Research Proposal

Topic: Exploring complexity metrics and model comprehension for artifacts-based process models

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Abstract

This study will explore complexity metrics for business artifacts processes models, which is an emerging way to model business processes. Business process management (BPM) is a relatively mature discipline with a large number of practitioners. BPM technology is based on directed graphs that describe control flow. Petri-Nets provide the theoretical foundation for BPM. Over the last decade a new way to describe data intensive business processes has emerged, for which Petri-Net is not a good foundation, because the focus has changed from control flow to the business data. This new emerging method has been called business artifacts process models with guard-stage-milestone (GSM) and is being used to describe more flexible processes, including case management processes. A case management modeling standard is being created by the object management group (OMG) standard organization. This emerging standard is heavily influenced by the work on business artifacts with GSM.

Complexity metrics have been developed and empirically verified for traditional BPM models based on directed graphs, such as the business processes modeling and notation (BPMN). However, directed graphs are not suitable for describing the business artifacts process models used to describe case management. Therefore, complexity metrics developed for traditional process models may not be applicable to business artifacts process models. Current, business artifacts research has focus on the applicability of business artifacts to business process and its formal verification, but not on complexity metrics.

This study will contribute to the literature by exploring complexity metrics for business artifacts processes models with GSM, of the sort that are used to describe case management processes. The findings of this study will have practical implications for the emerging case management standard and commercial products.

Keywords:

Business artifact, Business artifact process, Business artifact process model, Business process management, Case handling, Case management, Complexity metric, Guard-stage milestone, Model comprehension, Perceived complexity, Process model

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1 Introduction

Business process management (BPM) technology is a procedural way to describe and automate business processes. Those BPM processes consist of an organized set of business activities required to achieve a business goal. The activities can be either automatically executed by a computer system or manually executed by a person interacting with a computer system. Business process management can be defined as "a series or network of value-added activities, performed by their relevant roles or collaborators, to purposefully achieve the common business goal" (Ko 2009:12)

Process modeling is used to describe the process to be automated by organizing the activities that need to be performed to achieve a business goal in the correct sequence. A business process model is described in a visual manner and represents the way that business representatives conduct the operation of a business (Bandara & Rosemann, 2005:347). Figure 1 shows an example of a business process model designed according to the business process model notation (BPMN).

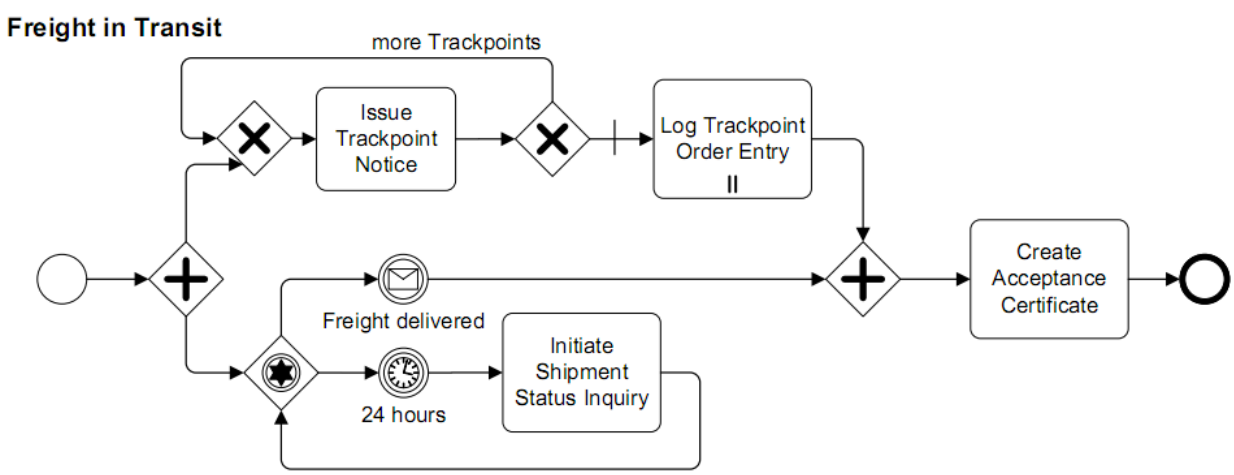

Figure 1. Modeling the freight in transit using business process management notation (Decker *et al.*, 2010:348).

Business artifacts are a new way to describe business processes from a data-centric perspective (Nigam & Caswell, 2003:428). Documents, like a Microsoft word document or an excel spreadsheet, are considered business artifacts, and some processes are based on the lifecycle of those documents. This led Kumaran *et al.* (2003:335) to the concept of adaptive documents as domain artifacts, which provided a document centric view of processes using business artifacts. This approach to business artifacts has been found useful to model real-world business processes, including case management (Vaculin *et al.*, 2011:160). Work on formal verification of business processes based on artifacts is an active area of research (Damaggio, 2011:1). Figure 2 shows an example of a business process model using business artifacts with guard-stage-milestones (GSM).

