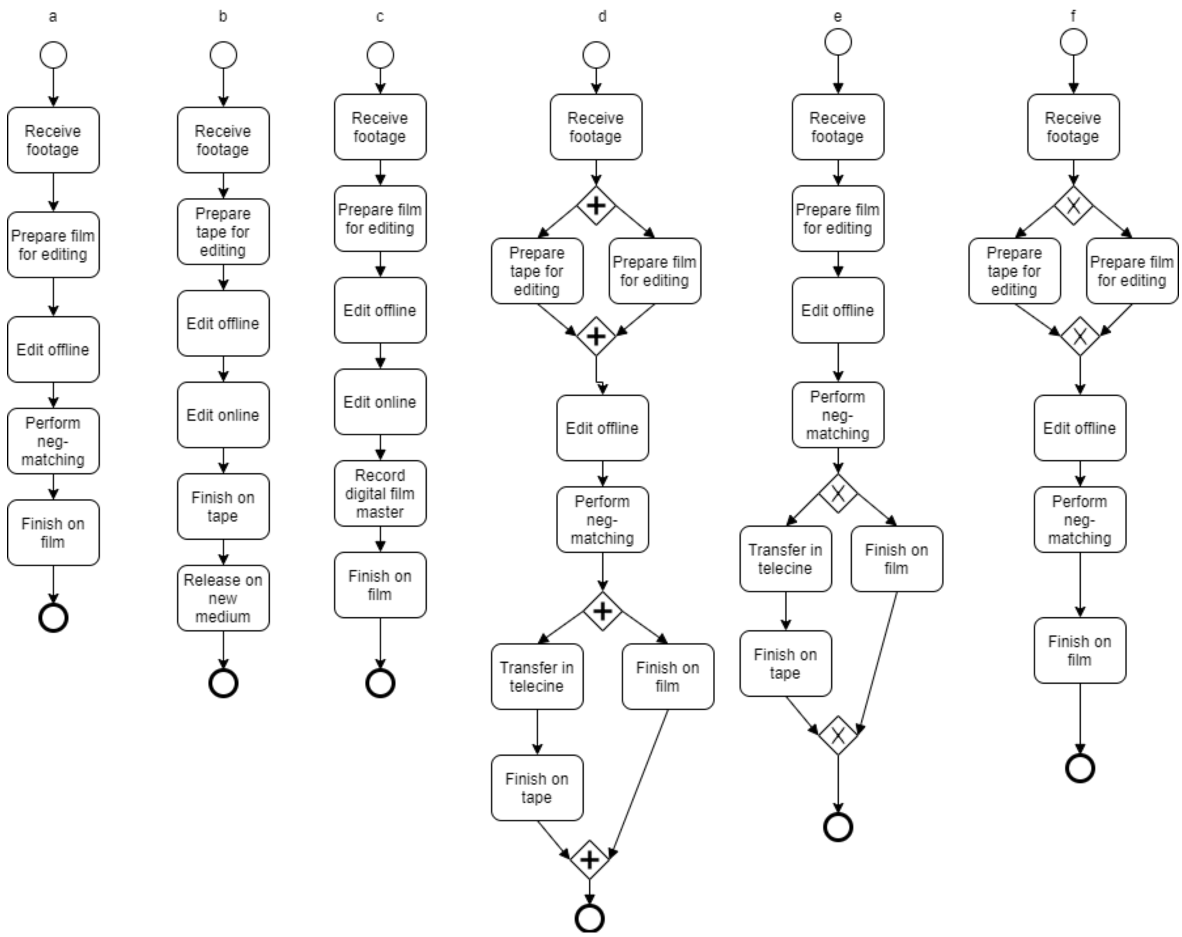


Figure 4-1 Multi-model for picture postproduction process

Table 4-1 Redundancy of activities for Multi-model of the picture postproduction process

Activity	Occurrences(x)	Duplicates(x-1)
Receive footage	6	5
Prepare film for editing	5	4
Edit offline	6	5
Perform negmatching	4	3
Prepare tape for editing	3	2
Finish on film	5	4
Edit online	2	1
Finish on tape	3	2
Release on new medium	1	0
Record digital film master	1	0
Transfer in telecine	2	1
Redundancy		27

Table 4-2 Measurements from multi-model for picture postproduction

Metric	Value
Redundancy	27

Complexity	6
Minimal Number of Change Operations	5

4.2 Single Model

The single model for the picture postproduction process is shown in Figure 4-2, and it is modelled using the BPMN standard. The model has a redundancy of 0. The model has four XOR-splits with two outgoing edges (CFC is 8), and two OR-split with two outgoing edges (CFC is 6), which makes the Control Flow Complexity (CFC) of all splits of the model to be 14. The minimal number of change operations needed to transform the single model to the “to-be” represented by the variant in Figure 4-1a is 6. In order to achieve the transformation, the following operations will need to be performed: deleting of “Prepare tape for editing”, “Edit online”, “Transfer in telecine”, “Finish on tape”, “Record digital film master”, and “Release on new medium”. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 4-3.

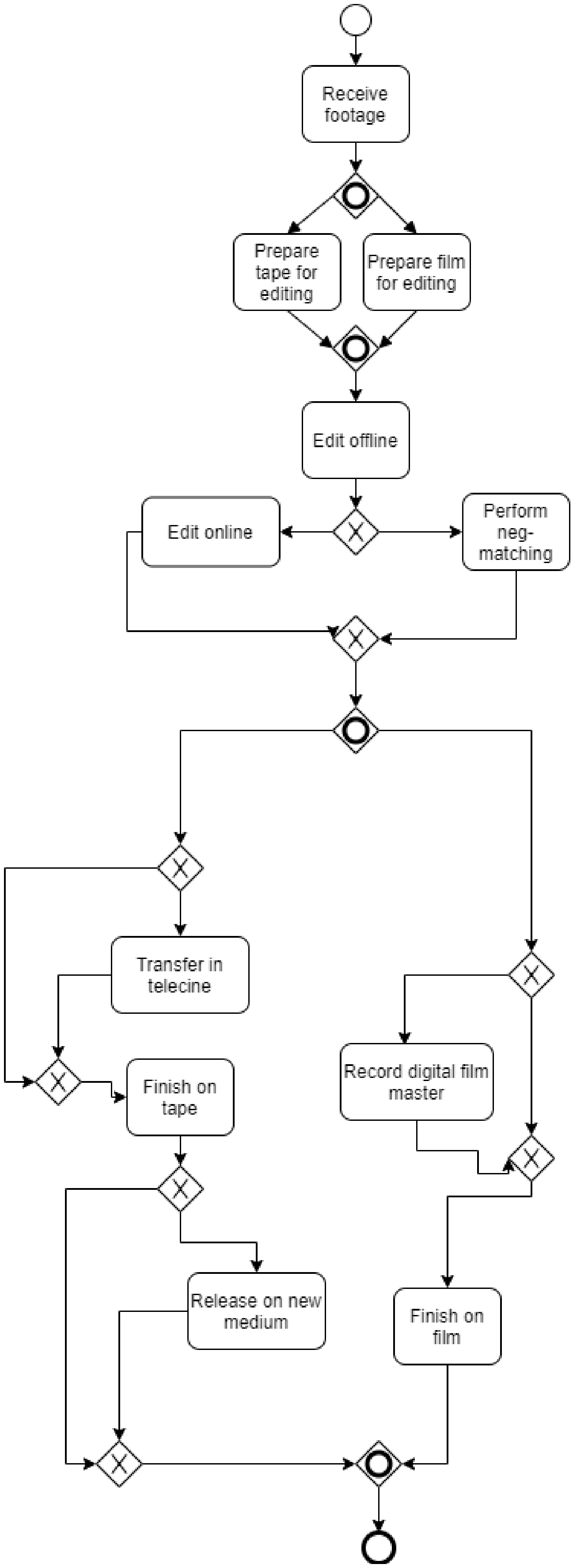


Figure 4-2 Single model for picture postproduction process

Table 4-3 Measurements from a single model for picture postproduction

Metric	Value
Redundancy	0
Complexity	14
Minimal Number of Change Operations	6

4.3 C-EPC and Configurative Process Modelling

Figure 4-3 shows the EPC model for the picture postproduction process with the redundancy of functions equal to 0. The model has three OR-split with two outgoing edges each, which results in a Control Flow Complexity of 9. The minimal number of change operations needed to transform the C-EPC model in Figure 4-3 to a variant represented by the model in Figure 4-1a is 6. This transformation is achieved by deleting the activities: "Prepare tape for editing", and "Edit online"; and skipping: "Transfer in telecine", "Finish on tape", "Record digital film master", and "Release on new medium". The functions with tick outline such as the "Transfer in telecine" can be included or skipped depending on the event before and the result of the evaluation of variables. The measurements for complexity, redundancy and minimal change operations are summarized in Table 4-4.

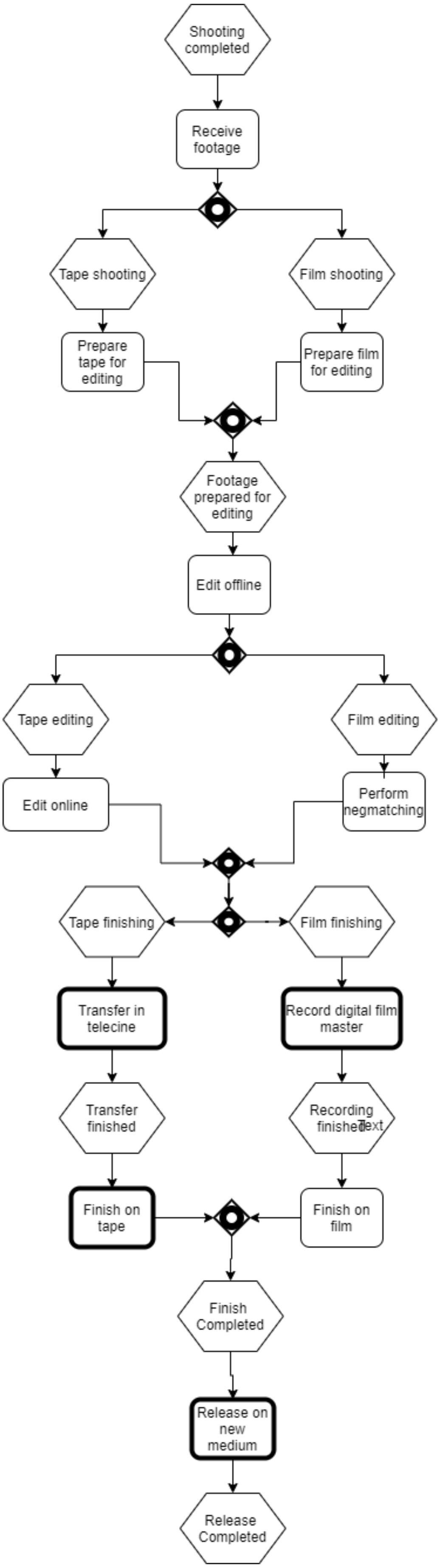

Shooting completed
Receive footage
Tape shooting
Film shooting
Prepare tape for editing
Prepare film for editing
Footage prepared for editing
Edit offline
Tape editing
Film editing
Edit online
Perform negmatching
Tape finishing
Film finishing
Transfer in telecine
Record digital film master
Transfer finished
Recording finished
Text
Finish on tape
Finish on film
Finish Completed
Release on new medium
Release Completed

Figure 4-3 C-EPC model for picture postproduction (Rosa et al., 2017)

Table 4-4 Measurements from C-EPC model for picture postproduction

Metric	Value
Redundancy	0
Complexity	9
Minimal Number of Change Operations	6

4.4 Provop

The main process model for the picture postproduction, which is based on the variant model shown in Figure 4-1d with related change operations is shown in Figure 4-4. The model has a redundancy of 0, and a complexity of 2, which is added by the two AND-split. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 4-1a is 4 because the activities, “Prepare tape for editing”, “Transfer in telecine”, and “Finish on tape” will be deleted, and the “Finish on film” will be moved as shown in the Figure 4-4. The measurements are summarized in Table 4-5.

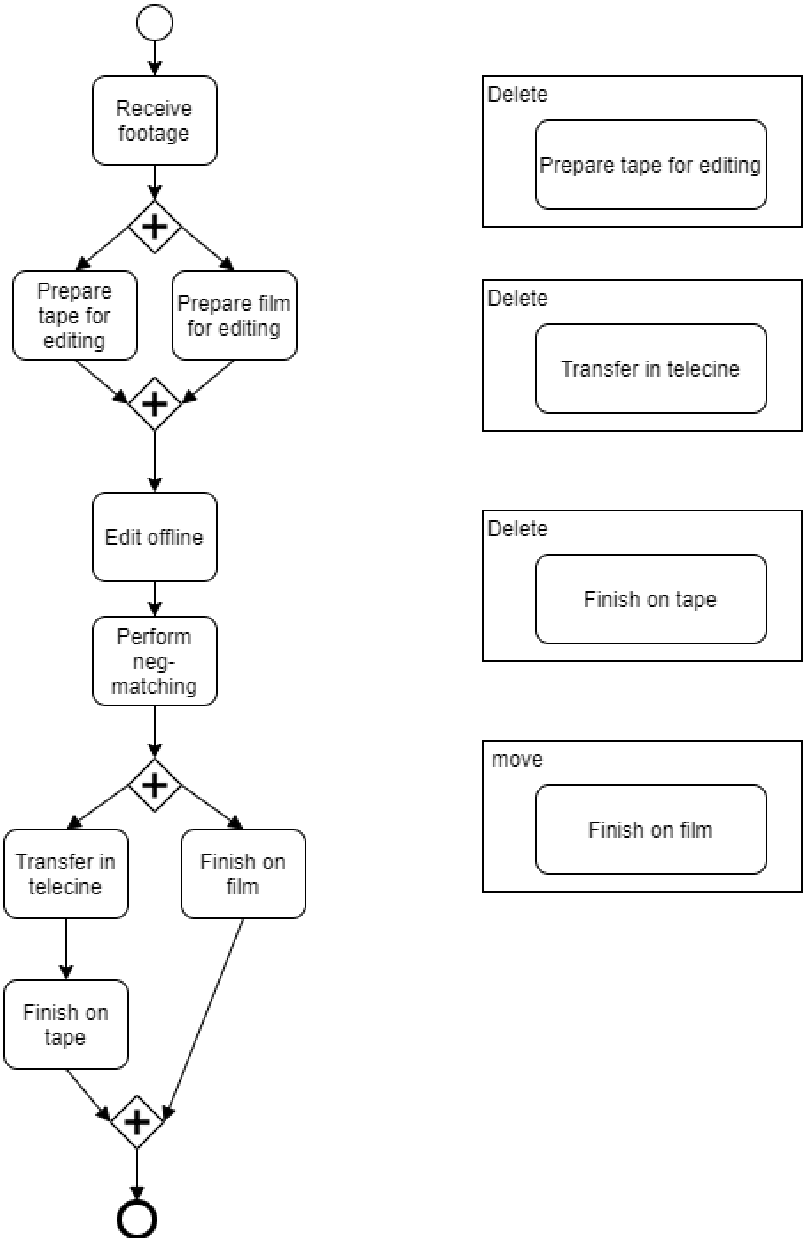


Figure 4-4 Provop model for picture postproduction

Table 4-5 Measurements from Provop model for picture postproduction

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	4

4.5 proCollab

Figure 4-5 shows a templet for the picture postproduction process which is based on the variant in Figure 4-1d, with a complexity of 2, because of the two AND-split and redundancy of 0 since there are no duplicate activities. To transform the model in Figure 4-5 to a proCollab variant templet which is equivalent to the variant in Figure 4-1a, the change operations, delete “Prepare tape for editing”, “Transfer in telecine”, and “Finish on tape”; and move “Finish on film” will be performed. The transformation results in a minimal number of change operations which is equal to 4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 4-6.

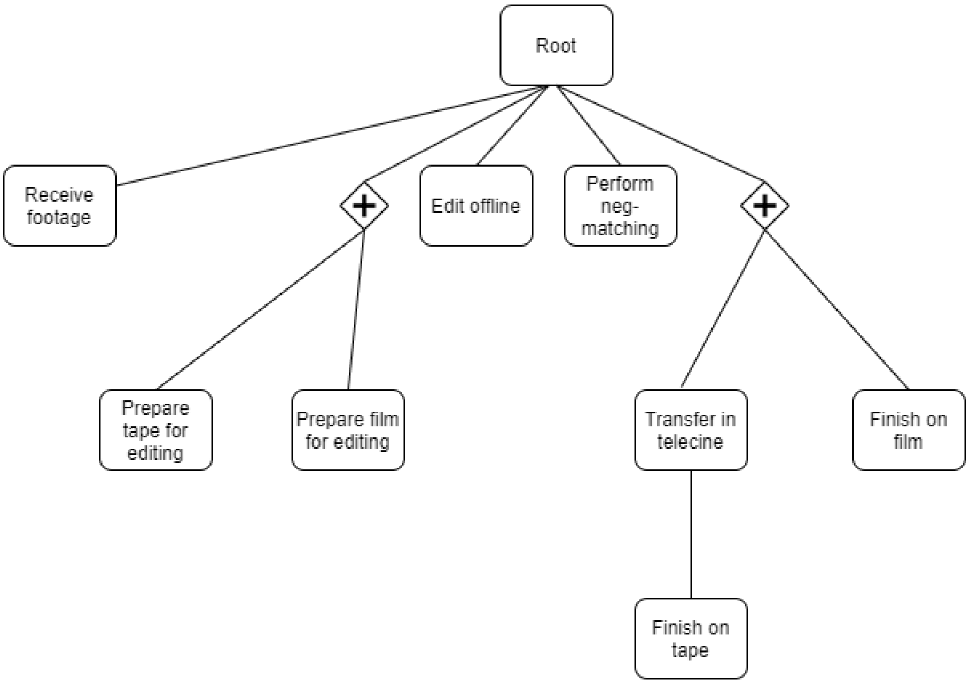


Figure 4-5 proCollab model for picture postproduction

Table 4-6 Measurements from proCollab model for picture postproduction

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	4

4.6 PESOA

Figure 4-6 shows the PESOA model for the picture postproduction process with a redundancy of 2. It has one XOR-split with two outgoing edges (adds a CFC of 2), one OR-split with two outgoing edges (adds a CFC of 3) and one AND-split (adds a CFC of 1), making the complexity of the model to be 6. The minimal number of change operations for transforming the model in Figure 4-6 to the “to-be” variant represented by the model in Figure 4-1a is 6. In order to achieve this transformation, five subprocesses and one activity will need to be deleted. The measurements for the redundancy, complexity and the minimal number of change operations are summarized in Table 4-7.

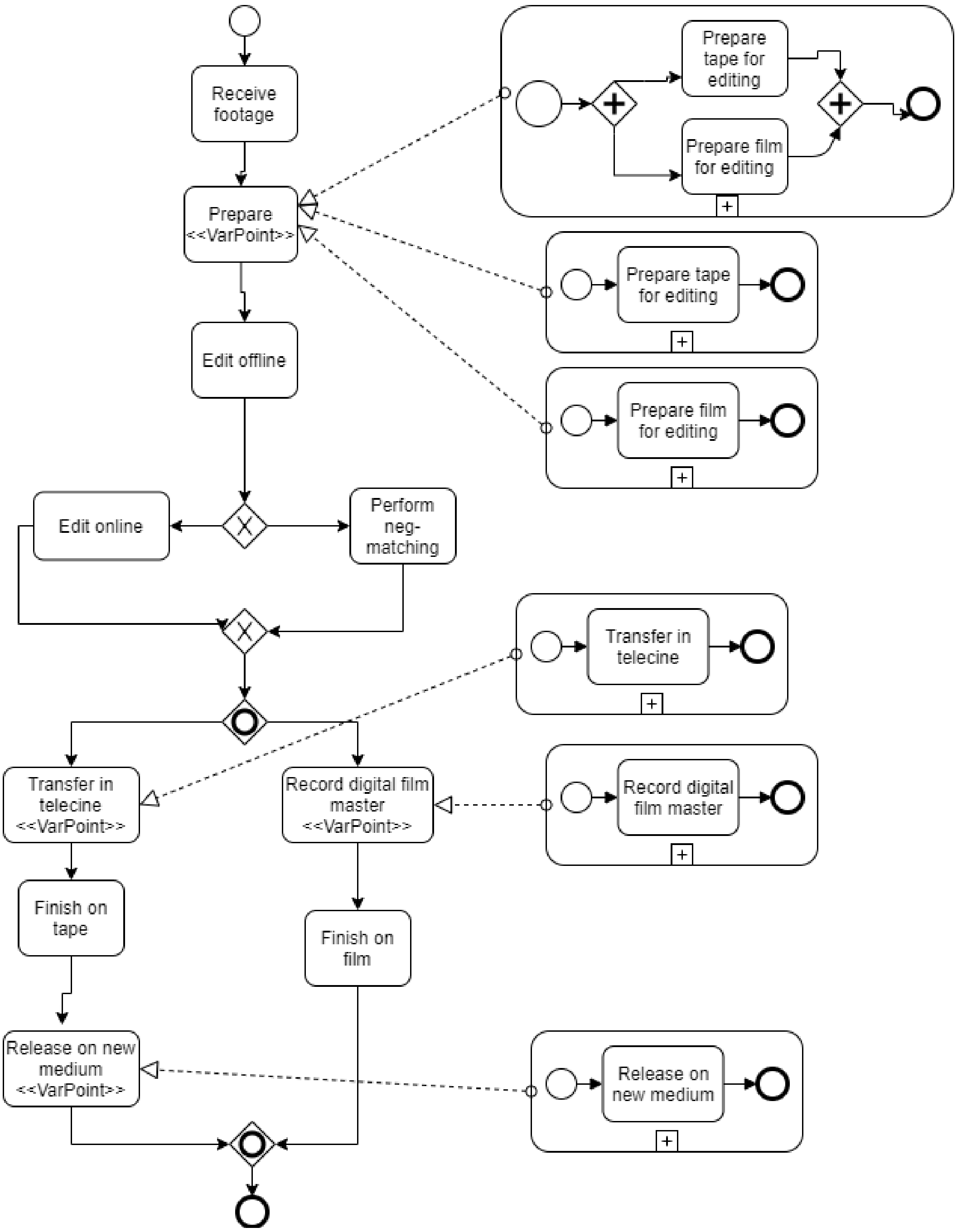


Figure 4-6 PESOA model for picture postproduction

Table 4-7 Measurements from PESOA model for picture postproduction

Metric	Value
Redundancy	2
Complexity	6
Minimal Number of Change Operations	6

Chapter 5 Vehicle Repair Process

The business process model in Figure 5-1d represents the "to-be" business process variant that will be derived from the vehicle repair business process ("as-is" business process model) modelled in different business process modelling approaches. We will use the vehicle repair business process presented in (Hallerbach, Bauer and Reichert, 2010).

