

# Measures for BPMN models

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## 1. MEASURES DEFINED FOR BPMN MODELS

We defined a set of measures for business process models represented with BPMN. These have been placed in two categories: base measures and derived measures.

The base measures consist principally of counting the business process model's significant elements. With the definition of these base measures, it is possible to discover how many significant elements there are in the business process diagram. Nevertheless, starting from the base measures a set of derived measures has been defined which allows us to see the proportions that exist between the different elements of the model.

Actually we are working with a selection of 29 measures from a set of 60 measures originally defined. The selection took place on the basis of those measures considered more representatives at the time of analyzing the structural complexity of business processes models. In addition the measures were grouped according to the main group of elements that compose them, being defined three groups with a total of 29 measures. Tables 1, 2 and 3 shows the groups of measures.

Table 1. Group A – Gateways and Control Flows (6 base measures, 1 derived measure)

GROUP	Principal Element	Base Measures(6)		Derived Measures (1)	
A	Control-Flow from Gateways	NEDDB	Number of Exclusive Decision Data Based	TNG	Total Number of Gateways $TNG = NEDDB + NEDEB + NID + NCD + NPF$
		NEDEB	Number of Exclusive Decision Event Based		
		NID	Number of Inclusive Decision		
		NCD	Number of Complex Decision		
		NPF	Number of Parallel Forking		
		NSFG	Number of Sequence Flows coming from Gateways		

Table 2. Group B – Pools, Lanes, Sequence Flows and Data Object (5 base measure, 6 derived measures)

GROUP	Principal Element	Base Measures(5)		Derived Measures(6)	
B	Pools/Lanes	NP	Number of Pools	CLP	Connectivity Level between Participants (Pools) $CLP = \frac{NMF}{NP}$
		NL	Number of Lanes	PLT	Proportion of Pools and/or Lanes of the Process and Activities in the Model $PLT = \frac{NL}{TNT}$
	Messages	NMF	Number of Message Flows between participants		
	Data Object	NDOIn	Number of Data Object of Input to activities	TNDO	Total Number of Data Objects in the Process Model $TNDO = NDOIn + NDOOut$
		NDOOut	Number of Data Object of Output to activities.	PDOPIIn	Proportion of Data Object as Incoming Product and the total of Data Objects $PDOPIIn = \frac{NDOIn}{TNDO}$
				PDOPOut	Proportion of Data Object as Outgoing Product and the total of Data Objects $PDOPOut = \frac{NDOOut}{TNDO}$
				PDOTOut	Proportion of Data Object as Outgoing Product of Activities of the Model $PDOTOut = \frac{NDOOut}{TNT}$

Table 3. Group C - Activities, Events, Sequence Flows (7 base measures, 4 derived measures)

GROUP	Principal Element	Base Measure(7)		Derived Measure (4)	
C	Events	TNSE	Total Number of Start Events	TNE	Total Number of Events $TNE = NTSE + NTIE + TNEE$
		TNIE	Total Number of Intermediate Events		
		TNEE	Total Number of End Events		
		NSFE	Number of Sequence Flows output of events		
	Precedence of Activities	TNT	Total Number of Tasks	TNA	Total Number of Activities $TNA = TNT + TNCS$
		TNCS	Total Number of Sub-Process		
		NSFA	Number of Sequence Flows between activities	CLA	Connectivity Level between Activities $CLA = \frac{TNA}{NSFA}$
			TNSF	Total Number of Sequence Flows $TNSF = NSFG + NSFE + NSFA$	

With the defined base and derived measures, it is possible to evaluate the structural complexity of business process models developed with BPMN. When we analyse the model structurally, it is thus also possible for us to evaluate its internal quality.

Moreover, in line with our objective, which is that of discovering which of the defined measures may provide useful and objective information about the external quality of the business process models (BPMs), we will focus on two characteristics of the external quality of the ISO 9126: *Usability and Maintainability*. These will be evaluated by means of the following two sub-characteristics which are respectively:

- *Understandability*. The ease with which the model can be understood by the user.
- *Modifiability*. The ease with which the model can be modified, by possible errors, by requesting a specific modification or by new requirements.