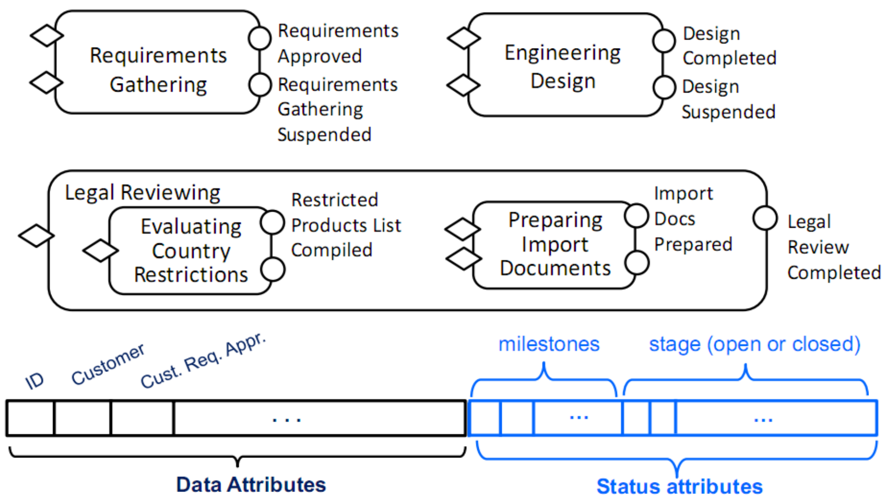

Figure 2. Modeling of engineering requirements using business artifacts (Damaggio *et al.*, 2011:400).

Business users need to understand process models to communicate with members of the information technology (IT) department and with other business users. Understanding the business models is not only important for communication between the IT department and business users, but also facilitates the communication and transfer of knowledge regarding BPM technology throughout the organization (Swan, 2007:i). Complexity metrics can be used to describe the extent of ease or difficulty involved for a human to understand a business process (Gruhn & Laue, 2006:1).

Extensive research has been conducted on the complexity of traditional BPM models. For example, Cardoso (2007:38) presented a set of complexity metrics for business processes models. Gruhn and Laue (2006:10) adapted several software engineering complexity metrics to business processes and proposed future research in this area. However, there is currently no research on the complexity of business artifacts processes models. Based on Figure 1 and Figure 2, it is clear that BPM models and business artifacts process models are very different, thus, most of the research on complexity metrics and user comprehension for BPM models may not apply to business artifacts processes models. Complexity metrics and user comprehension are based on the graphical notation of the models, and as shown in Figure 2, business artifacts with GSM models are missing the connectors (arrowed lines), gateways (diamonds), and events (circles) that describe the execution sequence of the BPM model (see Figure 1).

The proposed study will explore complexity metrics for business artifacts processes models. In particular, this study will focus on the case management modeling and notation (CMMN) (OMG, 2012:6), which is heavily influenced by business artifacts with GSM. In this proposal the terms CMMN, and business artifacts with GSM are interchangeable, because CMMN is based on business artifacts with GSM. This may contribute to new knowledge by providing an understanding of complexity metrics and user comprehension of business artifacts process models with GSM. In addition, this study will contribute to the literature theoretical identification and empirical validation of complexity metrics for process models based on business artifacts, with GSM, of the sort used by case management processes. Furthermore, this study will have practical implications for case management products and the emerging case management standard.

1.1 Background to the study

Although process models play an important role in the analysis and implementation of business processes (Lassen & van der Aalst, 2009:625), both process engineers and end users often have problems understanding these models. Since 2005, two main criticisms of BPM technology have been identified:

1) Some researchers have criticized the BPMN standard as being too complex for users. Recker *et al.* (2009:6) found standard BPMN to be more complex than the unified modeling language (UML). In addition, BPMN has a complex modeling vocabulary (Zur Muehlen *et al.*, 2007:478).
2) Researchers and practitioners have found BPM to be too restrictive for some cases and have proposed case management (also called case handling) as a flexible alternative to BPM. Van der Aalst *et al.* (2005:129) proposed a case-handling

paradigm to address BPM deficiencies in the area of flexible routing. Case handling may provide a solution to the lack of flexibility of workflow or BPM system (Vanderfeesten *et al.*, 2008:187). These findings led some industry analysts to propose case management as a solution to BPM inflexibility. Kerremans (2008:1) identified case management as difficult to implement with current BPM technology.

In September of 2009 representatives of the Object Management Group (OMG) issued a case management process modeling (CMPM) request for proposal (OMG, 2009:1). A group of 10 companies answering the request for proposal produced an initial draft named CMMN (OMG, 2012:6). As described by Marin *et al.* (2012), the proposed CMMN specification is based on using business artifacts with GSM to model case management systems. The final revised submission is expected by November 12, 2012 (Business Modeling & Integration Domain Task Force, 2012).

Business artifacts with GSM are declarative, as opposed to traditional processes models that are prescriptive (Vaculin *et al.*, 2011:152). The implications of using prescriptive direct graph models in BPMN, versus the use of descriptive models in CMMN, is that complexity metrics and user comprehensive studies designed for BPMN may not apply to CMMN. In the proposed research, the author plans to explore complexity metrics for CMMN models.

1.2 Problem statement

Process models based on business artifacts with GSM are gaining acceptance in the area of case management, because their declarative approach is more flexible than are current BPM prescriptive models. The research on complexity metrics and user comprehension for BPM may not apply to business artifacts process models, and in particular to CMMN. Therefore, there is a need to understand the applicability of BPM research regarding complexity metrics and user comprehension to business artifacts process models and to create and empirically validate specific complexity metrics for business artifacts process models.