5.1 Multi-Model

Figure 5-1shows the Multi model for the vehicle repair process modelled using the BPMN modelling language. The redundancy across variants is 12, as shown in Table 5-1. The variant in Figure 5-1a has one AND-split with two outgoing edges (adding a CFC of 1) and one XOR-split with two outgoing edges (adding a CFC of 2). The variant in Figure 5-1b has one XOR-split with two outgoing edges (adding a CFC of 2). The variant in Figure 5-1c has one AND-split with two outgoing edges (adding a CFC of 1), and one XOR-split with two outgoing edges (adding a CFC of 2). The variant in Figure 5-1d has one XOR-split with two outgoing edges (adding a CFC of 2). The CFC across the variants is 10. The minimal number of change operations is 5, which is the number of activities needed to model the "to-be" shown in Figure 5-1d from scratch. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 5-2.

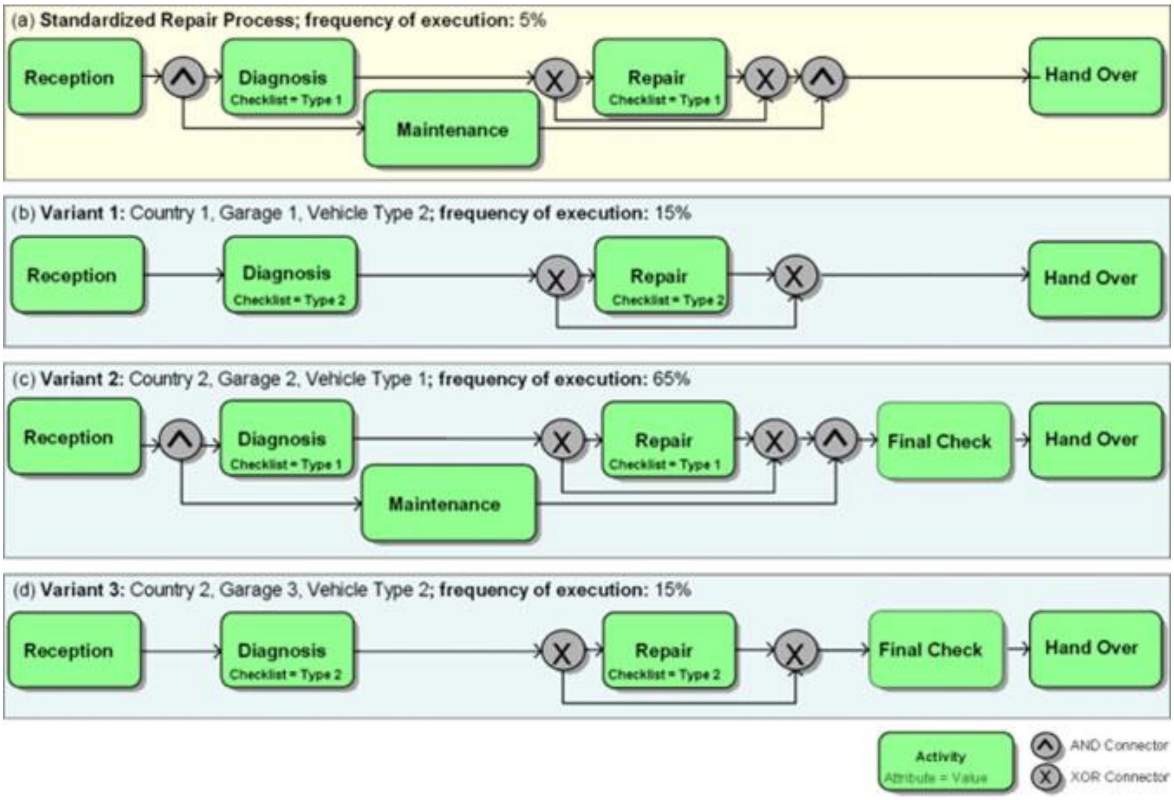


Figure 5-1 Multi-model for the vehicle repair process (Hallerbach, Bauer and Reichert, 2010)

Table 5-1 Redundancy of activities in Multi model for the vehicle repair process

Activity	Occurrences(x)	Duplicates(x-1)
Reception	4	3
Diagnosis Checklist = Type 1	2	1
Diagnosis Checklist = Type 2	2	1
Maintenance	2	1
Repair Checklist = Type 1	2	1
Repair Checklist = Type 2	2	1
Final Check	2	1
Hand Over	4	3
Redundancy		12

Table 5-2 Measurements from Multi model for the vehicle repair process

Metric	Value
Redundancy	12
Complexity	10
Minimal Number of Change Operations	5

5.2 Single Model

The single model for the vehicle repair process is shown in Figure 5-2, and it is modelled using the BPMN standard. The model has a redundancy of 0. The single model has one AND-split with two outgoing edges (CFC is 1), three XOR-splits with two outgoing edges (CFC is 6), and one XOR-splits with three outgoing edges (CFC is 3), which make a total CFC of 10. The minimal number of change operations needed to transform the single model to the "to-be" represented by the variant in Figure 5-1d is 3. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 5-3.

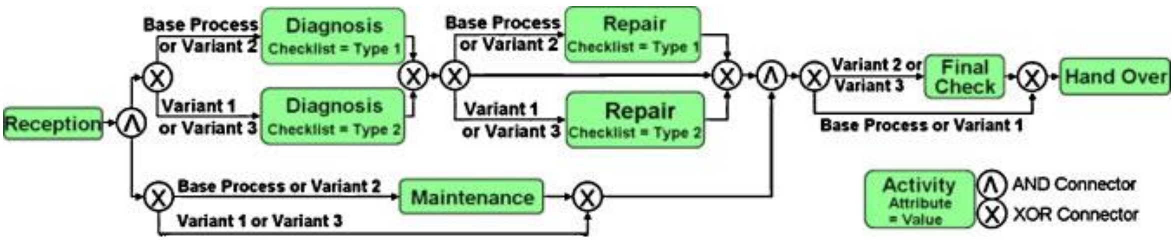


Figure 5-2 Single model for the vehicle repair process (Hallerbach, Bauer and Reichert, 2010)

Table 5-3 Measurements from Single model for the vehicle repair process

Metric	Value
Redundancy	0
Complexity	10
Minimal Number of Change Operations	3

5.3 C-EPC and Configurative Process Modelling

Figure 5-3 shows the EPC model for the vehicle repair process with the redundancy of functions equal to 0. The model has two XOR-splits with two outgoing edges (adding a CFC of 4), and one AND-split with two outgoing edges (adding a CFC of 1), which make a total CFC of 5. The minimal number of change operations needed to transform the C-EPC model in Figure 5-3 to a variant represented by the model in Figure 5-1a is 3. To achieve the transformation, the activities, “Diagnosis Checklist = Type 1”, and “Repair Checklist = Type 1” will have to be deleted and the activity “Maintenance” will be skipped, making a total of three operations. The measurements for complexity, redundancy and minimal change operations are summarized in Table 5-4.

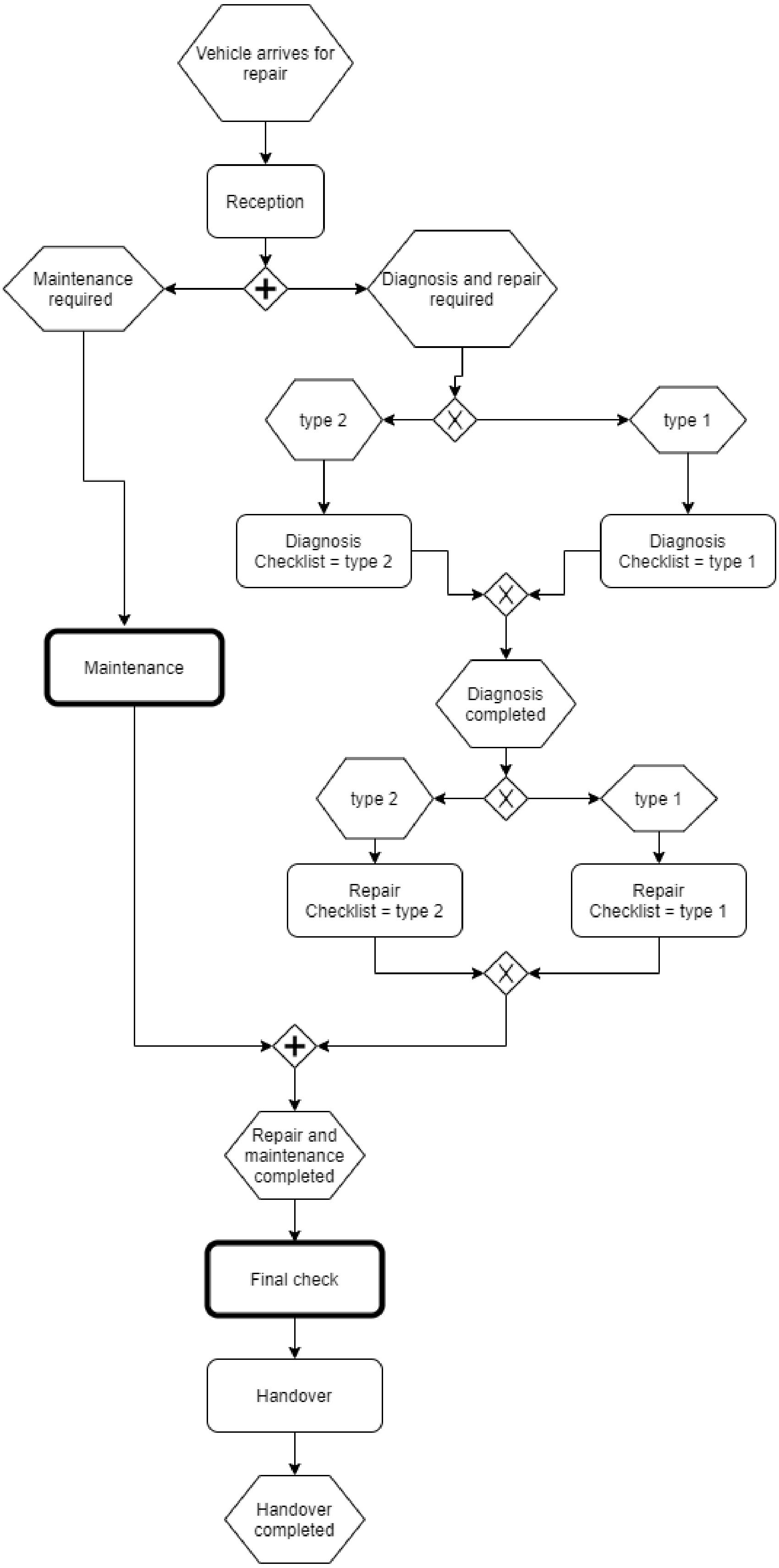


Figure 5-3 C-EPC model for the vehicle repair process

Table 5-4 Measurements from C-EPC model for the vehicle repair process

Metric	Value
Redundancy	0
Complexity	5
Minimal Number of Change Operations	3

5.4 Provop

Figure 5-4 shows the provop model for the vehicle repair process with related change operations where the main process model is based on the variant model shown in Figure 5-1a. The model has a redundancy of 0 and a complexity of 3. The model has one AND-split with two outgoing edges (adding CFC of 1) and one XOR-split with two outgoing edges (adding CFC of 2), which results to a total CFC of 3. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 5-1d is 4, as can be seen in Figure 5-4b.

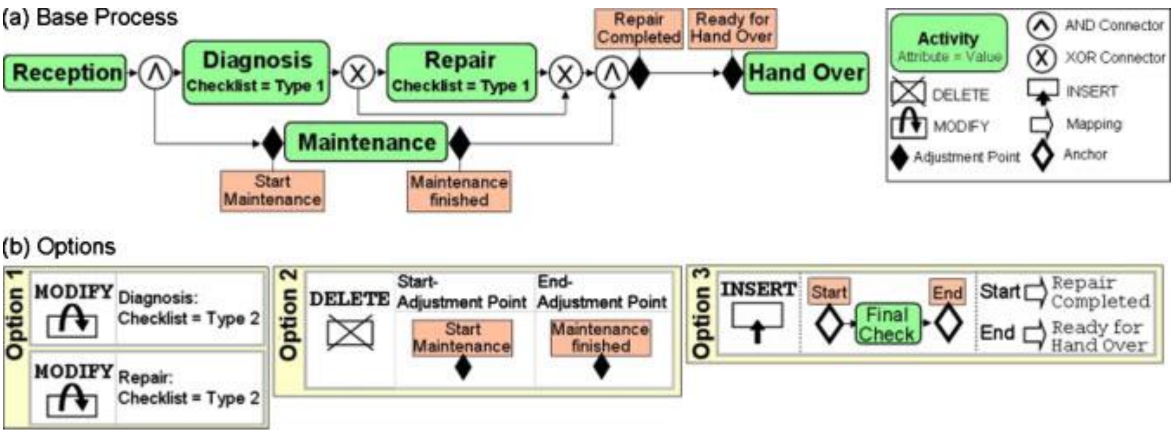


Figure 5-4 Provop model for the vehicle repair process (Hallerbach, Bauer and Reichert, 2010)

Table 5-5 Measurements from Provop model for the vehicle repair process

Metric	Value
Redundancy	0
Complexity	3
Minimal Number of Change Operations	4

5.5 proCollab

Figure 5-5 shows a templet for the vehicle repair process, which is based on the variant in Figure 5-1a. The model has a redundancy of 0 and a complexity of 2. To transform the model in Figure 5-5 to a proCollab variant templet which is equivalent to the variant in Figure 5-1d the following change operations will have to be performed: delete the activities, “Maintenance”, “Diagnosis Checklist Type = 1”, and “Repair Checklist Type = 1”; and insert “Diagnosis Checklist Type = 2”, “Repair Checklist Type = 2”, and “Final Check”, which gives a total 6 change operations. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 5-6.

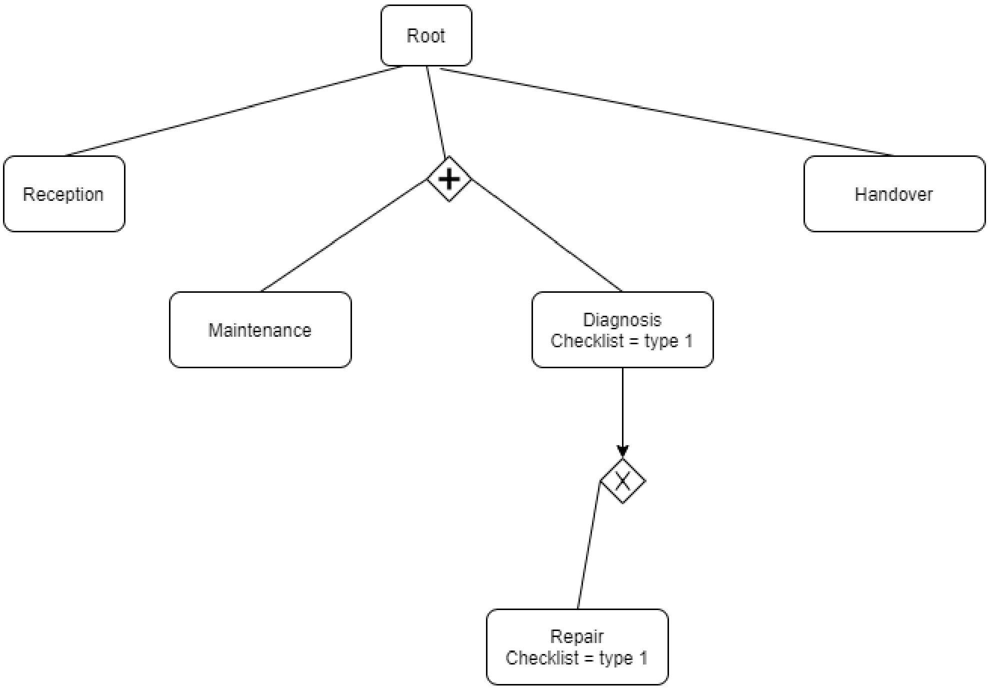


Figure 5-5 proCollab model for the vehicle repair process

Table 5-6 Measurements from proCollab model for the vehicle repair process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	6

5.6 PESOA

Figure 5-6 shows the PESOA model for the vehicle repair process. The model has a redundancy of 0 and a complexity of 7. One AND-split adds a CFC of 1 and the six association lines add a CFC of 6, which totals to 7. The minimal number of change operations for transforming the model in Figure 5-6 to the “to-be” variant represented by the model in Figure 5-1d is 3. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 5-7.

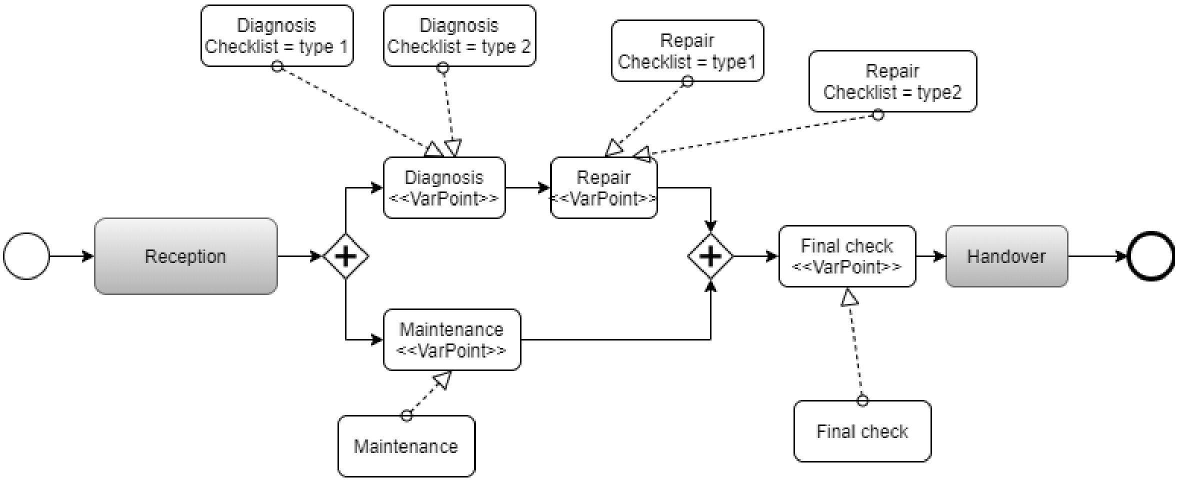


Figure 5-6 PESOA model for the vehicle repair process

Table 5-7 Measurements from PESOA model for the vehicle repair process

Metric	Value
Redundancy	0
Complexity	7
Minimal Number of Change Operations	3

Chapter 6 Foreign Exchange (FX) and Money Market (MM) Process

The business process model in Figure 6-1a represents the "to-be" business process variant that will be derived from the foreign exchange and money market business process ("as-is" business process model) modelled in different business process modelling approaches. The foreign exchange (FX) and money market (MM) process are adapted from (Milani *et al.*, 2016).

6.1 Multi-Model

Figure 6-1 shows the Multi model for the foreign exchange and money market process modelled separately using the BPMN modelling language. The multi-model has a redundancy of 7 as can be seen from Table 6-1. The CFC is 4 because of two XOR-split with two outgoing edges. The minimal number of change operations needed to model the variant Figure 6-1a is 7. The summary of the measurements is in Table 6-2.