In order to discover what measures may serve as useful indicators to evaluate the understandability and modifiability of the MPNs, two families of experiments has been carried out. The experimental plan for the second family is described next.

## 2. EXPERIMENTAL PLAN

The second family of experiments included the development of five experiments which were carried out in similar circumstances and in the same context. In the experiments of the second family the understandability and modifiability aspects were analyzed. The analysis was carried out with separate experiments designed to analyze each aspect. In this way, of the five experiments included in the second family, the first three were carried out to analyze the understandability of the models and in the fourth and fifth experiment the modifiability was evaluated. In the following sections we describe the general plan of the second family of experiments.

### 2.1 Research Objectives

Using the GQM template (Goal Question Metric) the goal of the experiment is defined as: To analyse measures of BPM structural complexity, with the purpose of evaluating them as regards their capability of being used as indicators of business process model understandability and modifiability. The last two features will be assessed by the researchers in the context of PhD students, research assistants and lecturers in software engineering.

### 2.2 Participants

The subjects were chosen as suited our purposes and all of them had a broad knowledge of the modelling of the product (UML, data bases, etc). But they had no previous experience of the conceptual modelling of business processes, so were given a preparatory lesson before the experiment was carried out.

In this session they received an explanation of the BPMN standard notation for the modelling of business processes. Nevertheless, although they took part in this training session, our subjects were not made aware of the aspects that we were attempting to study. The participant groups in the second family of experiments can be seen in Table 4.

**Table 4. Participant groups in second family of experiments.**

Exp.	Group	N° Sub.	Profiles
1 (Und)	UCLM (Spain)	22	PhD students and students in computer engineering.
2 (Und)	UCLM (Spain)	40	Students of 4 <sup>th</sup> year in Computer engineering.
3 (Und)	UCLM (Spain)	9	PhD students and students in computer engineering.
4 (Mod)	University of Bari (Italy)	29	Students in computer engineering
5 (Mod)	UAT- (México)	15	Master's Students in Information Systems.

### 2.3 Material

The material prepared to analyze the understandability aspect consisted of fifteen business process models represented with BPMN, which have different structural characteristics and dimensions from each other, which is to say that models with different degrees of complexity were selected. These had been obtained by varying the value of the measures in each model, as can be seen in Table 5. Moreover, a questionnaire was formulated for each of the aforementioned models, which consisted of a series of questions related to the model's understandability.