Users find complex process models difficult to understand, and complex models are more likely to contain design errors (Lassen & van der Aalst, 2009:610). Therefore, research on complexity metrics and on user comprehension of process models is important. Several studies on the subject have been conducted (Bandara & Rosemann, 2005; Cardoso, 2006, 2007; Gruhn

& Laue, 2006, 2009; Swan, 2007; Vanderfeesten *et al.*, 2008; Lassen & van der Aalst, 2009; Melcher *et al.*, 2009; Recker *et al.*, 2009). In the cited studies the researchers used UML, BPMN, workflow nets, or proprietary BPM product models, all of which are based on directed graphs and are prescriptive in nature. Business processes based on business artifacts with GSM are declarative (Vaculin *et al.*, 2011:152); therefore, research on complexity metrics and user comprehension based on directed graph process models (e.g., see Figure 1) may not be applicable to business processes based on business artifacts with GSM (e.g., see Figure 2). This gap in the literature exists because case management based on business artifacts with GSM is an emerging technology.

1.3 Purpose of the study

The purpose of this quantitative study is to develop and validate complexity metrics for business artifacts process models with GSM of the sort being use by the CMMN standard (OMG, 2012:6). The study will be experimental in design and have two phases. In the first phase, the researcher will identify and theoretically validate feasible complexity metrics. The set of metrics will contain both metrics created for this study and metrics adapted from relevant BPM complexity metrics described in the literature, as shown in Appendix A. In the second phase, experiments will be conducted to empirically validate the proposed calculated complexity metrics, with the goal of identifying the best complexity metrics.

1.4 Research goal and objectives

The goal of this experimental study is to identify complexity metrics for business artifacts process models with GSM. The type of business artifacts process models that will be studied are those used in the CMMN standard (OMG, 2012:6). User comprehension of the models and user perceived complexity of the models will be used to empirically validate the identified metrics.

1.5 Scope of the study

The study will be limited to the identification and validation of a small set of complexity metrics for business artifacts process models with GSM. The identified complexity metrics will be theoretically and empirically validated, following the suggestions of Misra *et al.* (2012:323) and Briand *et al.* (1995:3).

It is expected that the CMMN standard (OMG, 2012:6) based on business artifacts process models with GSM will be available in November 2012 (Business Modeling & Integration Domain Task Force, 2012). This study will be based on that standard, which is a particular type of artifact process models with GSM. In the case of a delay in producing the OMG standard, this study will be based on the most recent business artifacts process models with GSM descriptions in the literature (e.g., Vaculin *et al.*, 2011:151). Finally, the empirical study will be limited to the use of students as subjects.

1.5.1 Assumptions

It is assumed that some BPM complexity metrics described in the literature are adaptable to business artifacts process models with GSM. The possibility of creating new complexity metrics is also assumed. These assumptions were based on the observation that even though declarative business artifacts process models with GSM are different from prescriptive BPM models, there are sufficient commonalities on the applicability and usage of the models that identifying valid metrics should be feasible.

It is assumed that students can be used as subjects for the empirical experiment in phase 2. Using students as proxies for other populations introduces external validity concerns (Zikmund, 2003). However, researchers investigating management decision making using students as subjects have found no significant differences between student and manager groups (Williams, 1986). Research on management decision making using student subjects as proxies is an accepted approach (William, 1986). Therefore, it is assumed that the use of students for the experiment is acceptable.

2 Research design and methodology

Phase one will identify and theoretically validate potential complexity metrics for CMMN models. It will start with a literature review of BPM complexity metrics to identify potential metrics that can be adapted to business artifacts process models with GSM. The literature review will be followed by designing new complexity metrics based on the characteristics of the CMMN models. For each identified metric a theoretical validation will be conducted to guarantee the metrics have good mathematical properties as described by Briand *et* *al.* (1995:3) and Misra *et al.* (2012:323). The identified metrics that pass the theoretical validation will be referred to as the calculated complexity metrics for phase two.

Phase two will empirically validate the identified calculated complexity metrics. An experiment will be conducted to examine differences between the calculated complexity metrics in terms of the perceived complexity and model comprehension. A within-subjects experimental design will be used to perform the empirical validation. The independent variable will be the treatment to which the subjects will be exposed. The treatment will consist of a set of ten CMMN models with different calculated complexity. All the subjects will be exposed to all the treatments, however, the instruments will be ordered differently for each subject. The design of the experiment may follow the design used by Canfora *et al.* (2005:118-120).

2.1 Research questions

The following research questions are identified for both phases of this proposal.

Q0. Are there applicable complexity metrics for business artifacts process models with GSM of the sort being use by the CMMN standard (OMG, 2012:6)?

Q1. What is the relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and the "subjective evaluation" of the complexity of the process model, as measured by an instrument based on the work of Rolon *et al.* (2008:59) and developed for this study, among senior college students of business administration and computer science?

Q2. What is the relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and user model comprehension of the process models, as measured by an instrument based on the work of Hadar (2010:2326) and developed for this study, among senior college students of business administration and computer science?

Q3. What is the relationship between the perceived complexity of the process models presented, as measured by "subjective evaluation" (Rolon *et al.*, 2008:59), and user model comprehension of the process models, as measured by an instrument based on the work of Hadar (2010:2326) and developed for this study, among senior college students of business administration and computer science?

2.2 Phase 1 (Complexity metrics identification and theoretical validation)

In the first phase of the study, potential calculated complexity metrics will be identified for business artifacts process models with guard-stage milestones. Two mechanisms to identify those metrics will be used:

- BPM complexity metrics present in the literature will be analyzed for applicability to business artifacts process models with guard-stage milestones. Modifications to those metrics may be required to enable adjustment to the new type of process models. The resulting metric may have different properties than the original BPM complexity metric.
- The researcher will also develop and propose new complexity metrics as part of this study.