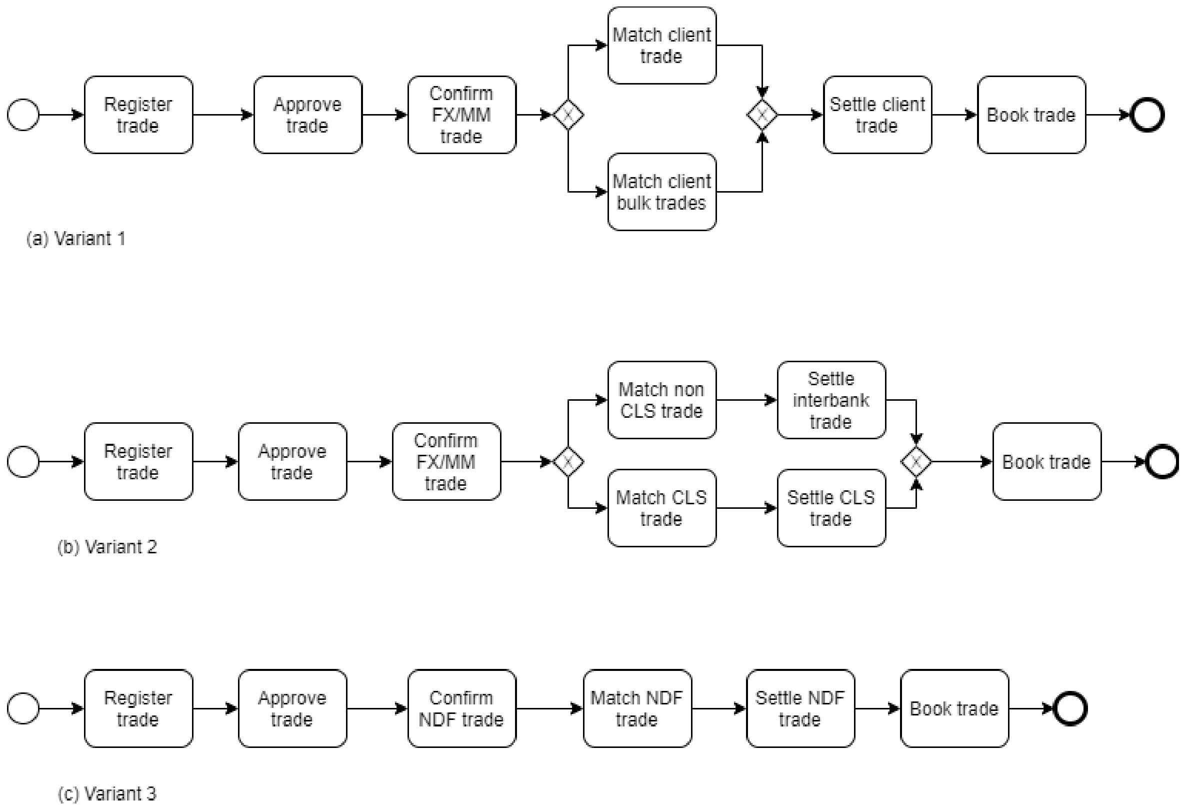


Figure 6-1 Multi-model for foreign exchange and money market process

Table 6-1 Redundancy of activities in Multi model for the foreign exchange and money market process

Activity	Occurrences(x)	Duplicates(x-1)
Register trade	3	2
Approve trade	3	2
Confirm FX/MM trade	2	1
Confirm NDF trade	1	0
Match client trade	1	0
Match client bulk trade	1	0
Match non CLS trade	1	0
Match CLS trade	1	0
Match NDF trade	1	0
Book trade	3	2
Settle client trade	1	0
Settle interbank trade	1	0
Settle CLS trade	1	0
Settle NDF trade	1	0
Redundancy		7

Table 6-2 Measurements from Multi model for the foreign exchange and money market process

Metric	Value
Redundancy	7
Complexity	4
Minimal Number of Change Operations	7

6.2 Single Model

The single model for the foreign exchange and money market process is shown in Figure 6-2, and it is modelled using the BPMN standard. The model has a redundancy of 0. The model has four XOR-splits with two outgoing edges (CFC is 8), which makes the Control Flow Complexity (CFC) of all splits in the model to be 8. The minimal number of change operations needed to transform the single model to the "to-be" represented by the variant in Figure 6-1a is 7. The transformation can be achieved by deleting the following activities: "Confirm NDF trade", "Match non-CLS trade", "Match CLS trade", "Match NDF trade", "Settle interbank trade", "Settle CLS trade", and "Settle NDF trade". The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 6-3.

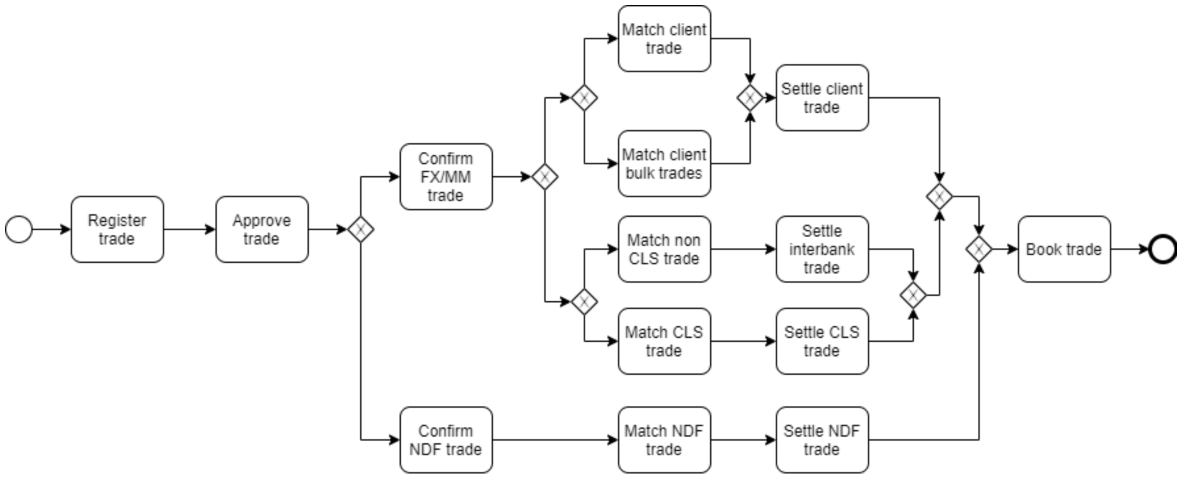


Figure 6-2 Single model for foreign exchange and money market process (Milani et al., 2016)

Table 6-3 Measurements from Single model for the foreign exchange and money market process

Metric	Value
Redundancy	0
Complexity	8
Minimal Number of Change Operations	7

6.3 C-EPC and Configurative Process Modelling

Figure 6-3 shows the EPC model for the foreign exchange and money market process with the redundancy of functions equal to 0. The complexity of the model is 8, which is added by four XOR-split with two outgoing edges. The minimal number of change operations needed to transform the C-EPC model in Figure 6-3to a variant represented by the model in Figure 6-1a is 7. The transformation can be achieved by deleting the following functions: “Confirm NDF trade”, “Match non-CLS trade”, “Match CLS trade”, “Match NDF trade”, “Settle interbank trade”, “Settle CLS trade”, and “Settle NDF trade”. The measurements for complexity, redundancy and minimal change operations are summarized in Table 6-4.

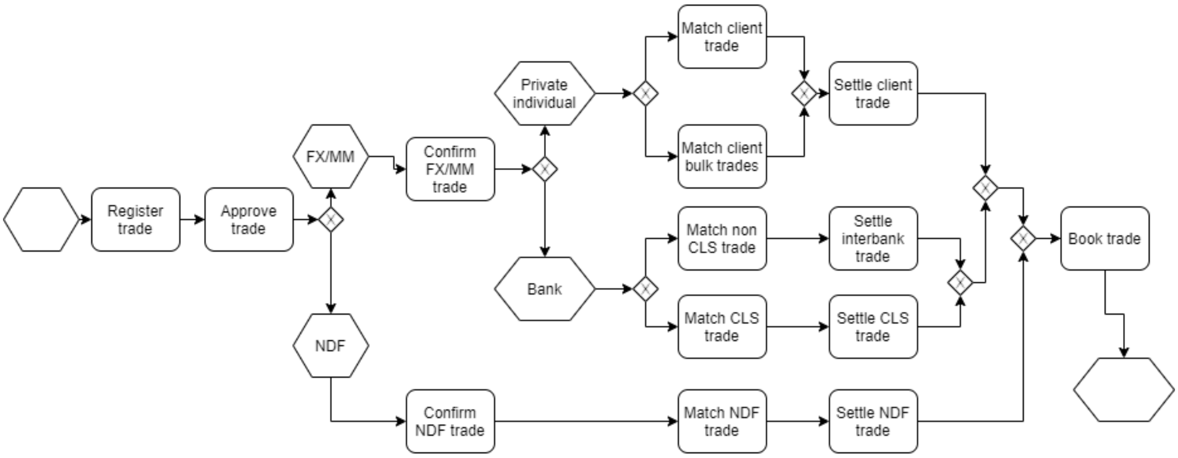


Figure 6-3 C-EPC model for foreign exchange and money market process

Table 6-4 Measurements from C-EPC model for the foreign exchange and money market process

Metric	Value
Redundancy	0
Complexity	8
Minimal Number of Change Operations	7

6.4 Provop

The Provop model with related change operations for the foreign exchange and money market process is shown in Figure 6-4, and the main process model is based on the variant model shown in Figure 6-1b. The model has a redundancy of 0 and a complexity of 2, which is added by one XOR-split and two outgoing edges. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 6-1a is 7, as shown by the number of change operations in Figure 6-4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 6-5.

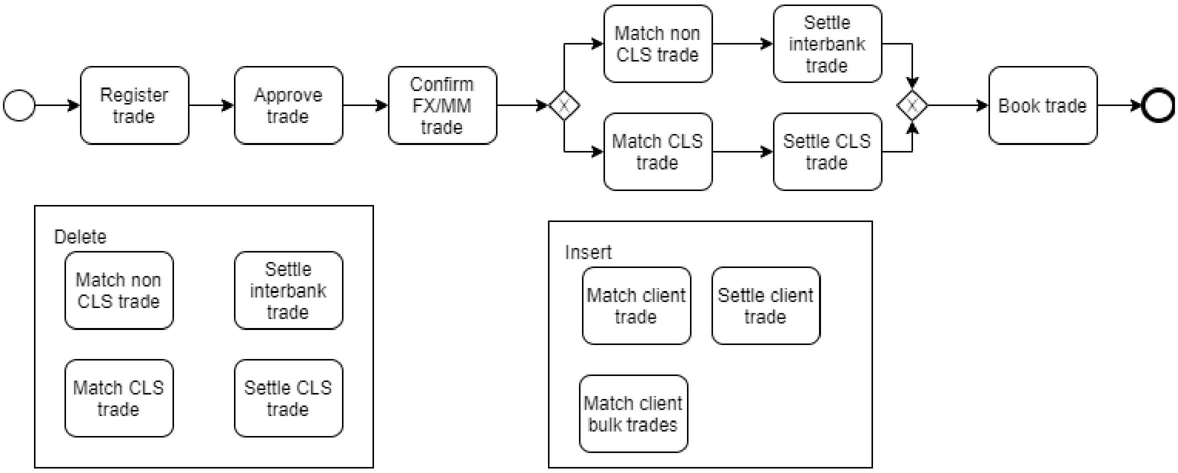


Figure 6-4 Provop model for foreign exchange and money market process

Table 6-5 Measurements from Provop model for the foreign exchange and money market process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

6.5 proCollab

Figure 6-5 shows a templet for the foreign exchange and money market process, which is based on the variant in Figure 6-1b, with a redundancy of 0 and a complexity of 2. In order to transform the model in Figure 6-5 to a proCollab variant templet which is equivalent to the variant in Figure 6-1a, the following change operations will have to be performed: delete “Match non-CLS trade”, “Match CLS trade”, “Settle interbank trade”, and “Settle CLS trade”; insert “Match client trade”, “Match client bulk trade”, and “Settle client trade”. This makes a total of 7 change operations. The summary of the measurements for redundancy, complexity and the minimal number of change operations are shown in Table 6-6.

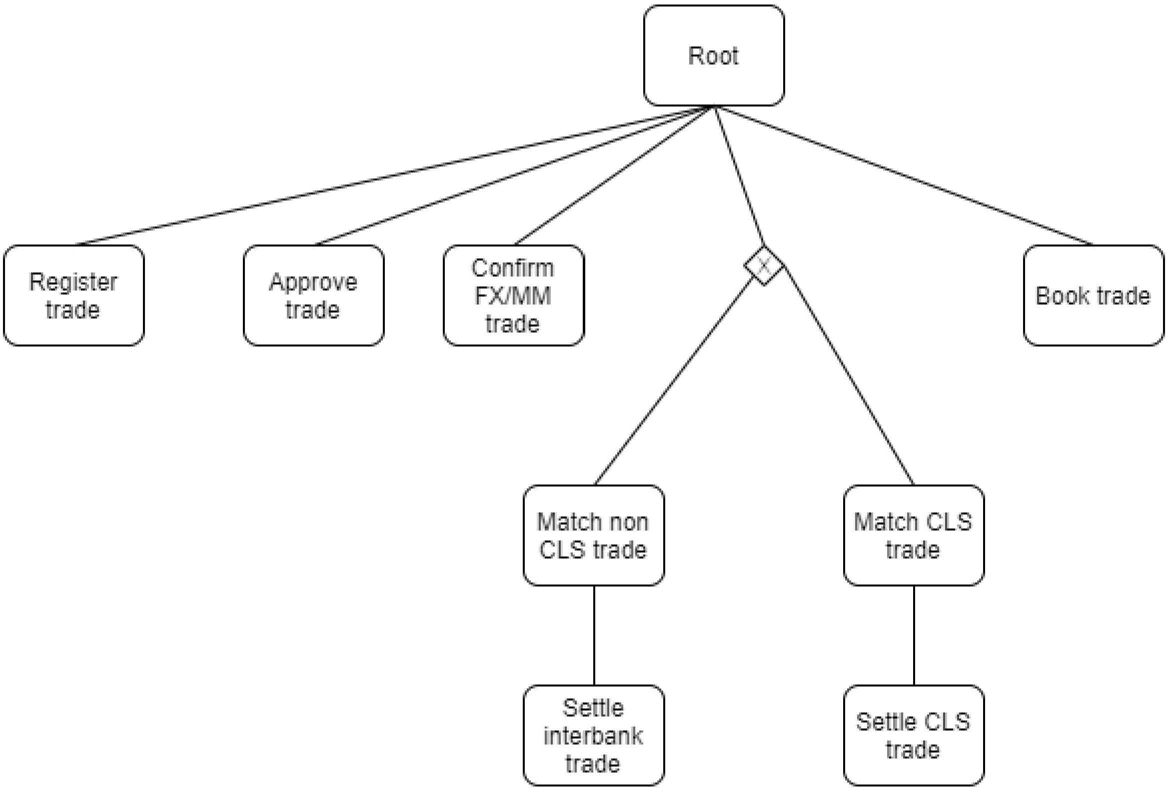


Figure 6-5 proCollab model for foreign exchange and money market process

Table 6-6 Measurements from proCollab model for the foreign exchange and money market process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

6.6 PESOA

Figure 6-6 shows the PESOA model for the foreign exchange and money market process with a redundancy of 0 and a complexity of 11, which is added by the 11 association lines. The minimal number of change operations for transforming the model in Figure 6-6 to the "to-be" variant represented by the model in Figure 6-1a is 8. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 6-7.

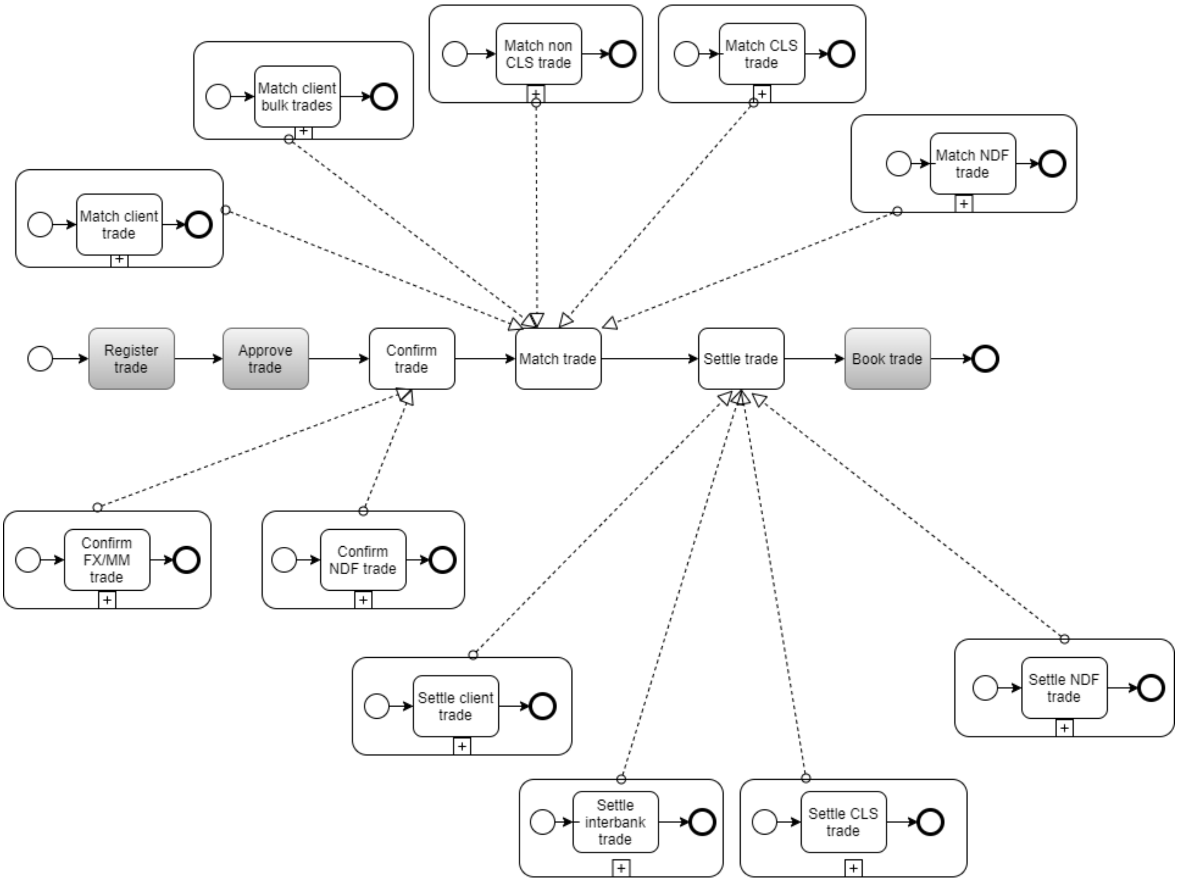


Figure 6-6 PESOA model for foreign exchange and money market process

Table 6-7 Measurements from PESOA model for the foreign exchange and money market process

Metric	Value
Redundancy	0
Complexity	11
Minimal Number of Change Operations	8

Chapter 7 Construction Plan Process

The business process model in Figure 7-1a represents the "to-be" business process variant that will be derived from the construction plan business process ("as-is" business process model) modelled in different business process modelling approaches. The construction plan business process is adapted from (Milani *et al.*, 2016).

7.1 Multi-Model

Figure 7-1 shows the Multi model for the construction plan process modelled separately using the BPMN modelling language. The Multi-model has a redundancy of 2, as shown in Table 7-1, and the complexity of the models is 0. The minimal number of change operations needed to model the "to-be" process is 4. The summary of the redundancy, complexity and the number of minimal change operations are shown in Table 7-2.

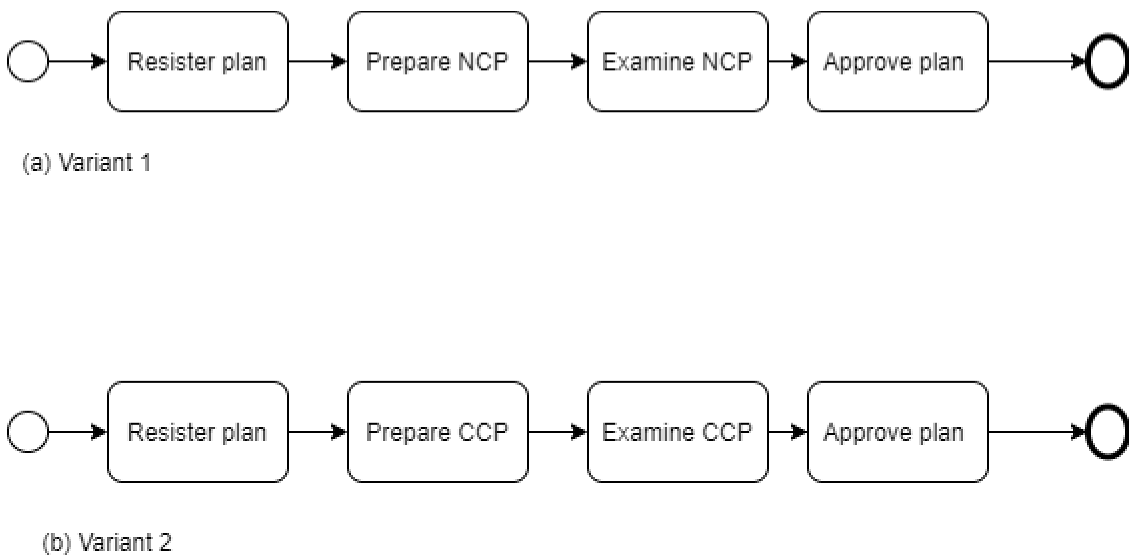


Figure 7-1 Multi-model for construction plan process

Table 7-1 Redundancy of activities in multi-model for the construction plan process

Activity	Occurrences(x)	Duplicates(x-1)
Register plan	2	1
Prepare NCP	1	0
Prepare CCP	1	0
Examine NCP	1	0
Examine CCP	1	0
Approve plan	2	1

Redundancy	2

Table 7-2 Measurements from multi-model for the construction plan process

Metric	Value
Redundancy	2
Complexity	0
Minimal Number of Change Operations	4

7.2 Single Model

The single model for the construction plan process is shown in Figure 7-2, and it is modelled using the BPMN standard. The model has a redundancy of 0 and a complexity of 2, added by one XOR-split with two outgoing edges. The minimal number of change operations needed to transform the single model to the "to-be" represented by the variant in Figure 7-1a is 2, which can be achieved by deleting the activities, "Prepare CCP" and "Examine CCP". The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 7-3.