**Table 5. Value of Measures.**

Model	Base Measures																Derived Measures												
	NEDDB	NEDEB	NID	NCD	NPF	NSFG	NP	NL	NMF	NDOIn	NDOOut	TNSE	TNIE	TNEE	NSFE	TNT	TNCS	NSFA	TNG	CLP	PLT	TNDO	PDOPIn	PDOPOut	PDOTOut	TNE	TNA	CLA	TNSF
1	2	4	1	2	0	23	2	0	3	1	2	2	4	2	3	24	1	24	9	1,5	0	3	0,33333	0,66667	0,08333	8	25	1,04	50
2	5	2	4	1	1	28	2	0	2	0	2	1	3	2	2	18	2	19	13	1	0	2	0	1	0,11111	6	20	1,05	49
3	4	3	3	3	2	33	3	0	16	2	3	3	1	9	4	42	2	43	15	5,33	0	5	0,4	0,6	0,07143	13	44	1,02	80
4	6	1	2	4	3	41	2	0	2	0	0	1	0	2	1	44	1	45	16	1	0	0	0	0	0	3	45	1	87
5	1	0	0	0	0	2	1	0	0	0	0	1	0	1	1	4	0	4	1	0	0	0	0	0	0	2	4	1	7
6	3	0	0	0	2	9	4	2	8	10	10	3	0	3	3	13	0	13	5	2	0,15	20	0,5	0,5	0,76923	6	13	1	25
7	3	0	0	1	0	9	5	3	11	8	8	3	3	3	7	11	0	8	4	2,2	0,27	16	0,5	0,5	0,72727	9	11	1,38	24
8	2	0	0	0	0	5	3	0	13	3	3	2	1	2	3	22	2	23	2	4,33	0	6	0,5	0,5	0,13636	5	24	1,04	31
9	3	0	0	0	0	8	2	3	5	5	5	4	0	3	4	20	2	23	3	2,5	0,15	10	0,5	0,5	0,25	7	22	0,96	35
10	0	0	0	0	0	0	1	0	0	2	1	1	0	1	1	3	0	3	0	0	0	3	0,66667	0,33333	0,33333	2	3	1	4
11	1	0	0	0	0	2	3	2	12	2	2	3	5	4	8	25	3	24	1	4	0,08	4	0,5	0,5	0,08	12	28	1,17	34
12	2	0	0	0	0	4	2	0	6	0	0	2	3	3	5	12	4	14	2	3	0	0	0	0	0	8	16	1,14	23
13	4	0	0	0	0	8	5	0	18	8	7	4	7	8	11	31	9	35	4	3,6	0	15	0,53333	0,46667	0,22581	19	40	1,14	54
14	2	0	0	0	0	4	4	0	11	8	8	1	1	6	2	19	11	29	2	2,75	0	16	0,5	0,5	0,42105	8	30	1,03	35
15	0	0	0	0	0	0	1	0	0	0	0	1	1	1	2	3	1	3	0	0	0	0	0	0	0	3	4	1,33	5

The experimental material used for the development of experiments with the objective to analyze the modifiability aspect, consisted of a selection of twelve models from the fifteen used to analyze the understandability. For these twelve business process models a questionnaire was formulated which proposed two modifications to be carried out in the model.

In addition, at the end of each questionnaire a question was included, whereby the subjects were asked to assess the complexity of the models presented in a subjective manner.

The material also included a guide to BPMN notation and an example of a solution which showed how the exercises should be done.

### 2.4 Experimental Design

A within-subjects design was carried out, in which all the subjects had to answer all the tests. The ten business process models which were handed out to each subject were given in a different order in each case. While the material described was being given out to the subjects, there was a brief explanation of how to fill in the test—they were told that there was no time limit for the completion of this. They were encouraged to ask the person in charge of the organization of the experiment about any doubts they might have.

## 2.5 Experimental Task

Each subject received material composed of overall business process models aforementioned. Depending on the experiment type (understandability or modifiability) the subjects have to carry out one of the following tasks: to answer “yes” or “no” to three questions about the model or to carry out two modifications consisting of adding and/or deleting tasks, data objects, events, roles or dependences among these elements.

Each type of task (understandability or modifiability) to be developed has to be similar in its complexity. For this reason, the only source of variation in effort to perform tasks of the same type is the complexity of each model. Before starting to perform the tasks required in each model the subjects are required to write down the starting time, and at the end they have to write down the finishing time.

Finally, the subjects were asked to give a subjective assessment of the overall complexity of the model as they had experienced it. To do that they had available a scale of 1-5, with linguistic values attached (1= very simple, to 5= very complex).

## 2.6 Variables

The independent variables correspond with the proposed measures, which is to say the base measures and derived measures already described. The dependent variables are those relating to the understandability and modifiability of the BPMs which were measured according to the answer times, correct answer, subjective evaluation and subjects’ efficiency when performing the tasks, which is calculated as the ratio between the number of correct answers and the time.

## 2.7 Hypothesis

The hypotheses proposed with respect to the objective of our investigation are the following:

- Null hypothesis,  $H_{0u}$ : There is no significant correlation between the structural complexity measures and the understandability.
- Alternative hypothesis,  $H_{1u}$ : There is a significant correlation between the structural complexity measures and the understandability.
- Null hypothesis,  $H_{0m}$ : There is no significant correlation between the structural complexity measures and the modifiability.
- Alternative hypothesis,  $H_{1m}$ : There is a significant correlation between the structural complexity measures and the modifiability.