The identified metrics will be theoretically validated according to the suggestion of Briand *et al.* (1995:3) and Misra *et al.* (2012:323), and each metric will be validated through the application of measurement theory and using Weyuker's properties (1988:1357), as suggested by Misra *et al.* (2012:325). Although measurement theory has been questioned as a way to evaluate complexity measures by Misra and Kilic (2007:1), it still serves the purpose of formalizing and validating important mathematical qualities of a complexity metric.

The result of this first phase will be a set of approximately six to 12 calculated complexity metrics.

2.3 Phase 2 (Empirical validation)

The empirical validation will use the identified complexity metrics as calculated complexity and will explore the relationship with model comprehension and perceived complexity. The independent variable, treatment, will be the calculated complexity operationalized with a set of ten CMMN models. Each of the identified complexity metrics will be calculated for each of the ten CMMN models. The dependent variables will be model comprehension and perceived complexity. Model comprehension will be measured on the basis of an instrument based on the method proposed by Hadar (2010:2326) and developed for this study. Perceived complexity will be measured by an instrument based on the work of Rolon et al. (2008:59) and Dyck (2005:41) and adapted for this study.

2.3.1 Hypotheses

It is expected that calculated complexity will correlate negatively with model comprehension, because as the model becomes more complex the user comprehension of the model should decrease. It is also expected that calculated comprehension will correlate positively with perceived complexity, because calculated complexity should be consistent with user perceived complexity. It is also expected that perceived complexity will correlate negatively with model comprehension, as the model becomes more complex the user comprehension of the model should decrease. Figure 3 shows the expected relationship of the independent variable to the dependent variables.

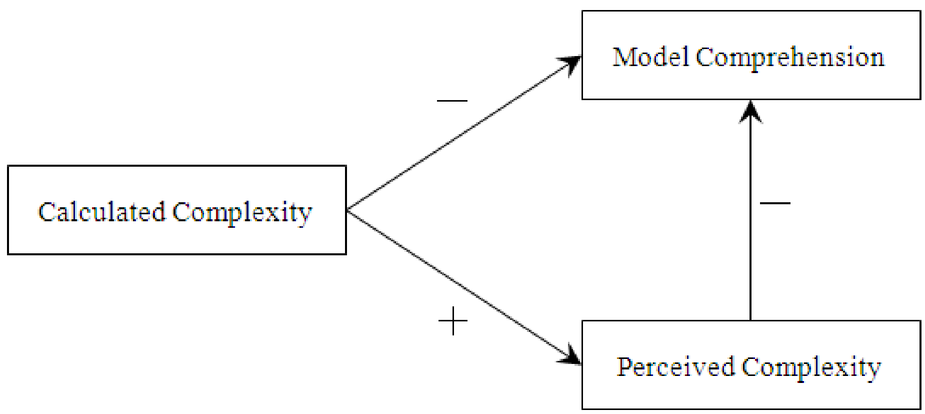

Figure 3. Hypothesized relationship between independent and dependent variables.

Based on the model and the research questions, the following hypotheses are formulated.

H1$_0$: There is no significant relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and the user perceived complexity of the process model, as measured by "subjective evaluation" (Rolon *et al.*, 2008:59), among senior college students of business administration and computer science.

H1$_a$: There is a significant relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and the user perceived complexity of the process model, as measured by "subjective evaluation" (Rolon *et al.*, 2008:59), among senior college students of business administration and computer science.

$H2_0$: There is no significant relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and user model comprehension of the process models, as measured by an instrument based on (Hadar, 2010:2326) but developed for this study, among senior college students of business administration and computer science.

$H2_a$: There is a significant relationship between the calculated complexity of the process models presented, as measured by the complexity metrics created for this study, and user model comprehension of the process models, as measured by an instrument based on (Hadar, 2010:2326) but developed for this study, among senior college students of business administration and computer science.

$H3_0$: There is not a significant relationship between the perceived complexity of the process models presented, as measured by "subjective evaluation" (Rolon *et al.*, 2008: 59), and user model comprehension of the process models, as measured by an instrument based on (Hadar, 2010:2326) but developed for this study, among senior college students of business administration and computer science.

$H3_a$: There is a significant relationship between the perceived complexity of the process models presented, as measured by "subjective evaluation" (Rolon *et al.*, 2008:59), and user model comprehension of the process models, as measured by an instrument based on (Hadar, 2010:2326) but developed for this study, among senior college students of business administration and computer science.

2.3.2 Research paradigm

The research methodology will follow a within-subjects experimental design. The participants will consist of a convenient sample of senior college students majoring in computer science and business administration at a state university, most likely in California. The research questions will be designed to examine the relationship between the independent variable, the calculated complexity (X), and the dependent variables, model comprehension (Y_1) and perceived complexity (Y_2).

2.3.2.1 Operational definition of variables

Calculated complexity and the dependent variables will be measured on an ordinal scale. College major (business management vs. computer science), a dichotomous nominal variable, will be computed as a covariate. Table 1 shows the operational definition of the variables.

Calculated complexity can be operationalized using a set of 10 process models, each one with different calculated complexity. Each of the complexity metrics identified in the first phase of the study will be associated with each of the 10 process models.