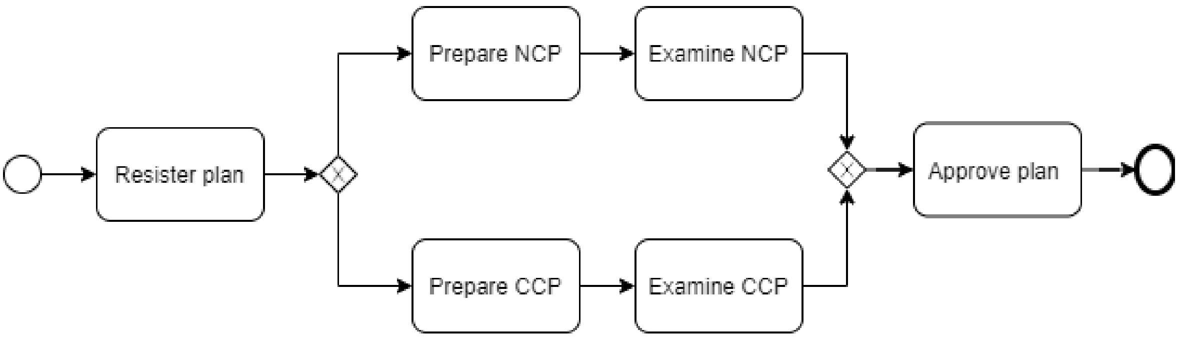


Figure 7-2 Single model for construction plan process (Milani et al., 2016)

Table 7-3 Measurements from a single model for the construction plan process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	2

7.3 C-EPC and Configurative Process Modelling

Figure 7-3 shows the EPC model for the construction plan process with the redundancy of functions equal to 0. The complexity of the model is 2, which is added by one XOR-split with two outgoing edges. The minimal number of change operations needed to transform the EPC model in Figure 7-3 to a “to-be” EPC variant represented by the variant in Figure 7-1a is 2. The measurements for complexity, redundancy and minimal change operations are summarized in Table 7-4.

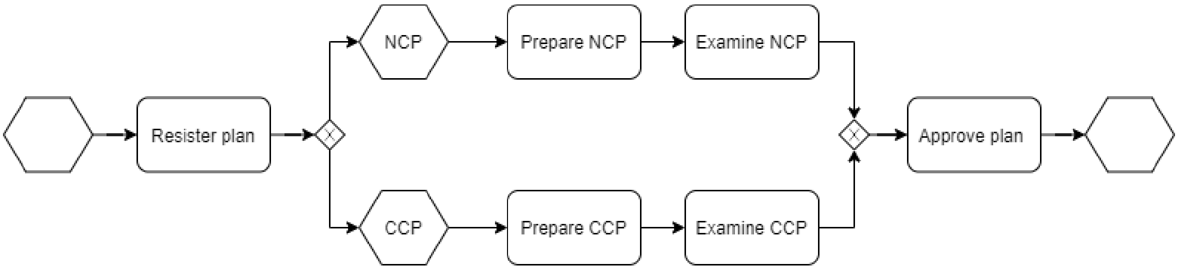


Figure 7-3 C-EPC model for construction plan process

Table 7-4 Measurements from C-EPC model for the construction plan process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	2

7.4 Provop

The Provop model with related change operations for the construction plan process is shown in Figure 7-4, and the main process model is based on the variant model shown in Figure 7-1b. The model has a redundancy of 0 and a complexity of 0. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 7-1a is 4, as shown by the number of change operations in Figure 7-4. The summary of the measurements for redundancy, complexity and the minimal number of change operations are shown in Table 7-5.

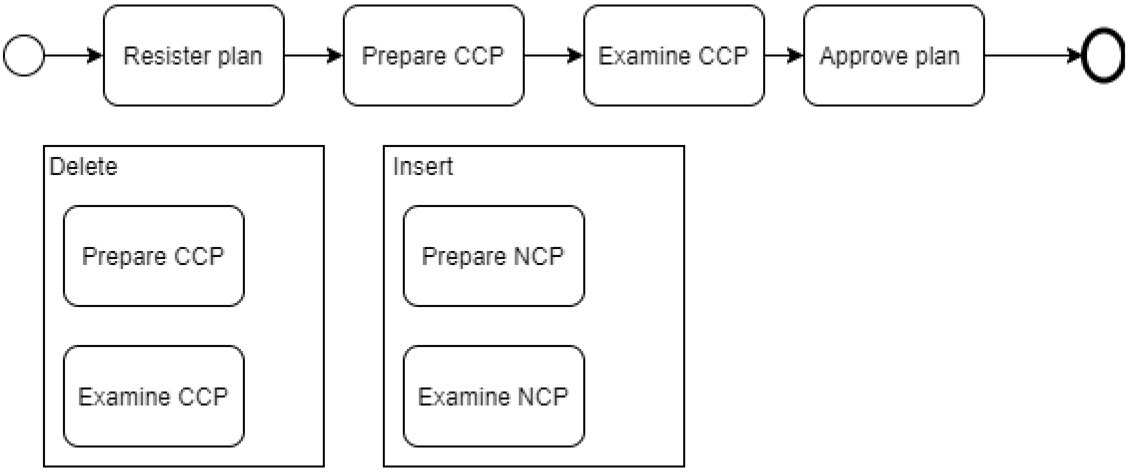


Figure 7-4 Provop model for construction plan process

Table 7-5 Measurements from Provop model for the construction plan process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	4

7.5 proCollab

Figure 7-5 shows a templet for the construction plan process which is based on the variant in Figure 7-1b, with a complexity of 0 since there are no split construct and redundancy of 0 since there are no duplicate activities. To transform the model in Figure 7-5 to a proCollab variant templet which is equivalent to the variant in Figure 7-1a the following change operations will have to be performed: delete “Prepare CCP” and “Examine CCP”; and insert “Prepare NCP” and “Examine NCP”, which gives a total of 4 change operation. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 7-6.

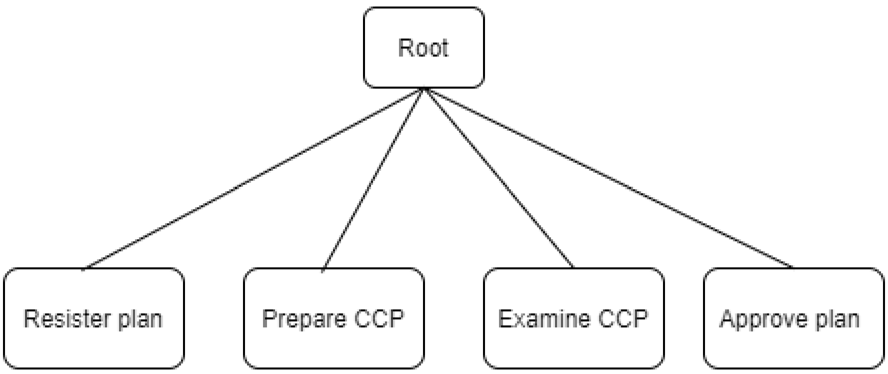


Figure 7-5 proCollab model for construction plan process

Table 7-6 Measurements from proCollab model for the construction plan process

Metric	Value
Redundancy	0
Complexity	0
Minimal Number of Change Operations	4

7.6 PESOA

Figure 7-6 shows PESOA model for the construction plan process with a redundancy of 0 and a complexity of 4, which is added by the four association lines linking the subprocesses to the variation points. The minimal number of change operations for transforming the model in Figure 7-6 to the "to-be" variant represented by the model in Figure 7-1a is 2. In order to achieve this transformation, two subprocesses will need to be deleted. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 7-7.

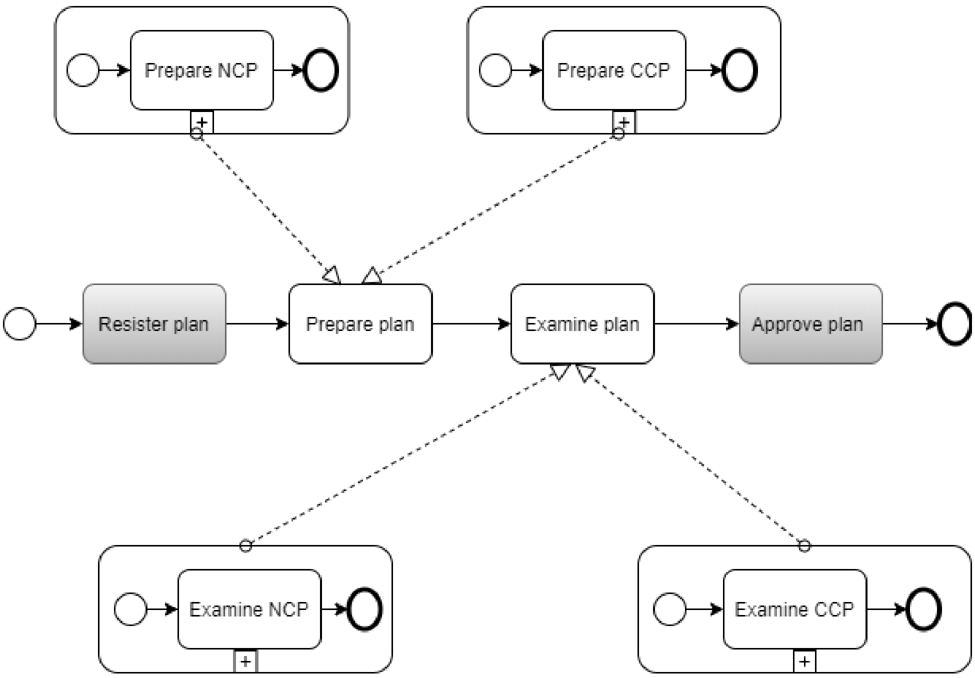


Figure 7-6 PESOA model for construction plan process

Table 7-7 Measurements from PESOA model for the construction plan process

Metric	Value
Redundancy	0
Complexity	4
Minimal Number of Change Operations	2

Chapter 8 DNA Sequencing Process

The business process model in Figure 8-1c represents the "to-be" business process variant that will be derived from the DNA sequencing business process ("as-is" business process model) modelled in different business process modelling approaches. The DNA sequencing business process is adapted from (Milani *et al.*, 2016).

8.1 Multi-Model

Figure 8-1 shows the multi-model for the DNA sequencing process, modelled separately using the BPMN modelling language. The models have redundancy of 6 as can be seen from Table 8-1, and the CFC is 7 because of two XOR-split with two outgoing edges and one XOR-split with three outgoing edges in the models. The minimal number of change operations needed to model the "to-be" variant in Figure 8-1c is 6. The summary of the measurements is in Table 8-2.

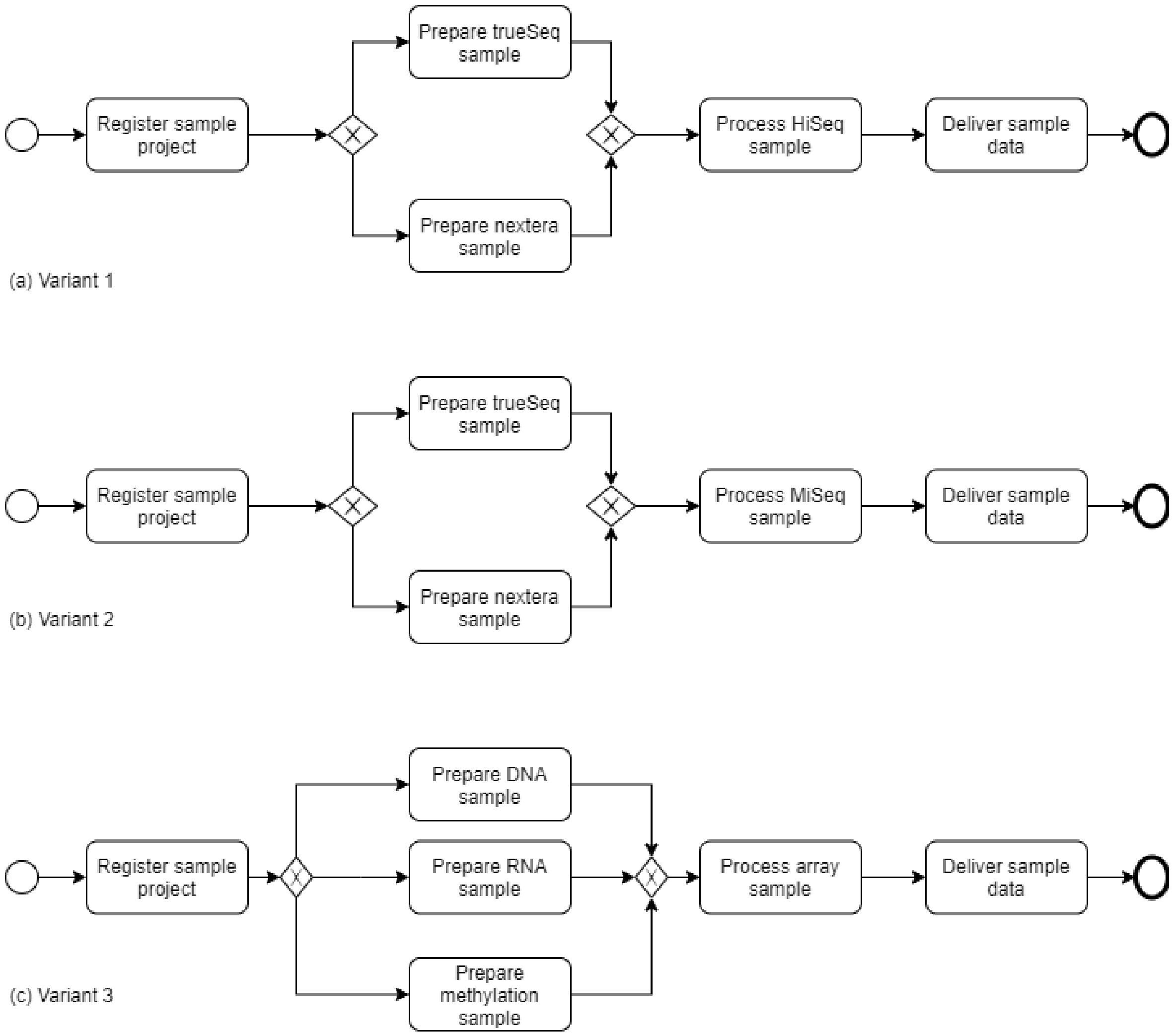


Figure 8-1 Multi-model for DNA sequencing process

Table 8-1 Redundancy of activities in Multi model for the DNA sequencing process

Activity	Occurrences(x)	Duplicates(x-1)
Register sample project	3	2
Prepare trueSeq sample	2	1
Prepare nextera sample	2	1
Prepare DNA sample	1	0
Prepare RNA sample	1	0
Prepare methylation sample	1	0
Prepare HiSeq sample	1	0
Prepare MiSeq sample	1	0
Prepare array sample	1	0
Deliver sample data	3	2
Redundancy		6

Table 8-2 Measurements from Multi model for DNS sequencing process

Metric	Value
Redundancy	6
Complexity	7
Minimal Number of Change Operations	6

8.2 Single Model

The single model for the DNA sequencing process is shown in Figure 8-2, and it is modelled using the BPMN standard. The model has a redundancy of 0. The model has three XOR-splits with two outgoing edges (CFC is 6) and one XOR-splits with three outgoing edges (CFC is 3), which makes the Control Flow Complexity (CFC) of all splits in the model to be 9. The minimal number of change operations needed to transform the single model to the “to-be” variant represented by the variant in Figure 8-1c is 4. The transformation can be achieved by deleting the following activities: “Prepare trueSeq sample”, “Prepare nextera sample”, “Prepare HiSeq sample”, and “Prepare MiSeq sample”, which is 4 operations. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 8-3.

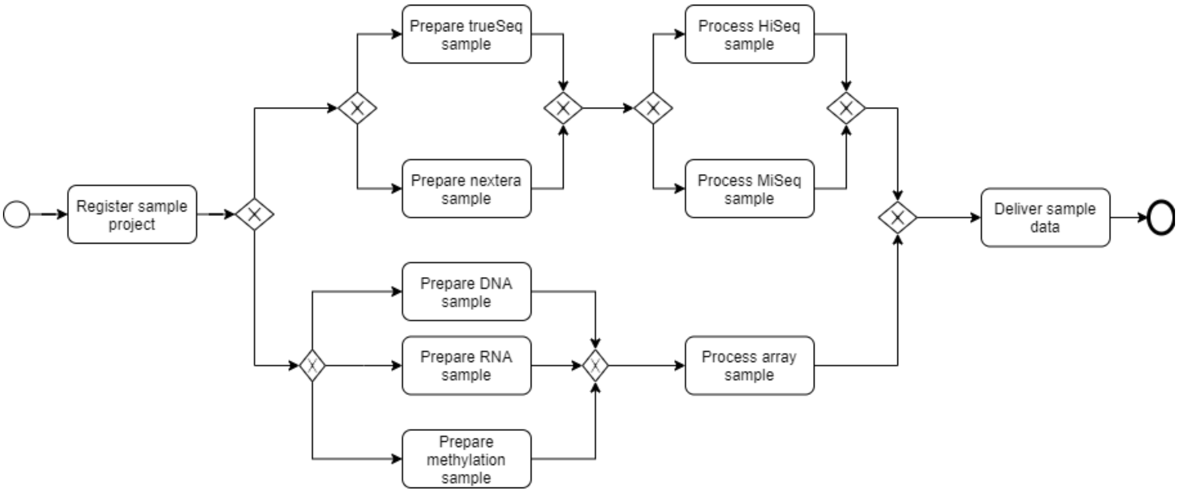


Figure 8-2 Single model for DNA sequencing process (Milani et al., 2016)

Table 8-3 Measurements from Single model for DNS sequencing process

Metric	Value
Redundancy	0
Complexity	9
Minimal Number of Change Operations	4

8.3 C-EPC and Configurative Process Modelling

Figure 8-3 shows the EPC model for the DNA sequencing process with the redundancy of functions equal to 0. The complexity of the model is 9, which is added by one XOR-split with two outgoing edges and 3 XOR-split with three outgoing edges. The minimal number of change operations needed to transform the EPC model in Figure 8-3 to a “to-be” EPC variant represented by the variant in Figure 8-1c is 4. The measurements for complexity, redundancy and the minimal number of change operations are summarized in Table 8-4.

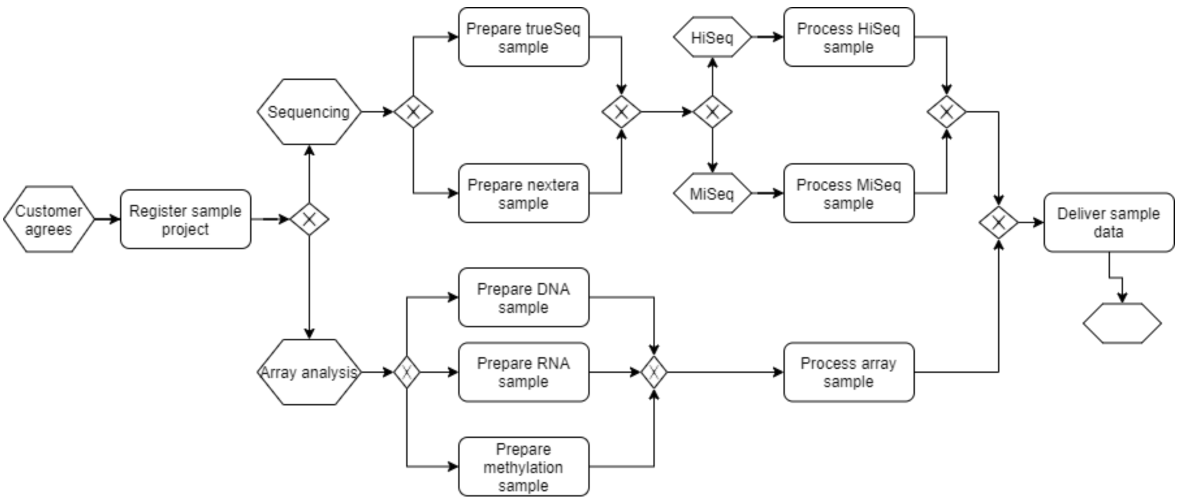


Figure 8-3 C-EPC model for DNA sequencing process

Table 8-4 Measurements from C-EPC model for DNS sequencing process

Metric	Value
Redundancy	0
Complexity	9
Minimal Number of Change Operations	4

8.4 Provop

The Provop model with related change operations for the DNA sequencing process is shown in Figure 8-4, and the main process model is based on the variant model shown in Figure 8-1a. The model has a redundancy of 0 and a complexity of 2. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 8-1c is 7, as shown by the number of change operations in Figure 8-4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 8-5.

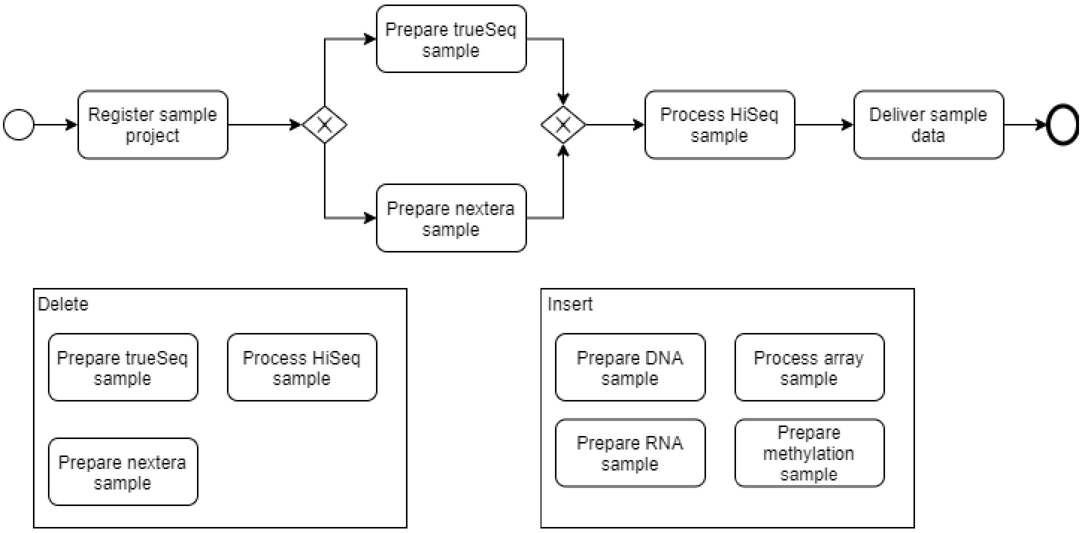


Figure 8-4 Provop model for DNA sequencing process

Table 8-5 Measurements from Provop model for DNA sequencing process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

8.5 proCollab

Figure 8-5 shows a templet for the DNA sequencing process, which is based on the variant in Figure 8-1a, with a complexity of 2 and redundancy of 0. In order to transform the model in Figure 8-5 to a proCollab variant templet which is equivalent to the variant in Figure 8-1c the following change operations will have to be performed: delete “Prepare trueSeq sample”, “Prepare nextera sample”, “Prepare HiSeq sample”; and insert the activities “Prepare DNA sample”, “Prepare RNA sample”, “Prepare array sample”, and “Prepare methylation sample”. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 8-6.

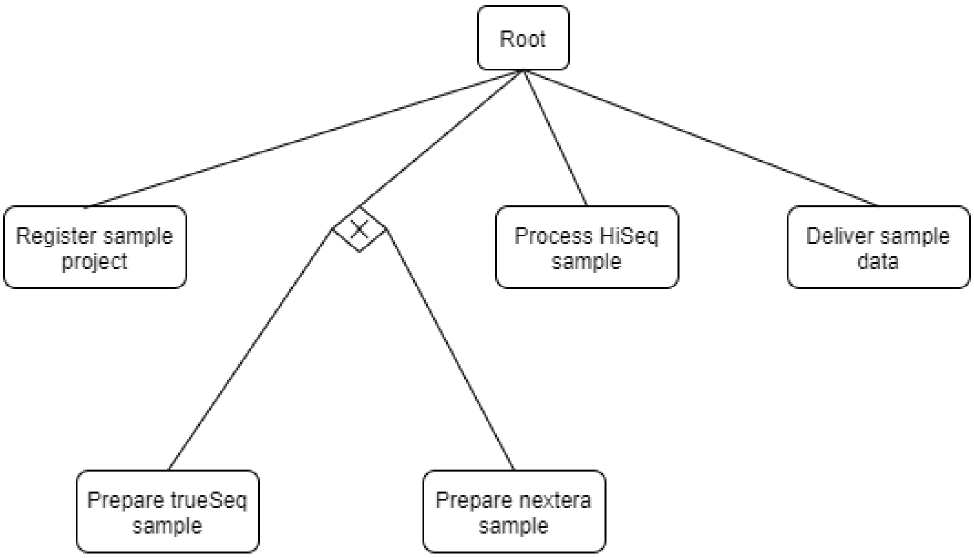


Figure 8-5 proCollab model for DNA sequencing process

Table 8-6 Measurements from proCollab model for DNA sequencing process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

8.6 PESOA

Figure 8-6 shows the PESOA model for the DNA sequencing process with a redundancy of 0 and a complexity of 8, which is added by the eight association lines. The minimal number of change operations for transforming the model in Figure 8-6 to the “to-be” variant represented by the model in Figure 8-1c is 4. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 8-7.

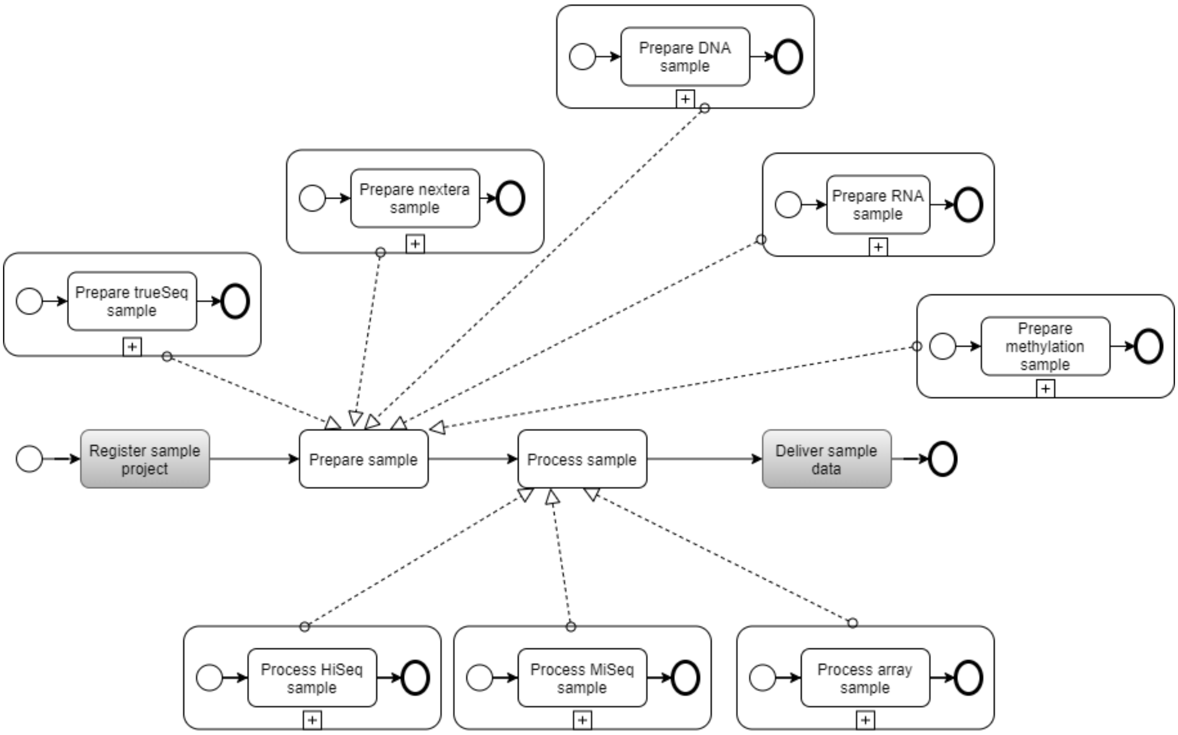


Figure 8-6 PESOA model for DNA sequencing process

Table 8-7 Measurements from PESOA model for DNS sequencing process

Metric	Value
Redundancy	0
Complexity	8
Minimal Number of Change Operations	4

Chapter 9 Network Diagnostics Process

The business process model in Figure 9-1c represents the “to-be” business process variant that will be derived from the network diagnostics business process (“as-is” business process model) modelled in different business process modelling approaches. The network diagnostics business process is adapted from (Lu, Sadiq and Governatori, 2009).

9.1 Multi-Model

Figure 9-1 shows the separate models for the Network diagnostics process modelled with the BPMN modelling language. The multi-model has a redundancy of 8, as can be seen from Table 9-1. The CFC is 1 because of one AND-split with three outgoing edges. The minimal number of change operations needed to model the “to-be” variant in Figure 9-1c is 6. The summary of the measurements is in Table 9-2.

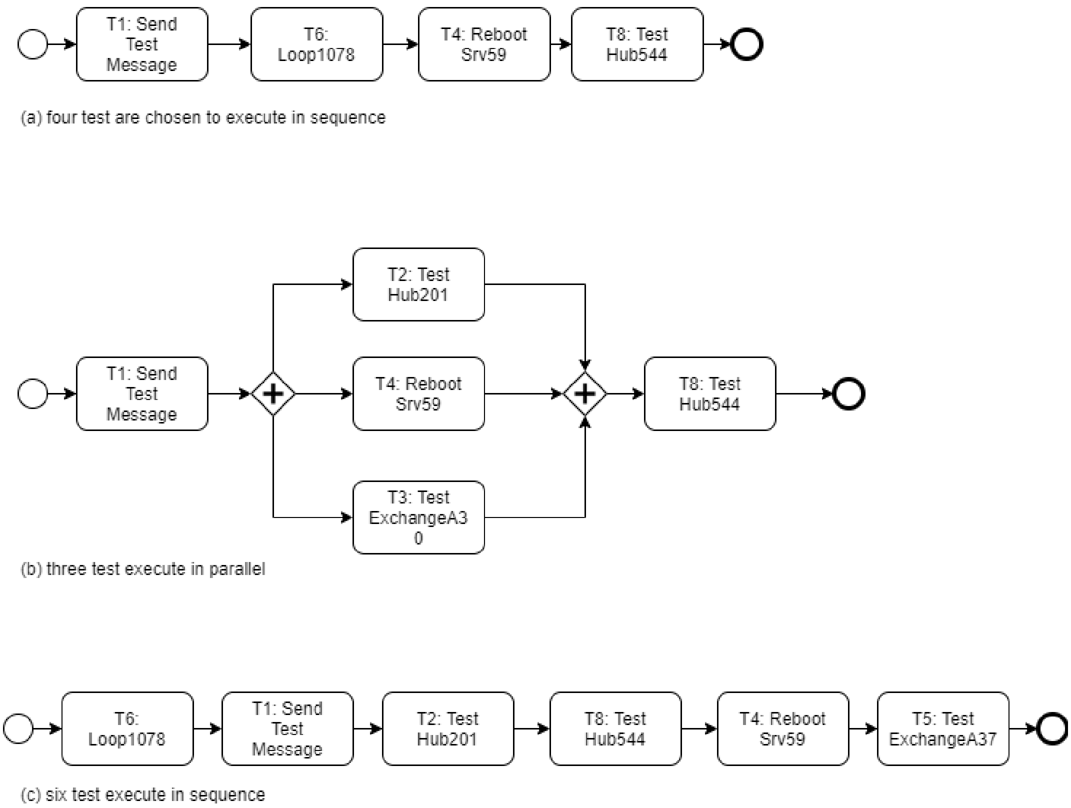


Figure 9-1 Multi-model for network diagnostics process (Lu, Sadiq and Governatori, 2009)

Table 9-1 Redundancy of activities in Multi model for the network diagnostics process

Activity	Occurrences(x)	Duplicates(x-1)
T1	3	2
T2	2	1
T3	1	0
T4	3	2
T5	1	0
T6	2	1
T8	3	2
Redundancy		8

Table 9-2 Measurements from Multi model for network diagnostics process

Metric	Value
Redundancy	8
Complexity	1
Minimal Number of Change Operations	6

9.2 Single Model

The single model for the Network diagnostics process is shown in Figure 9-2, and it is modelled using the BPMN standard. The model has a redundancy of 4 because T1 and T2 occur twice each and T4 occurs three times. The model has three XOR-splits with two outgoing edges (CFC is 6) and one AND-split with three outgoing edges (CFC is 1), which makes the Control Flow Complexity (CFC) of all splits in the model to be 7. The minimal number of change operations needed to transform the single model to the “to-be” variant represented by the variant in Figure 9-1c is 5. The transformation can be achieved by deleting the activities, “T1”, “T2”, “T3”, and two “T4”. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 9-3.

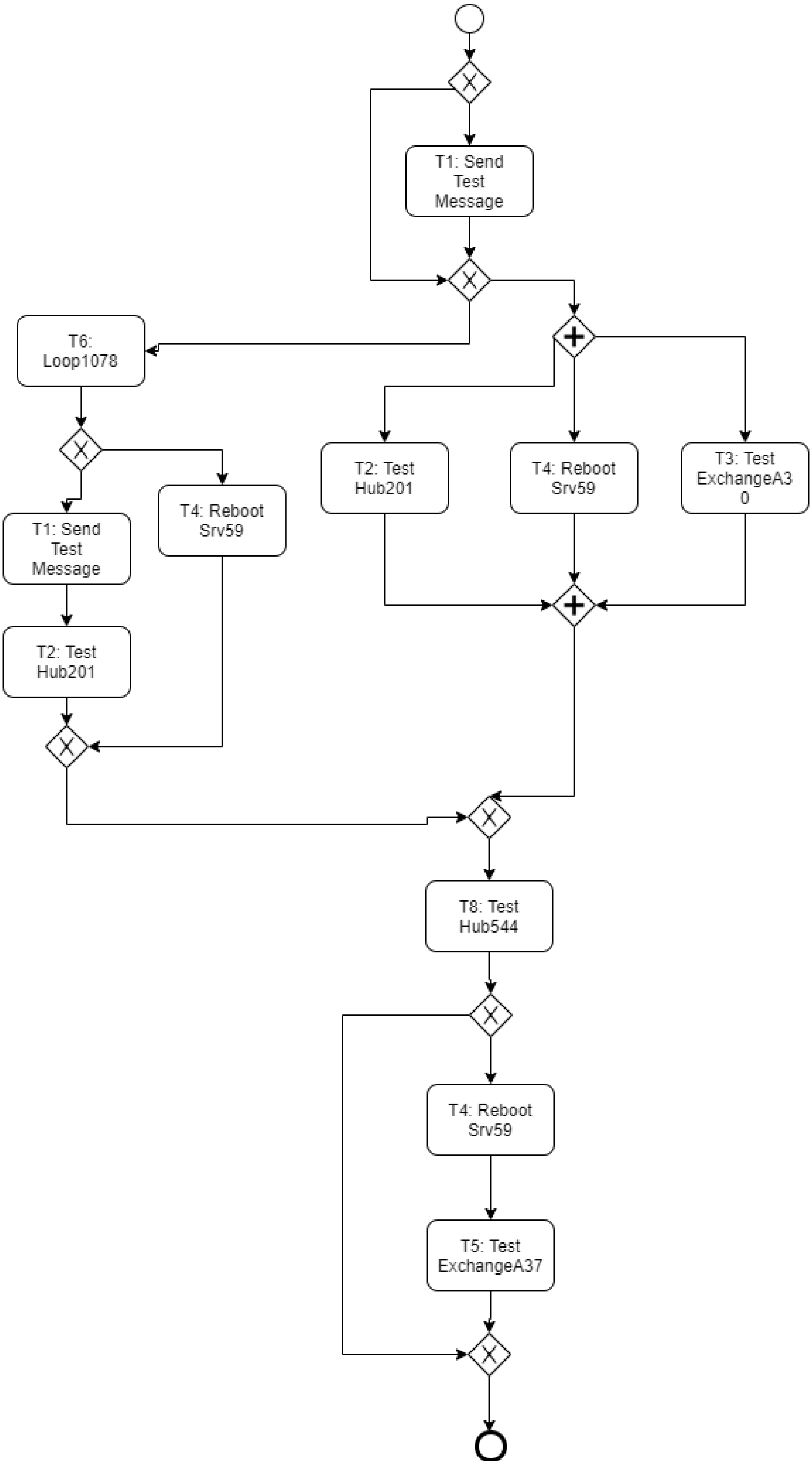


Figure 9-2 Single model for network diagnostics process

Table 9-3 Measurements from Single model for network diagnostics process

Metric	Value
Redundancy	4
Complexity	7
Minimal Number of Change Operations	5

9.3 C-EPC and Configurative Process Modelling

Figure 9-3 shows the EPC model for the Network diagnostics process with the redundancy of functions equal to 4. The complexity of the model is 3, which is added by one XOR-split with two outgoing edges and one AND-split with three outgoing edges. The minimal number of change operations needed to transform the EPC model in Figure 9-3 to a "to-be" EPC variant represented by the variant in Figure 9-1c is 5. This transformation is achieved by skipping "T1" and "T4", and deleting "T2", "T3" and "T4". The measurements for complexity, redundancy and the number of minimal change operations are summarized in Table 9-4.

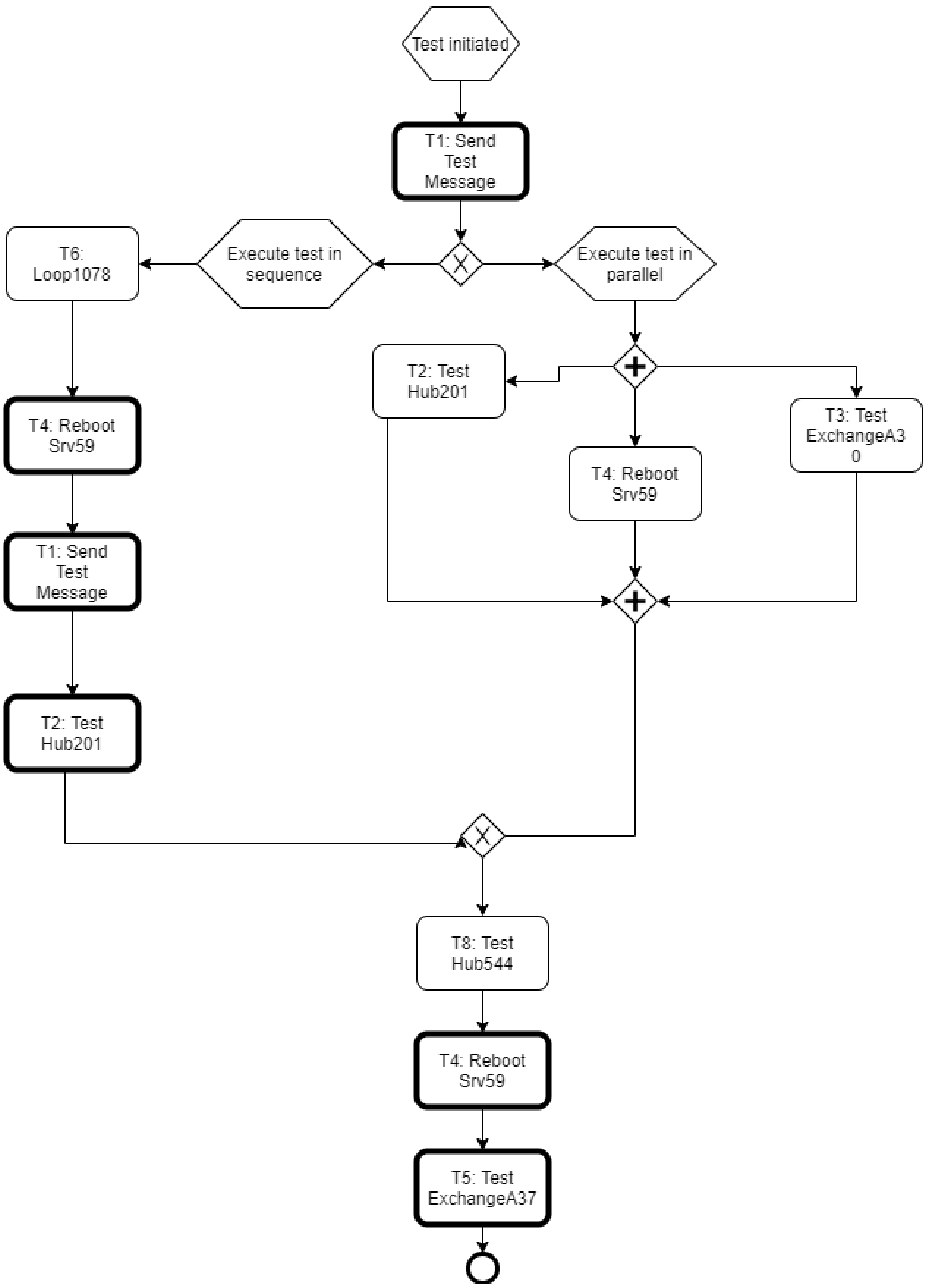


Figure 9-3 C-EPC model for network diagnostics process

Table 9-4 Measurements from C-EPC model for network diagnostics process

Metric	Value
Redundancy	4
Complexity	3
Minimal Number of Change Operations	5

9.4 Provop

The Provop model with related change operations for the Network diagnostics process is shown in Figure 9-4, and the main process model is based on the variant model shown in Figure 9-1b. The model has a redundancy of 0 and a complexity of 1. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 9-1c is 4, as shown by the number of change operations in Figure 9-4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 9-5.