Table 1. Operational definition of variables

Variable name	Variable type	Scale	Source of data	Possible values	Research question
Calculated complexity of model	Independent	Ordinal	Multiple metrics created for this study	Integer, 0 to 100	Q1 and Q2
Perceived complexity of model	Dependent	Ordinal	Instrument adapted from Rolon *et al.* (2008:59)	Integer, 1 to 7	Q1 and Q3
User model comprehension	Dependent	Ordinal	Instrument adapted from Hadar (2010:2326)	Integer, 1 to 7	Q2 and Q3
Educational major	Covariate	Nominal	Demographic questions	1 = Business administration 2 = Computer science	All

2.3.3 Data collection methods

The participants will consist of senior college students majoring in business administration and computer science. The test is expected to last approximately one hour and will be conducted in a classroom setting. A power analysis calculation will be conducted using G*Power 3.1 (Buchner *et al.*, 2007) to determine the number of participants required.

As participants enter the classroom, they will receive a package with instructions and copies of the instruments. A large wall clock will be used for students to record the times during the experiment. At the conclusion of the experiment, participants will return the envelope to the experimenter. The participants will be compensated with a $10 stipend for participating in the experiment.

The package handed to each participant is will contain the following documents and instruments:

1) A letter describing the experiment and the tasks the participant is expected to complete.

2) An informed consent form to be completed by the participant.

3) Demographics and a prior experience questionnaire to be completed by the participant.

4) A set of 10 process models, representing the treatment.

5) The instrument to measure model comprehension. This instrument will be the same for all participants. The instrument will contain questions about the structure and meaning of the diagrams, as presented by Hadar (2010:2326).

6) The instrument to measure perceived complexity. This instrument will be the same for all participants. The instrument will contain questions about the complexity of the diagrams, as presented by Rolon *et al.* (2008:59).

A pilot test will be conducted to validate the instruments created for this study. Data collected during the pilot test phase will be analyzed to identify and correct potential issues with the data being collected.

2.3.4 Data analysis

The analysis to be used for this study will be similar as that used by Canfora et al. (2005:118-120). P-P plots will be used to determine whether or not the residuals of the collected data are distributed normally. For example Spearman's correlation (non-parametric test) for non-normal data may be used, otherwise the Pearson correlation. Tests will be evaluated with a 95% level of confidence.

2.4 Research ethics

This study will comply with the University of South Africa (UNISA) research ethics policy (2007). Milestone five (see section 4.2) in the project timetable is to gain ethical clearance from the UNISA School of Computing. The participants in the experimental phase of the study will receive an informed consent form as part of the package. Students will have an option to decline participation in the study.

3 Significance of the study

Case management modeling, as defined by CMMN, is a very different declarative process style from BPM and BPMN models. Although case management is not well understood, business process improvement practitioners are increasingly interested in the field in many industries (Hill, 2012:1). Business artifacts are considered a new trend in BPM (Ying et al., 2011:15), and the emerging standard for case management is based on business artifacts process models with GSM (Marin *et al.*, 2012). Although there is active research on the validity of business artifacts with GSM (Damaggio, 2012:135), complexity has not yet been explored. This deficiency may be due in part to the lack of a standard modeling notation that is addressed by the emergent CMMN (OMG, 2012:25). The proposed study will contribute an understanding of complexity metrics and user comprehension of business artifacts process models with GSM, of the type used to define the new CMMN specification.

3.1 Implications of research and proposed contribution

Previous researchers have investigated how business users understand BPM models. Swan (2007:1) explored the use of two BPM modeling notations, the graphical process model (GPM) and the unified modeling language (UML), to discover the ease with which untrained people could understand BPM models. Zur Muehlen and Recker (2008:466) found evidence that BPMN may be too complex for the intended business audience. In both studies, the authors concluded that more research was needed to clarify how well business users understood business process models. The research topic of this study follows Swan's (2007:218) suggestions for further research in the areas of BPM user comprehension and the application of cognitive theory to BPM users, including an analysis of the effect of tacit BPM knowledge. This research topic expands on previous work, yet focuses on business artifact process models with GSM for which no complexity or user comprehension studies are reported in the literature.

Process models play an important role in the analysis and implementation of business processes (Lassen & van der Aalst, 2009:625). However, both process engineers and end users often have problems understanding these models. Business users need to understand process models to communicate with members of IT departments and with other business users. Understanding the business models not only is important for communication between members of IT departments and business users, but also provides a means of ensuring that knowledge is communicated and transferred among managers throughout an organization (Swan, 2007:5). The proposed study will also complement the research of Zur Muehlen and Recker (2008:466) regarding BPMN, according to which BPMN was too complex for business users. This contribution will consist of an analysis of the comprehension of business artifacts process models with GSM on the emerging CMMN standard, a type of process model that is different from traditional BPM models.

This research will contribute new knowledge by exploring complexity metrics and user comprehension of CMMN models. In addition, this study will contribute to the literature with a theoretical identification and an empirical validation of complexity metrics for process models based on business artifacts, with GSM. Furthermore, this study will have practical implications for case management products and the emerging CMMN standard.

4 Research plan

The research plan is designed to provide sufficient time to implement the two phases of this study and to report the results. The plan includes a timetable with 13 milestones mapping to the important phases of the project.

4.1 Preliminary structure of the dissertation

The proposed dissertation structure in Figure 4 is an adaptation of Hofstee (2006:36) classic dissertation structure.