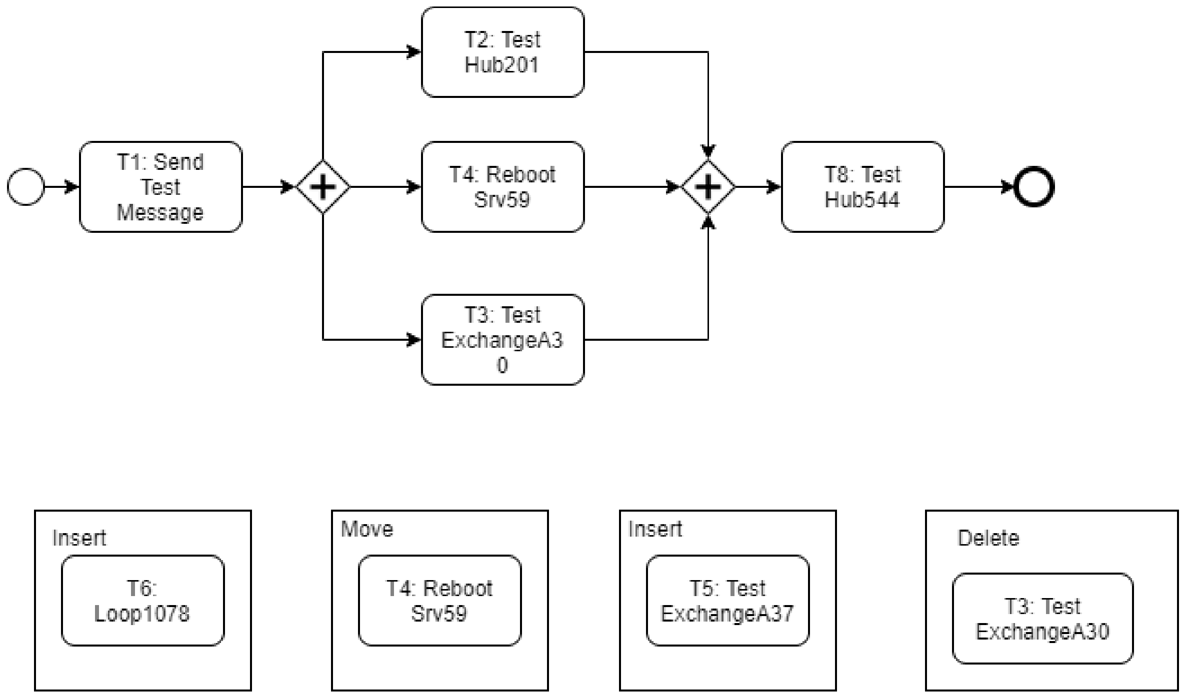


Figure 9-4 Provop model for network diagnostics process

Table 9-5 Measurements from Provop model for network diagnostics process

Metric	Value
Redundancy	0
Complexity	1
Minimal Number of Change Operations	4

9.5 proCollab

Figure 9-5 shows a templet for the Network diagnostics process, which is based on the variant in Figure 9-1b, with a complexity of 2 and redundancy of 0. To transform the model in Figure 9-5 to a proCollab variant templet which is equivalent to the variant in Figure 9-1c the following change operations will have to be performed: delete ("T3"), insert("T6" and "T5"), and move(“T4”, “T1”, “T2” and “T4”), which is a total of 7 operations. The summary of the measurements for redundancy, complexity and the minimal number of change operations are shown in Table 9-6.

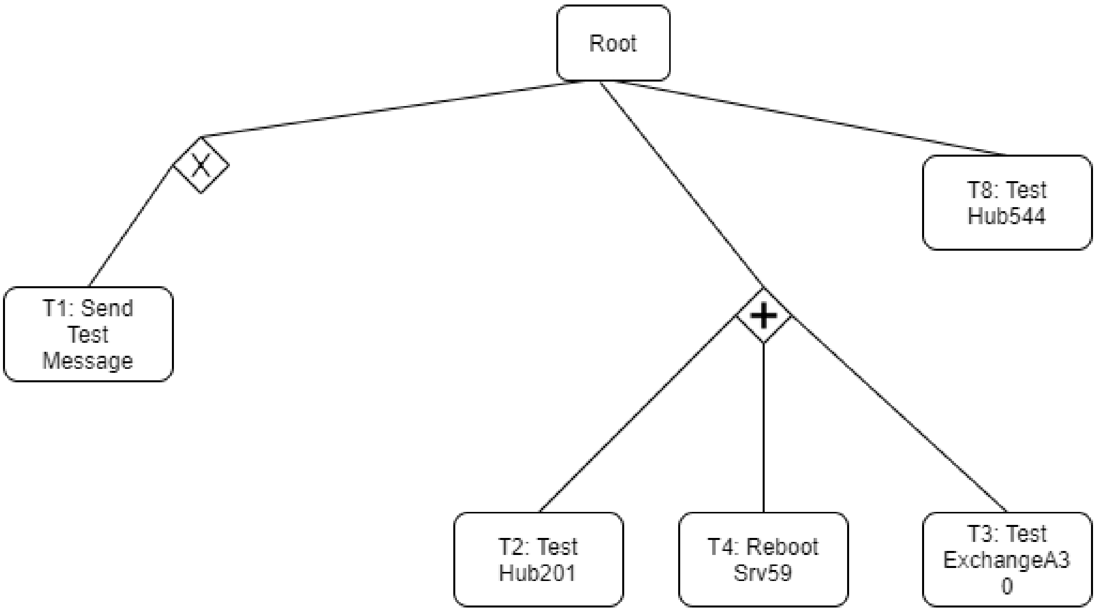


Figure 9-5 proCollab model for network diagnostics process

Table 9-6 Measurements from proCollab model for network diagnostics process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

9.6 PESOA

Figure 9-6 shows the PESOA model for the Network diagnostics process with a redundancy of 5 and a complexity of 6, which is added by the five association lines and one AND-split with three outgoing edges. The minimal number of change operations for transforming the model in Figure 9-6 to the “to-be” variant represented by the model in Figure 9-1c is 3. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 9-7.

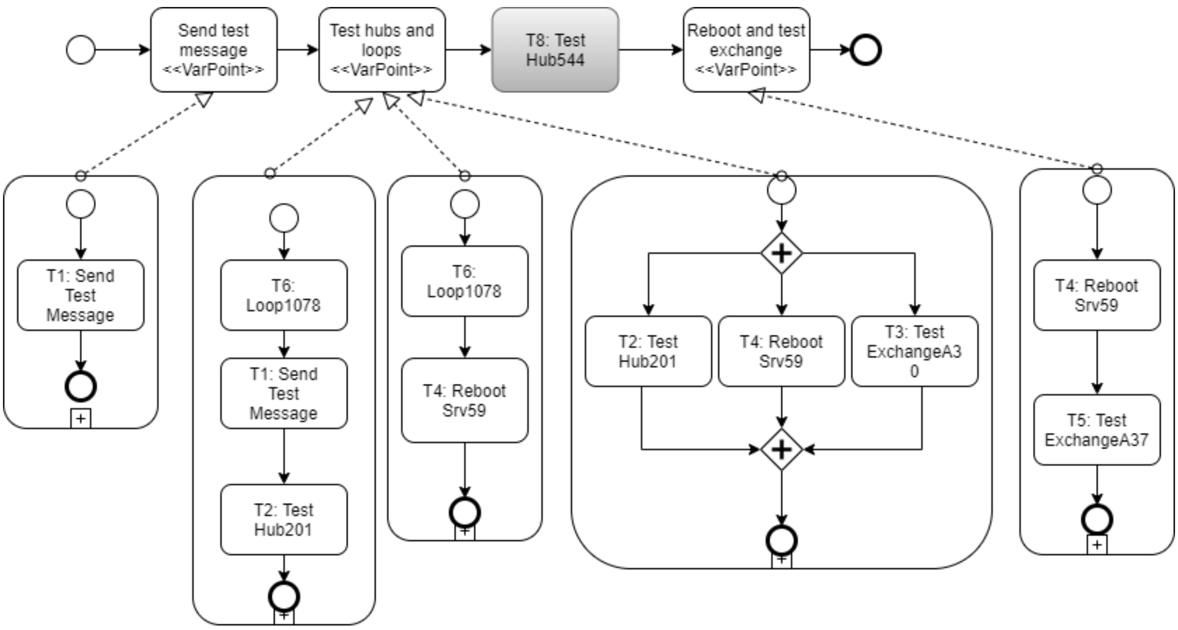


Figure 9-6 PESOA model for network diagnostics process

Table 9-7 Measurements from PESOA model for network diagnostics process

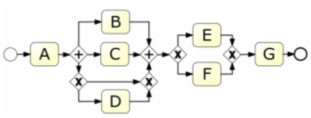
Metric	Value
Redundancy	5
Complexity	6
Minimal Number of Change Operations	3

Chapter 10Loan Application Process

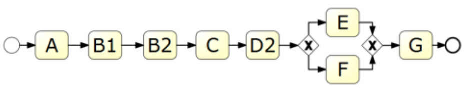
The business process model in Figure 10-1a represents the "to-be" business process variant that will be derived from the loan application business process ("as-is" business process model) modelled in different business process modelling approaches. The following activities: A, B, B1, B2, C, D, D2, E, F and G are used in the loan application process, where A = send e-mail, B = check credit, B1 = send check credit request, B2 = process check credit request response, C = calculate capacity, D = check system, D2 = check paper archive, E = accept, F = reject, G = send e-mail (Buijs and Reijers, 2014).

10.1 Multi-Model

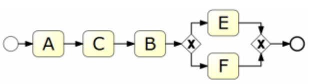
Figure 10-1 shows the Multi model for the Loan Application process modelled separately using the BPMN modelling language. The multi-model has a redundancy of 18 as can be seen from Table 10-1. The CFC is 13, which is added by six XOR-split with two outgoing edges and one AND-split with three outgoing edges. The minimal number of change operations needed to model the "to-be" variant in Figure 10-1a is 7. The summary of the measurements is in Table 10-2.



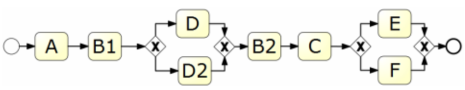
a. Variant 1



b. Variant 2



c. Variant 3



d. Variant 4

Figure 10-1 Multi-model for the loan application process (Buijs and Reijers, 2014)

Table 10-1 Redundancy of activities in Multi model for the loan application process

Activity	Occurrences(x)	Duplicates(x-1)
A	4	3
B	2	1
C	4	3
D	2	1
E	4	3
F	4	3
G	2	1
B1	2	1
B2	2	1
D2	2	1
Redundancy		18

Table 10-2 Measurements from Multi model for the loan application process

Metric	Value
Redundancy	18
Complexity	13
Minimal Number of Change Operations	7

10.2 Single Model

The single model for the Loan Application process is shown in Figure 10-2, and it is modelled using the BPMN standard. The model has a redundancy of 7 because of the two occurrences D, B, B2, D2, and four occurrences of C. The model has five XOR-splits with two outgoing edges (CFC is 10), one XOR-splits with three outgoing edges (CFC is 3), and one AND-split with three outgoing edges, which makes the Control Flow Complexity (CFC) of all splits in the model be 14. The minimal number of change operations needed to transform the single model to the "to-be" variant represented by the variant in Figure 10-1a is 10. The transformation can be achieved by deleting B, deleting three occurrences of C, B1, D, deleting two occurrences D2 and two occurrences of B2. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 10-3.

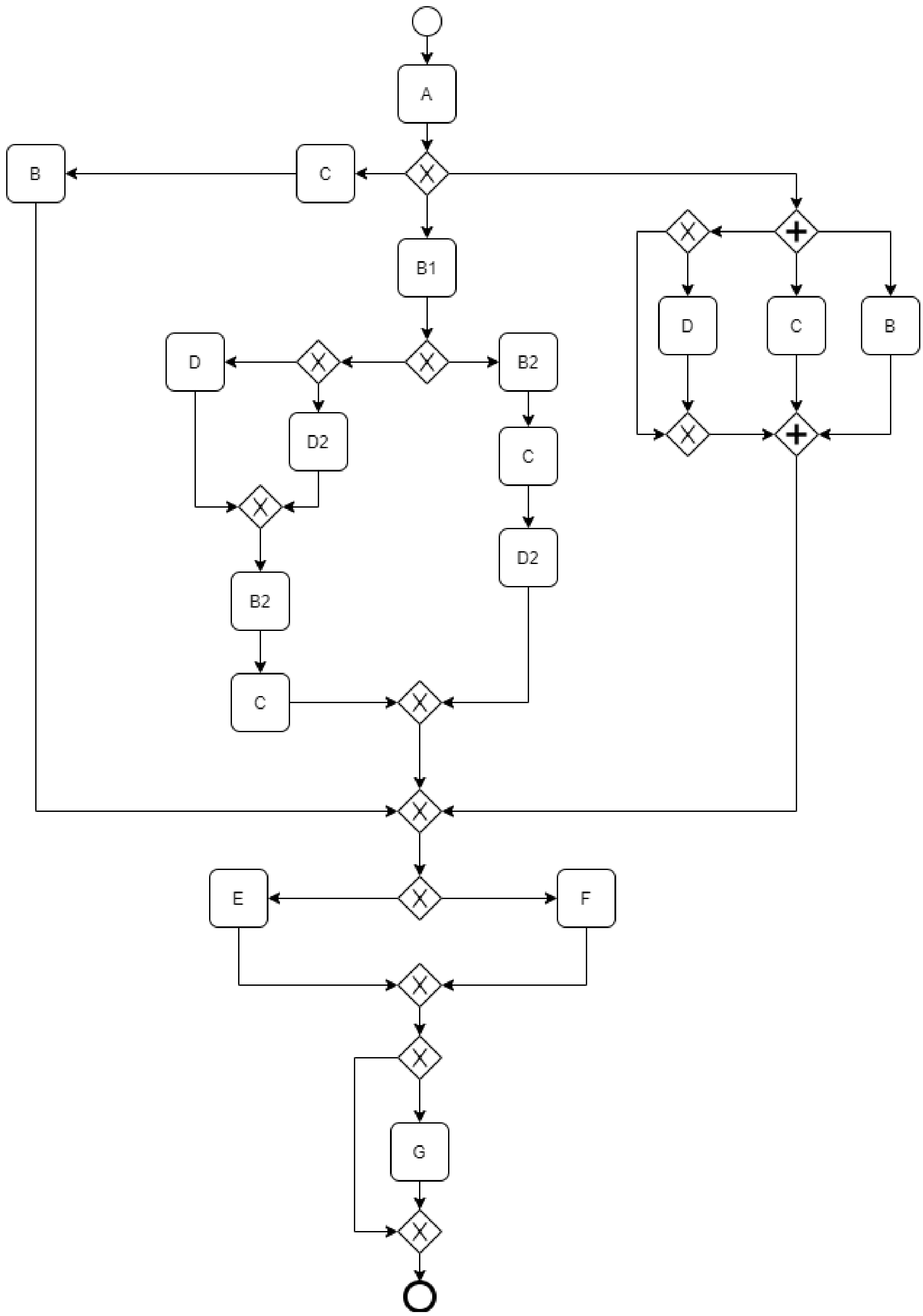


Figure 10-2 Single model for the loan application process

Table 10-3 Measurements from Single model for the loan application process

Metric	Value
Redundancy	7
Complexity	14
Minimal Number of Change Operations	10

10.3 C-EPC and Configurative Process Modelling

Figure 10-3 shows the EPC model for the Loan Application process with the redundancy of functions equal to 7. The model has four XOR-splits with two outgoing edges (CFC is 8), one XOR-splits with three outgoing edges (CFC is 3), and one AND-split with three outgoing edges, which makes the Control Flow Complexity (CFC) of all splits in the model to be 12. The minimal number of change operations needed to transform the EPC model in Figure 10-3 to a "to-be" EPC variant represented by the variant in Figure 10-1a is 10. The measurements for complexity, redundancy and minimal change operations are summarized in Table 10-4.

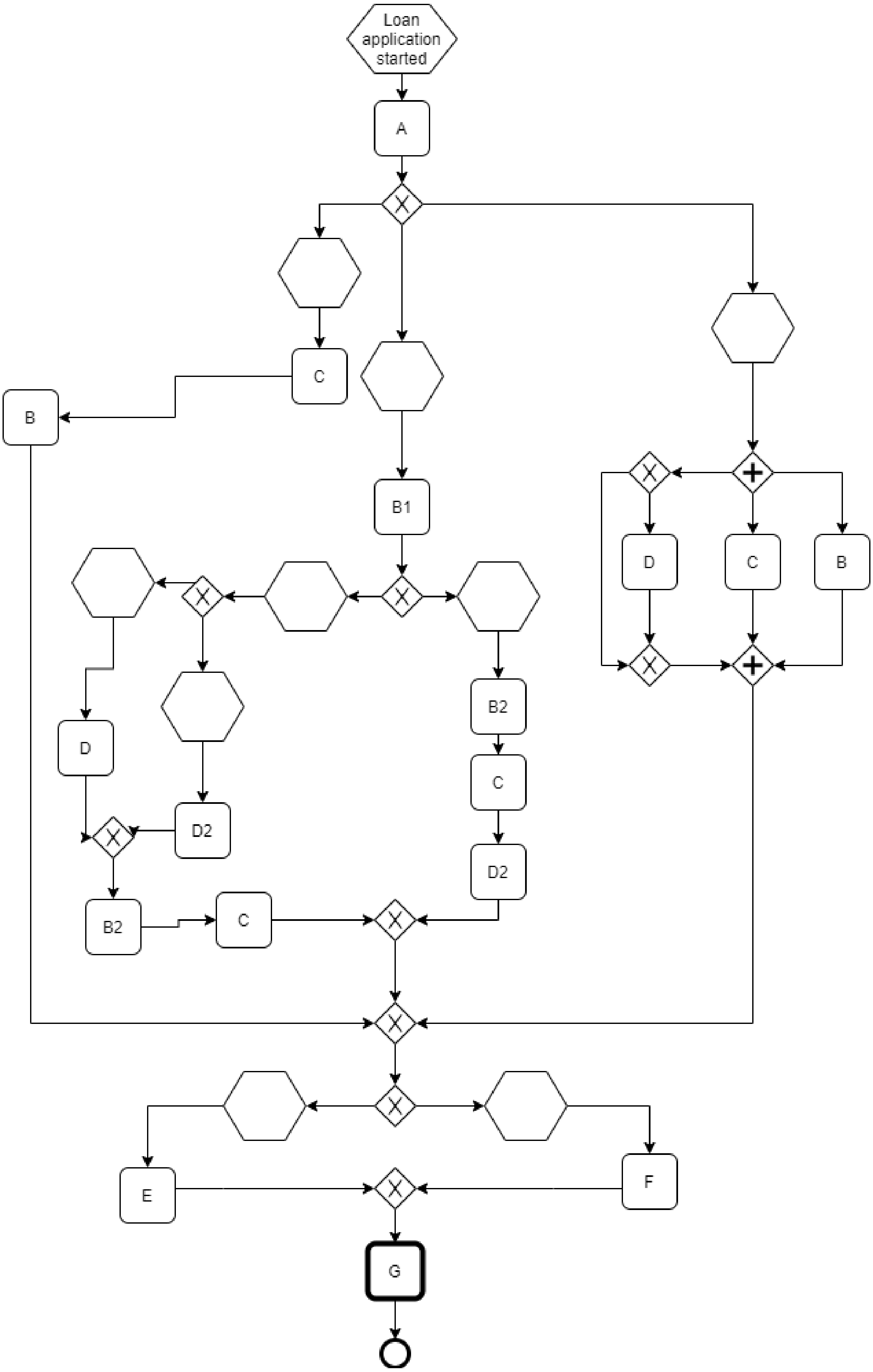


Figure 10-3 C-EPC model for the loan application process

Table 10-4 Measurements from C-EPC model for the loan application process

Metric	Value
Redundancy	7
Complexity	12
Minimal Number of Change Operations	10

10.4 Provop

The Provop model with related change operations for the Loan Application process is shown in Figure 10-4, and the main process model is based on the variant model shown in Figure 10-1d. The model has a redundancy of 0 and a complexity of 4, which is added by two XOR-split with two outgoing edges. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 10-1a is 6, as shown by the number of change operations in Figure 10-4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 10-5.

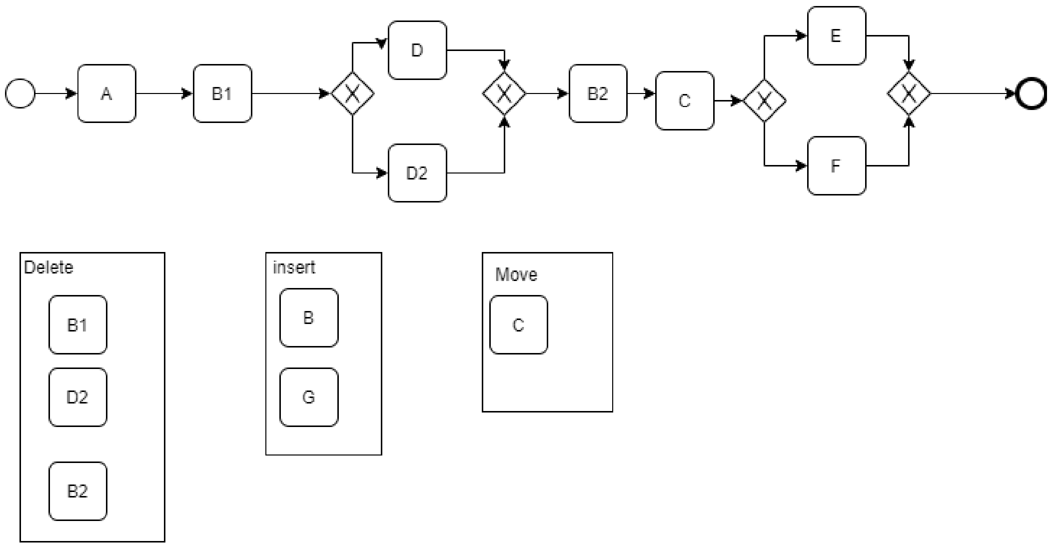


Figure 10-4 Provop model for the loan application process

Table 10-5 Measurements from Provop model for the loan application process

Metric	Value
Redundancy	0
Complexity	4
Minimal Number of Change Operations	6

10.5 proCollab

Figure 10-5 shows a templet for the Loan Application process, which is based on the variant in Figure 10-1d, with a complexity of 4 and redundancy of 0. To transform the model in Figure 10-5 to a proCollab variant templet which is equivalent to the variant in Figure 10-1a the following change operations will have to be performed: delete B1, D2, B2; insert B, G and move C and D, which is a total of 7 operations. The summary of the measurements for redundancy, complexity and the minimal number of change operations are shown in Table 10-6.