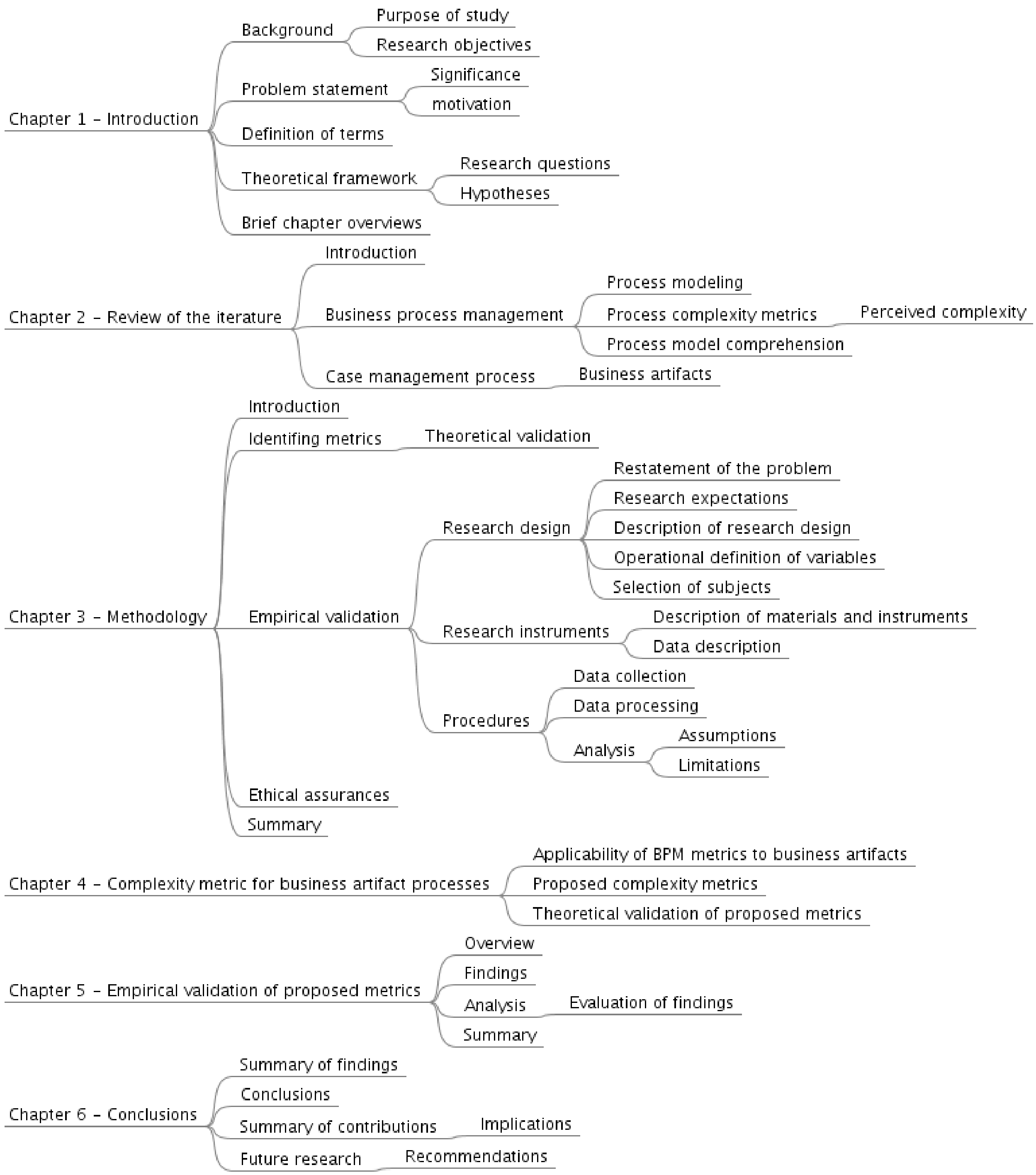

Figure 4. Proposed dissertation structure.

Chapter 1 will provide an introductory background and the problem statement. Chapter 2 will include a detailed literature review on the relevant topics for this work. Chapter 3 will describe the methodology of the study. Chapter 4 will identify the complexity metrics and provide theoretical validation for the identified metrics. Chapter 5 will describe the empirical validation of the metrics identified in chapter 4. Chapter 6 will present the conclusions and suggestions for further research.

4.2 Timetable

The project plan can be summarized by 13 milestones, as shown in Figure 5.

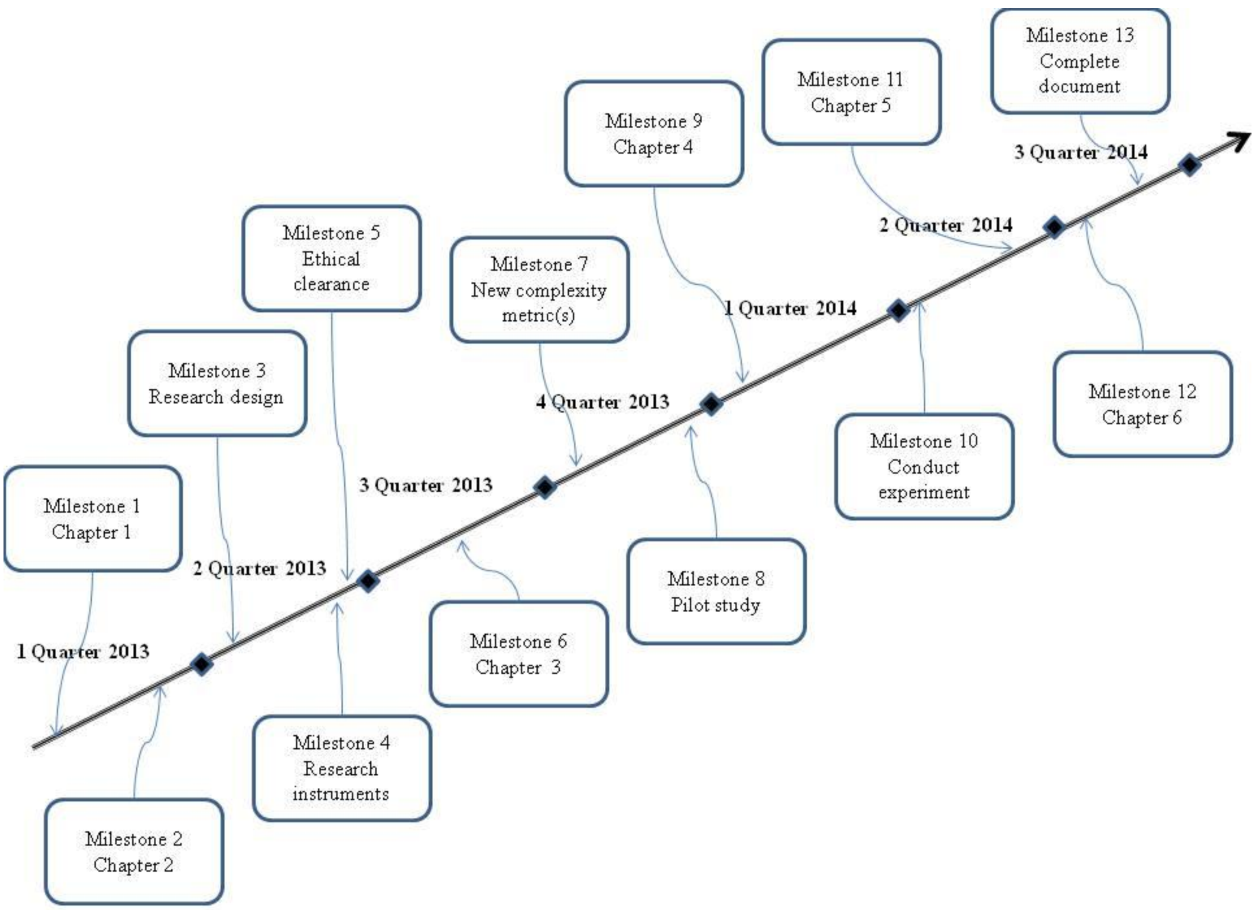

Figure 5. Planned dissertation milestones.

The detailed dissertation plan, including the milestones and sufficient time to account for supervisor reviews is presented in Table .

Table 2. Detailed dissertation plan

Milestone	Task	Duration (weeks)	Planned Begin
	Write chapter 1 (Introduction)	5	1-Dec-12
	Review chapter 1 with supervisor	3	5-Jan-13
Milestone 1	Complete chapter 1	-	26-Jan-13
	Write chapter 2 (Review of the literature)	4	19-Jan-13
	Review chapter 2 with supervisor	3	16-Feb-13
Milestone 2	Complete chapter 2	-	9-Mar-13
	Work on the research design	5	2-Mar-13
	Review research design with supervisor	3	6-Apr-13
Milestone 3	Complete research design	-	27-Apr-13
	Work on research instruments	6	20-Apr-13
	Review research instruments with supervisor	3	1-Jun-13
Milestone 4	Complete research instruments	-	22-Jun-13
	Submit ethical clearance form to the School of Computing	1	15-Jun-13
Milestone 5	Get ethical clearance from the School of Computing	-	22-Jun-13
	Write chapter 3 (Methodology)	5	22-Jun-13
	Review chapter 3 with supervisor	3	27-Jul-13
Milestone 6	Complete chapter 3	-	17-Aug-13
	Work on new business artifacts complexity metric(s) and theoretical validation	6	10-Aug-13

Milestone	Task	Duration (weeks)	Planned Begin
	Review new business artifacts complexity metric(s) with supervisor	3	21-Sep-13
Milestone 7	Complete proposed business artifacts complexity metric(s)	-	12-Oct-13
	Conduct pilot study to validate instruments and proposed complexity metrics	8	5-Oct-13
	Review results with supervisor	3	30-Nov-13
Milestone 8	Complete pilot study	-	21-Dec-13
	Write chapter 4 (identify complexity metric and theoretical validation)	4	14-Dec-13
	Review chapter 4 with supervisor	3	11-Jan-14
Milestone 9	Complete chapter 4	-	1-Feb-14
	Prepare experiment	5	25-Jan-14
	Discuss experiment with supervisor	3	1-Mar-14
	Conduct experiment	4	22-Mar-14
Milestone 10	Completed experiment	-	19-Apr-14
	Write chapter 5 (empirical validation of complexity metrics)	6	12-Apr-14
	Review chapter 5 with supervisor	3	24-May-14
Milestone 11	Complete chapter 5	-	14-Jun-14
	Write chapter 6 (Conclusions)	6	7-Jun-14
	Review chapter 6 with supervisor	3	19-Jul-14

Milestone	Task	Duration (weeks)	Planned Begin
Milestone 12	Complete chapter 6	-	9-Aug-14
	Work on overall thesis document	4	2-Aug-14
	Review thesis document with supervisor	3	30-Aug-14
Milestone 13	Complete thesis document	-	20-Sep-14
	Submit to School of Computing for approval	-	20-Sep-14

5 Definition of terms

The definitions in this section are derived from literature. The terms are commonly used within the body of relevant literature for business process management, process metrics, and case management.

Business artifact. A business artifact is a concrete, identifiable, self-describing piece of information that can be used by a business person to run a business (Nigam & Caswell, 2003:429-430). A business artifact is different from the object-oriented notion of object, because it is always an instance and does not provide encapsulation.