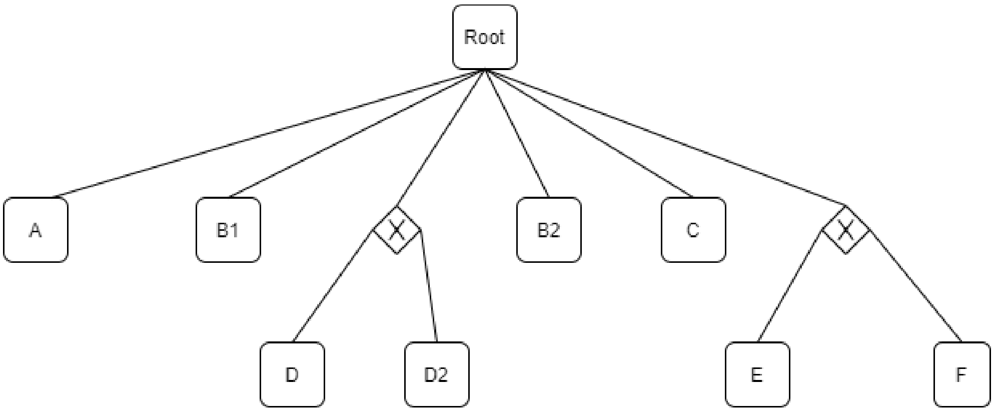


Figure 10-5 proCollab model for the loan application process

Table 10-6 Measurements from proCollab model for the loan application process

Metric	Value
Redundancy	0
Complexity	4
Minimal Number of Change Operations	7

10.6 PESOA

Figure 10-6 shows the PESOA model for the Loan Application process with a redundancy of 8 due to four occurrences of “C” and two occurrences of each of B, B1, B2, D and D2. The complexity of the model is 10, which is added by the seven association lines and two XOR-split with two outgoing edges and one AND-split with three outgoing edges.

The minimal number of change operations for transforming the model in Figure 10-6 to the “to-be” variant represented by the model in Figure 10-1a is 3 because three subprocesses will have to be deleted to achieve the transformation. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 10-7.

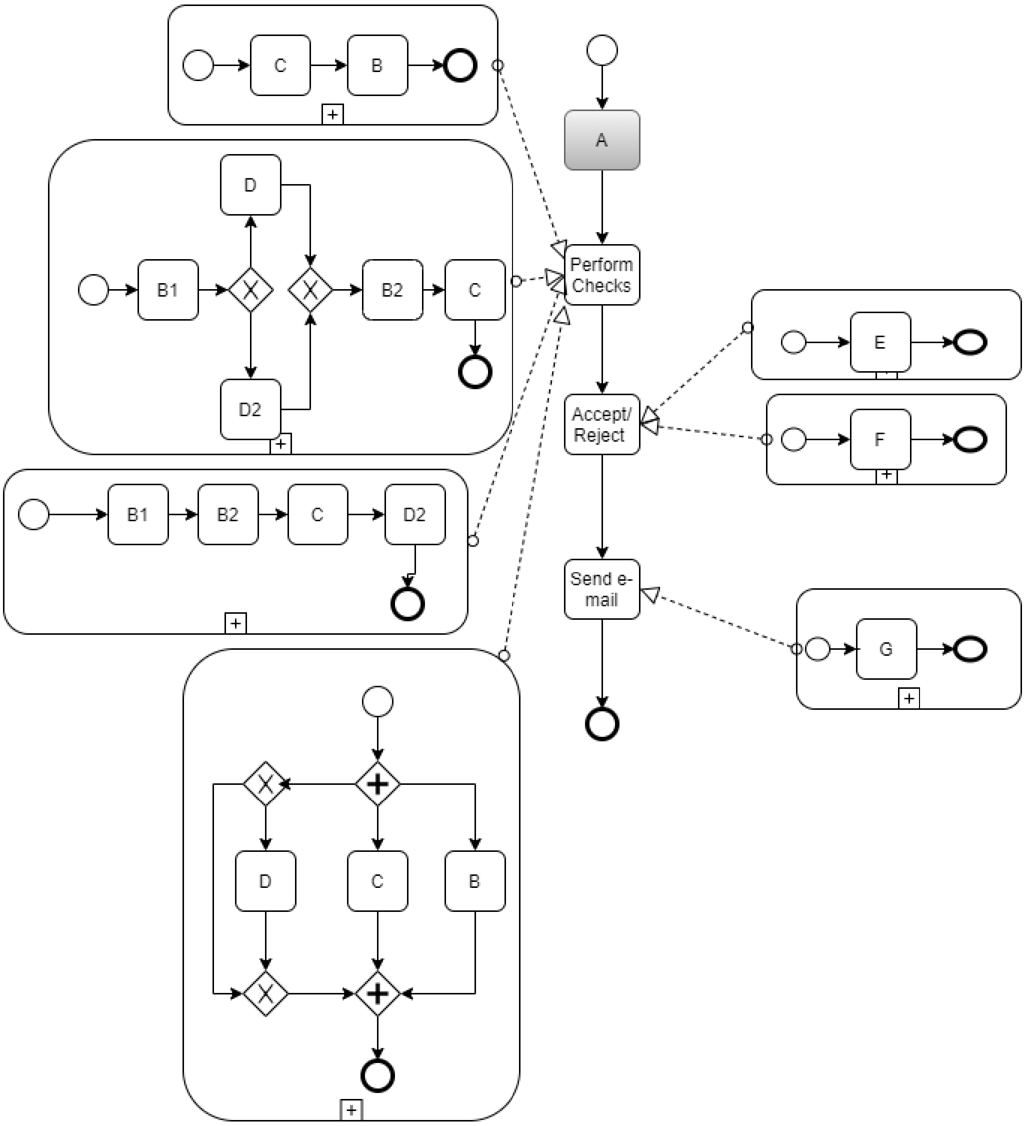


Figure 10-6 PESOA model for the loan application process

Table 10-7 Measurements from PESOA model for the loan application process

Metric	Value
Redundancy	8
Complexity	10
Minimal Number of Change Operations	3

Chapter 11Equity Trade Process

The business process model in Figure 11-1c represents the “to-be” business process variant that will be derived from the equity trade business process (“as-is” business process model) modelled in different business process modelling approaches. The equity trade business process is adapted from (Milani, Dumas and Matulevičius, 2012).

11.1 Multi-Model

Figure 11-1 shows the Multi model for the Equity Trade process modelled separately using the BPMN modelling language. The multi-model has a redundancy of 4 as can be seen from Table 11-1. The CFC is 2 because of one XOR-split with two outgoing edges. The minimal number of change operations needed to model the “to-be” variant in Figure 11-1c is 4. The summary of the measurements is in Table 11-2.

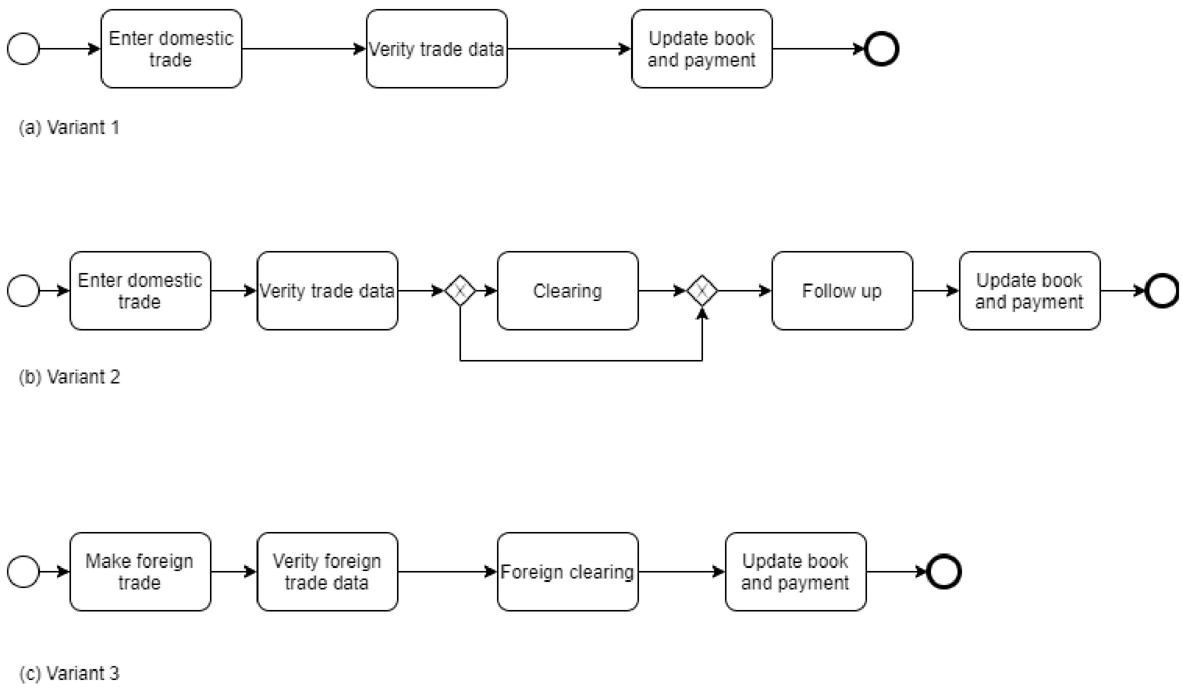


Figure 11-1 Multi-model for the equity trade process

Table 11-1 Redundancy of activities in Multi model for the equity trade process

Activity	Occurrences(x)	Duplicates(x-1)
Enter domestic trade	2	1
Verify trade data	2	1
Update book and payment	3	2
Redundancy		4

Table 11-2 Measurements from Multi model for the equity trade process

Metric	Value
Redundancy	4
Complexity	2
Minimal Number of Change Operations	4

11.2 C-EPC and Configurative Process Modelling

Figure 11-2 shows the EPC model for the Equity Trade process with the redundancy of functions equal to 0. The complexity of the model is 2, which is added by one XOR-split with two outgoing edges. The minimal number of change operations needed to transform the EPC model in Figure 11-2 to a "to-be" EPC variant represented by the variant in Figure 11-1c is 4. The transformation is achieved by deleting "Enter domestic trade", "Verify trade data", "Clearing", and "Follow up". The measurements for complexity, redundancy and the minimal number of change operations are summarized in Table 11-3.

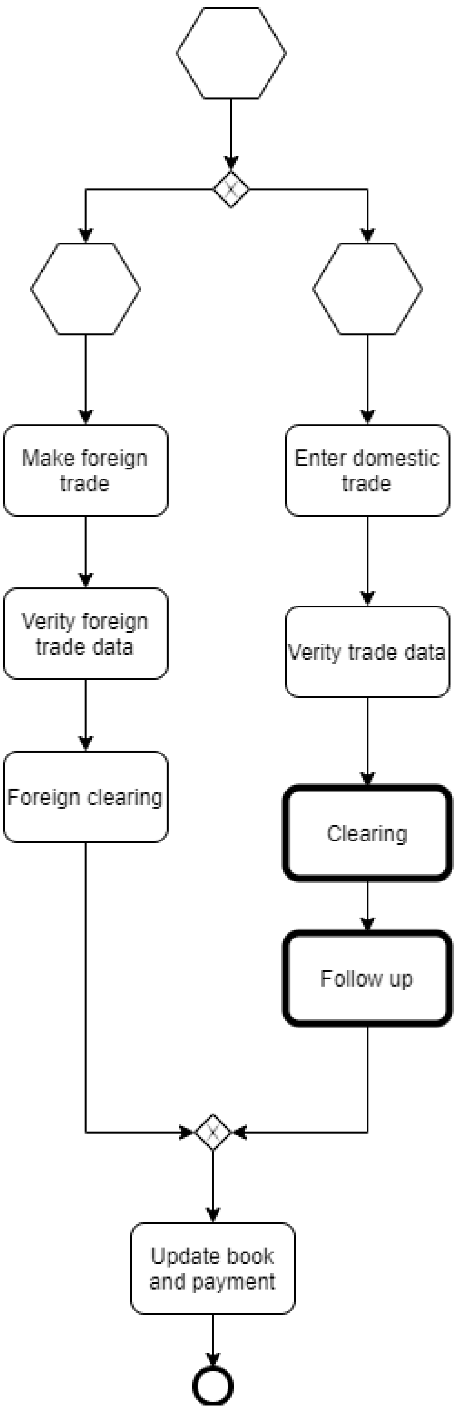


Figure 11-2 C-EPC model for the equity trade process

Table 11-3 Measurements from C-EPC model for the equity trade process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	4

11.3 Single Model

The single model for the Equity Trade process is shown in Figure 11-3, and it is modelled using the BPMN standard. The model has a redundancy of 0. The model has three XOR-splits with two outgoing edges (CFC is 6), which makes the Control Flow Complexity (CFC) of all splits in the model to be 6. The minimal number of change operations needed to transform the single model to the "to-be" variant represented by the variant in Figure 11-1c is 4. The transformation is achieved by deleting "Enter domestic trade", "Verify trade data", "Clearing", and "Follow up". A summary of the measurements for redundancy, complexity and the minimal number of change operations can be seen in Table 11-4.

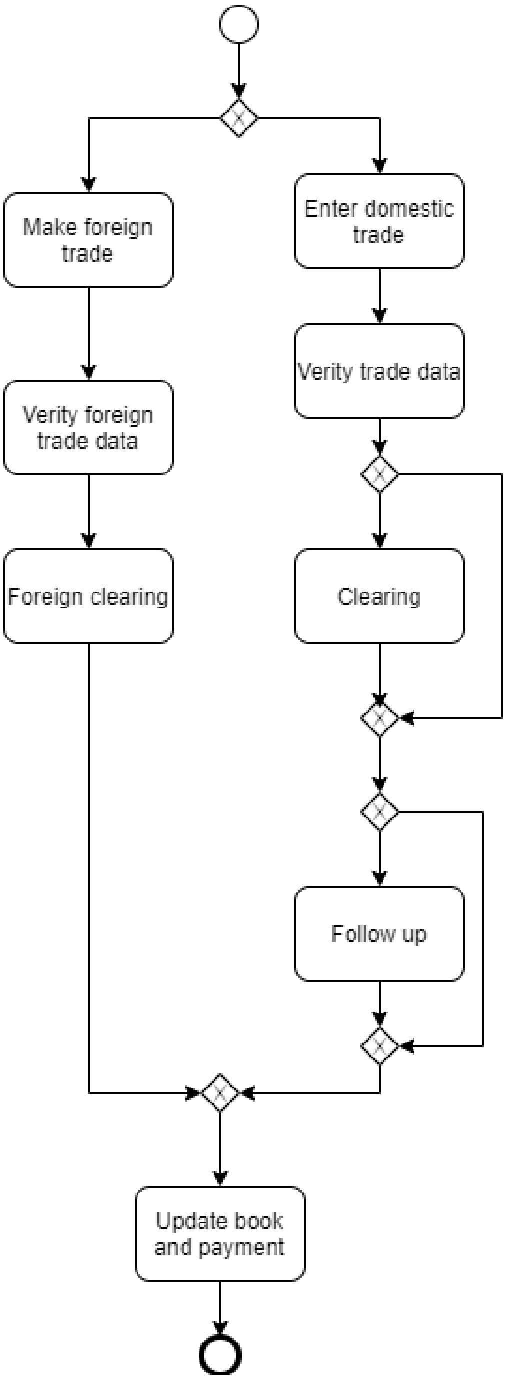


Figure 11-3 Single model for the equity trade process

Table 11-4 Measurements from Single model for the equity trade process

Metric	Value
Redundancy	0
Complexity	6
Minimal Number of Change Operations	4

11.4 Provop

The Provop model with related change operations for the Equity Trade process is shown in Figure 11-4, and the main process model is based on the variant model shown in Figure 11-1b. The model has a redundancy of 0 and a complexity of 2. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 11-1c is 7, as shown by the number of change operations in Figure 11-4. The summary of the measurements for redundancy, complexity and minimal change operations can be seen in Table 11-5.

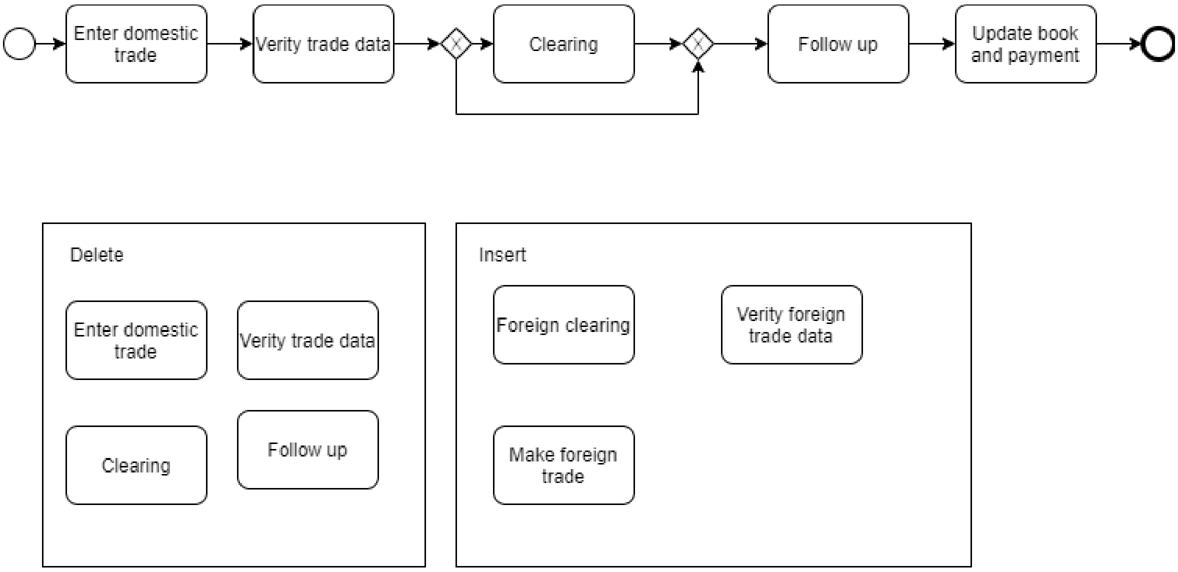


Figure 11-4 Provop model for the equity trade process

Table 11-5 Measurements from Provop model for the equity trade process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	7

11.5 proCollab

Figure 11-5 shows a templet for the Equity Trade process, which is based on the variant in Figure 11-1b, with a complexity of 1 and redundancy of 0. In order to transform the model in Figure 11-5 to a proCollab variant templet which is equivalent to the variant in Figure 11-1c, the following change operations will have to be performed: delete “Enter domestic trade”, “Verify trade data”, “Clearing”, and “Follow up”; and insert “Foreign clearing”, “Make foreign trade” and “Verify foreign trade data”. The change operations come to a total of 7 change operation.

The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 11-6.

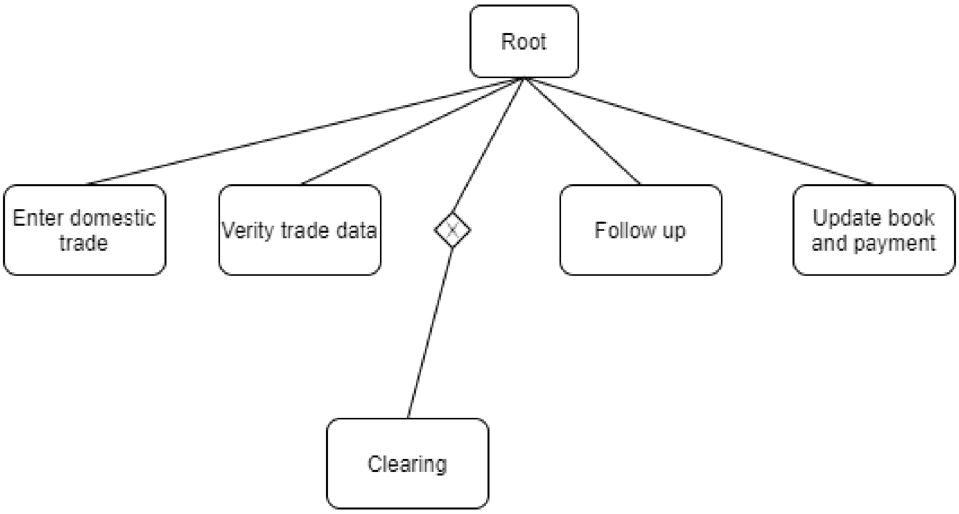


Figure 11-5 proCollab model for the equity trade process

Table 11-6 Measurements from proCollab model for the equity trade process

Metric	Value
Redundancy	0
Complexity	1
Minimal Number of Change Operations	7

11.6 PESOA

Figure 11-6 shows the PESOA model for the Equity Trade process with a redundancy of 0 and a complexity of 7, which is added by the seven association lines. The minimal number of change operations for transforming the model in Figure 11-6 to the "to-be" variant represented by the model in Figure 11-1c is 4. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 11-7.

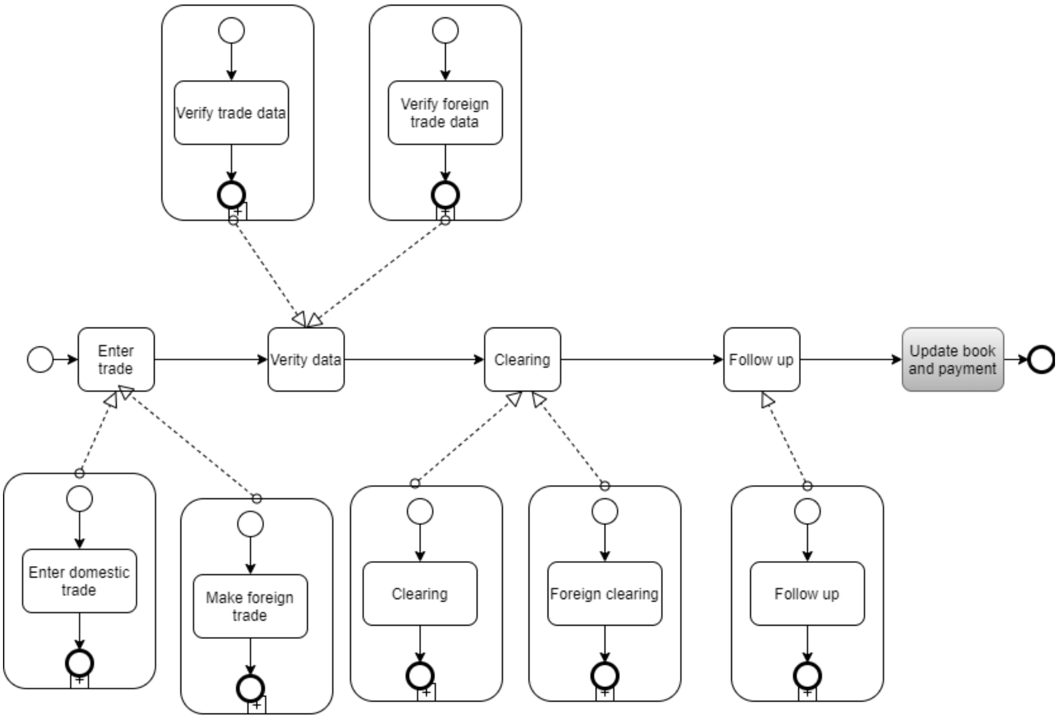


Figure 11-6 PESOA model for the equity trade process

Table 11-7 Measurements from PESOA model for the equity trade process

Metric	Value
Redundancy	0
Complexity	7
Minimal Number of Change Operations	4

Chapter 12 Hypothetical Process Model

The business process model in Figure 12-1b represents the “to-be” business process variant that will be derived from a hypothetical business process (“as-is” business process model) modelled in different business process modelling approaches. The hypothetical business process is shown in (Pourmasoumi *et al.*, 2015).

12.1 Multi-Model

Figure 12-1 shows a Hypothetical process with variants modelled separately using the BPMN modelling language. The multi-model has a redundancy of 20 as can be seen from Table 12-1, and the CFC is 13 because of five XOR-split with two outgoing edges and three AND-split with three outgoing edges. The minimal number of change operations needed to model the “to-be” variant in Figure 12-1b is 7. The summary of the measurements is in Table 12-2.

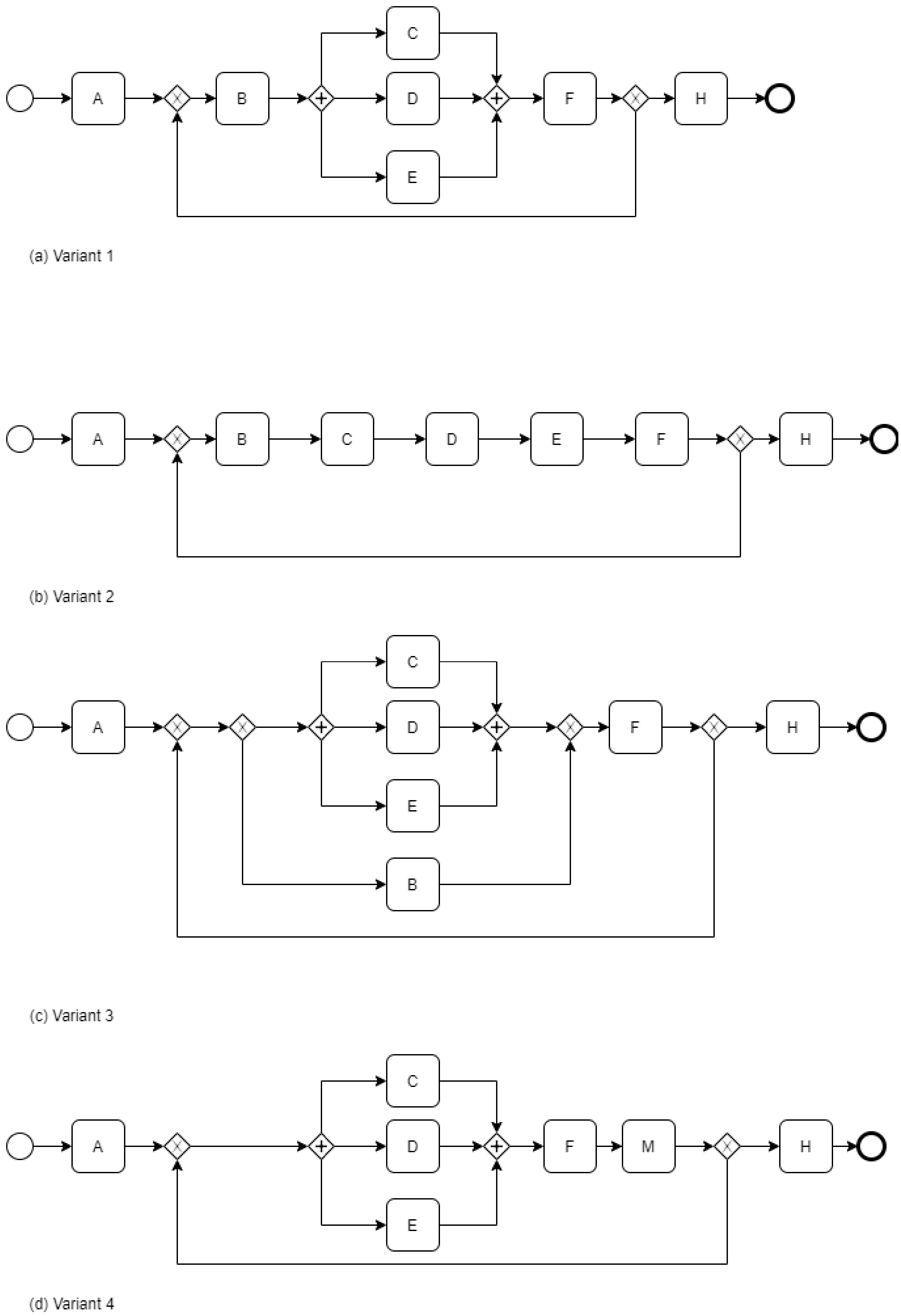


Figure 12-1 Multi-model for a hypothetical process (Pourmasoumi et al., 2015)

Table 12-1 Redundancy of activities in Multi model for the hypothetical process

Activity	Occurrences(x)	Duplicates(x-1)
A	4	3
B	3	2
C	4	3
D	4	3
E	4	3
F	4	3
H	4	3
M	1	0
Redundancy		20

Table 12-2 Measurements from Multi model for hypothetical process

Metric	Value
Redundancy	20
Complexity	13
Minimal Number of Change Operations	7

12.2 Single Model

The single model for the Hypothetical process is shown in Figure 12-2, and it is modelled using the BPMN standard. The model has a redundancy of 4 because each of the activities, B, C, D, and E occur two times in the model. The model has three XOR-splits with two outgoing edges (CFC is 6), one XOR-splits with three outgoing edges (CFC is 3), and one AND-split with three outgoing edges (CFC is 1) which makes the Control Flow Complexity (CFC) of all splits in the model to be 10. The minimal number of change operations needed to transform the single model to the “to-be” variant represented by the variant in Figure 12-1b is 5. The transformation can be achieved by deleting C, D, E, B and M, which gives a total of 5 operations. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 12-3.

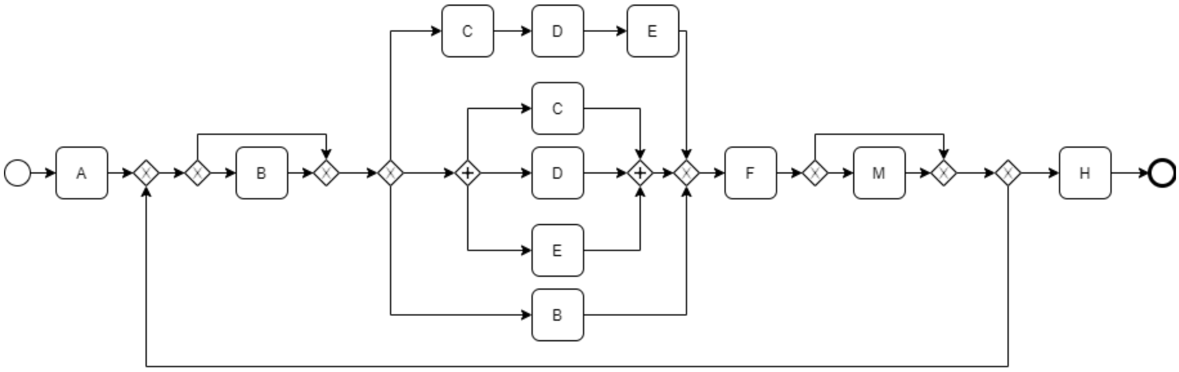


Figure 12-2 Single model for a hypothetical process

Table 12-3 Measurements from Single model for hypothetical process

Metric	Value
Redundancy	4
Complexity	10
Minimal Number of Change Operations	5

12.3 C-EPC and Configurative Process Modelling

Figure 12-3 shows the EPC model for the Hypothetical process with the redundancy of functions equal to 4. The complexity of the model is 6, which is added by one XOR-split with two outgoing edges, one XOR-split with three outgoing edges and one AND-split with three outgoing edges. The minimal number of change operations needed to transform the EPC model in Figure 12-3 to a "to-be" EPC variant represented by the variant in Figure 12-1b is 5, which can be achieved by deleting C, D, E, B and skipping M. The measurements for complexity, redundancy and minimal change operations are summarized in Table 12-4.

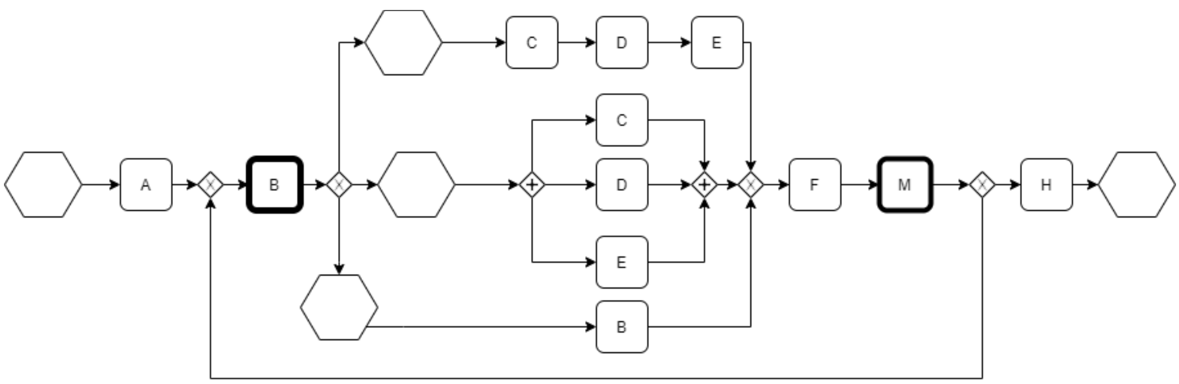


Figure 12-3 C-EPC model for a hypothetical process

Table 12-4 Measurements from C-EPC model for hypothetical process

Metric	Value
Redundancy	4
Complexity	6
Minimal Number of Change Operations	5

12.4 Provop

The Provop model with related change operations for the Hypothetical process is shown in Figure 12-4, and the main process model is based on the variant model shown in Figure 12-1a. The model has a redundancy of 0 and a complexity of 3. The minimal number of change operations needed to transform the main process to the variant represented by the model in Figure 12-1b is 2, as shown by the number of change operations in Figure 12-4. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 12-5.

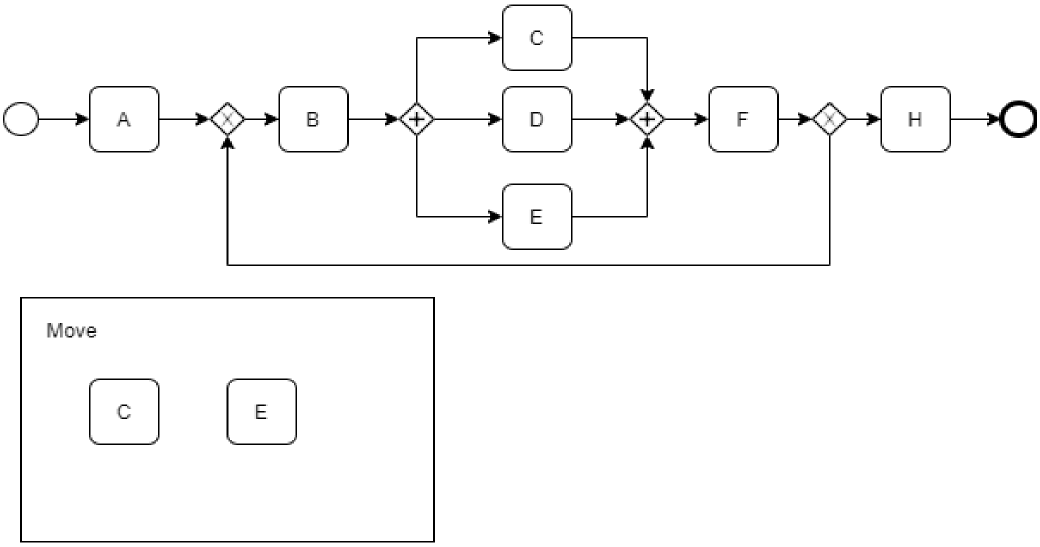


Figure 12-4 Provop model for a hypothetical process

Table 12-5 Measurements from Provop model for hypothetical process

Metric	Value
Redundancy	0
Complexity	3
Minimal Number of Change Operations	2

12.5 proCollab

Figure 12-5 shows a templet for the Hypothetical process, which is based on the variant in Figure 12-1a, and it has a complexity of 2 and redundancy of 0. In order to transform the model in Figure 12-5 to a proCollab variant templet which is equivalent to the variant in Figure 12-1b, the following change operations will have to be performed: move C, D and E to become siblings of B and F, which results to the minimal number of change operation equal to 3. The summary of the measurements for redundancy, complexity and minimal change operations are shown in Table 12-6.

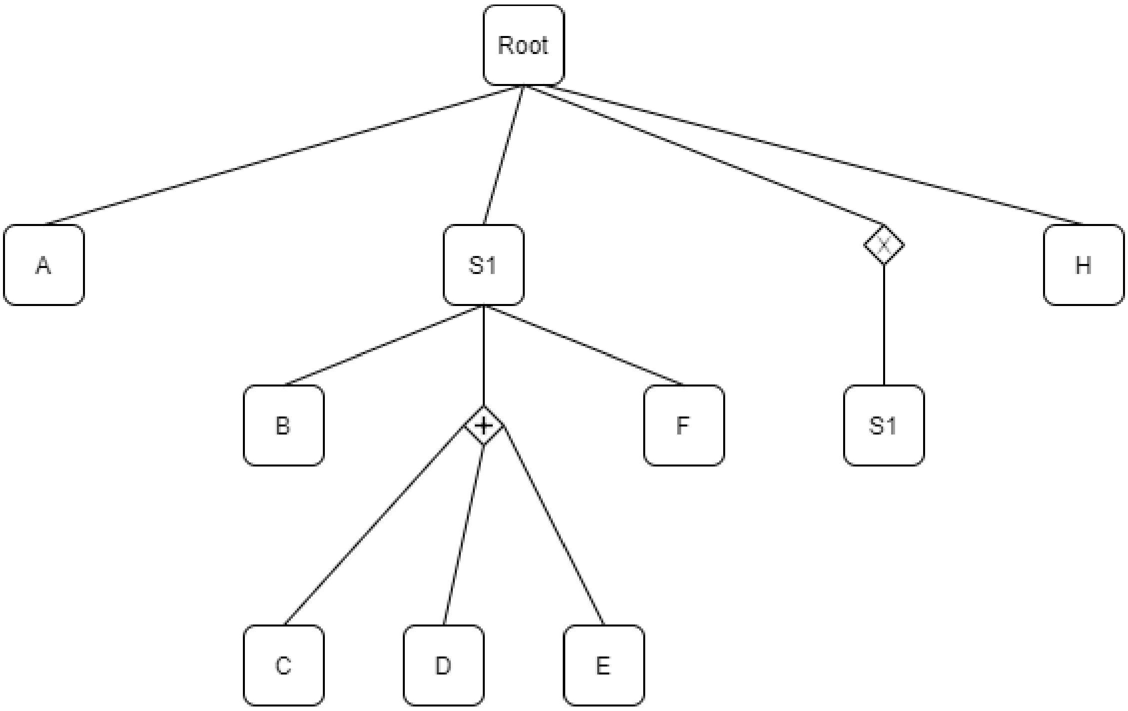


Figure 12-5 proCollab model for a hypothetical process

Table 12-6 Measurements from proCollab model for hypothetical process

Metric	Value
Redundancy	0
Complexity	2
Minimal Number of Change Operations	3

12.6 PESOA

Figure 12-6 shows the PESOA model for the Hypothetical process with a redundancy of 4 and a complexity of 6, which is added by the five association lines and one AND-split with three outgoing edges. The minimal number of change operations for transforming the model in Figure 12-6 to the "to-be" variant represented by the model in Figure 12-1b is 3 because three subprocesses can be deleted to achieve the transformation. The measurements for redundancy, complexity and the minimal number of change operations are summarized in Table 12-7.

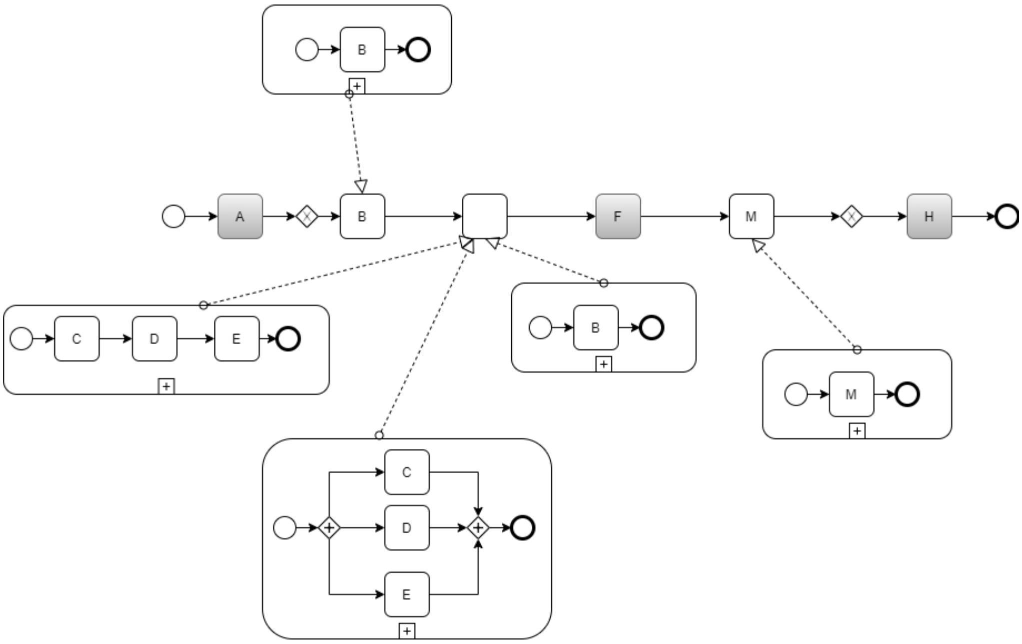


Figure 12-6 PESOA model for a hypothetical process

Table 12-7 Measurements from PESOA model for hypothetical process

Metric	Value
Redundancy	4
Complexity	6
Minimal Number of Change Operations	3

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