Business process management (BPM). Business process management is a self-documenting technology in which processes are modeled and then executed in a business process manager server. The technology allows processes to be controlled, monitored, and changed in real time (Vidgen & Wang, 2006:263).

Business process management notation (BPMN). Business process management notation is a standard graphical notation used to describe a business process. The notation is designed to facilitate communication between business users and technical developers in charge of implementing processes (OMG, 2010:1).

Business process model. A business process model, also referred to as a process model, is an abstract description of a process that can be enacted by a human or a machine. A business process model is described in a visual manner and represents the way that business representatives conduct the operation of a business (Bandara & Rosemann, 2005:48).

Case management. Case management, also known as case handling, is a particular type of business process that is "collaborative and nondeterministic, meaning it has one or more points where different continuations are possible, and it departs from traditional structured, sequential predefined processes. Case management work depends more on human decision making and content than other processes do" (Kerremans, 2008:2). The central concept of case management is the case, rather than the activities or the routing.

Case management process modeling (CMPM). Case management process modeling is the modeling of processes for case management applications, which require the concept of a case file to maintain information about the case, including history, documents, and notes. A "case management processes include knowledge encoded as rules that provides guidance, prompts, constraints and planning support for the human decision-maker" (OMG, 2009:1).

Case worker. A case worker is a participant in a case management process who oversees the case. The case worker is considered a knowledge worker. A case worker is expected to make decisions that affect the process applied to the particular case instance (Kerremans, 2008: 3).

Complexity metric. A complexity metric is a calculation on a business process model used to measure the degree in which the processes are difficult to analyze, understand, or explain to others (Cardoso, 2006:167). A complexity metric expresses the level of difficulty of a process definition for understanding and communicating to others.

Graphical process model (GPM). A graphical process model is a notation, based on formal graph theory, used to represent a business process model. Several types of GPMs exist, including UML and BPMN (Swan, 2007:1).

Guard-stage milestone (GSM). A guard-stage milestone is a declarative approach to define the lifecycle of business artifacts, using guards that are conditions enabling entry into a stage. The stage contains one or more activities needed to achieve a milestone (Hull *et al.*, 2010:2).

Model complexity. Model complexity is related to process complexity, because a model represents a process. Therefore, model complexity refers to the level of difficulty of analyzing, understanding, or explaining processes (Cardoso, 2006:167).

Process complexity. Process complexity is a metric designed to capture "the degree to which processes are difficult to analyze, understand, or explain. High complexity in a process has several undesirable drawbacks" (Cardoso, 2006:167).

User comprehension. User comprehension is an aspect of cognition that involves the mental processes an individual uses to grasp the meaning of something (Swan, 2007:5).

6 Preliminary literature review

Workflow technology was introduced during the 1990s to help organizations manage work and automate the business processes (Attinger, 1996:3). Business process model technology evolved from workflow technology in an attempt to automate the life cycle of business processes (Ko, 2009:15). The BPM market has grown to nearly $1.7 billion in 2006, attracting the interest of both practitioners and researchers (2009:11). The term business process originated in the development of business process re-engineering (BPR) in the early 1990s (Ko, 2009:12).

Research has been conducted to understand how business users understand BPM models. In a study of the use of two BPM modeling notations, Swan (2007:217) found the graphical process model (GPM) easier to understand than was UML for untrained people. Zur Muehlen and Recker (2008:478) found that BPMN practical complexity differs from the theoretical complexity, because practitioners limit the notational elements used to simplify the notation.

Researchers have uncovered deficiencies in the type of processes that BPM models can to represent. Case handling has been proposed as a solution to the rigidity of BPM technology for some business situations involving knowledge workers (van der Aalst, Weske, & Grunbauer, 2005:131). Case handling may provide a solution to the lack of flexibility in the workflow or BPM systems (Vanderfeesten, Reijers, & van der Aalst, 2008:187). In a quantitative experiment comparing the creation of business processes using BPM technology with the creation of business processes using a case-handling technology, BPM implementations were found to require less effort than did case handling implementations (Mutschler, Weber, & Reichert, 2008:87). Most BPM products cannot effectively handle case management loads, in part because case management requires hierarchical process structures (Kerremans, 2008:1-2).

Research has been conducted on complexity metrics for workflow and business process modeling, but not for business artifact-based processes. Cardoso (2007:37) identified several complexity metrics for business processes expressed in business process execution language, including activity complexity, control-flow complexity, data-flow complexity, and resource complexity. Gruhn and Laue (2006:10) adapted several software engineering complexity metrics to business processes, and proposed future research in this area. Lassen and van der Aalst (2009:610) presented three complexity metrics applicable to BPMN and UML. The first metric extended Cardoso's complexity metric, the second metric extended the Cyclomatic complexity presented by Gruhn and Laue, and the third metric is a newly identified metric. Lassen and van der Aalst used a case study to validate their metrics. Other researchers have look at complexity from a different perspective. For example, Gruhn and Laue (2009:339) examined business process model complexity from a cognitive point of view and found that minor modifications to the model may have a significant impact on user comprehension.

Initial research on business artifacts were presented by Nigam and Caswell (2003:428) and Kumaran *et al.* (2003:335). Their worked on modeling processes from a data centric perspective, where the documents in the process are the focus of the model. Over time this modeling approach became more declarative with the work on GSM by Hull *et al.* (2010:2) and Vaculin *et al.* (2011:151). Although, there is active research in the field of business artifacts (Damaggio, 2011:1), there is no research on complexity metrics for business artifacts.

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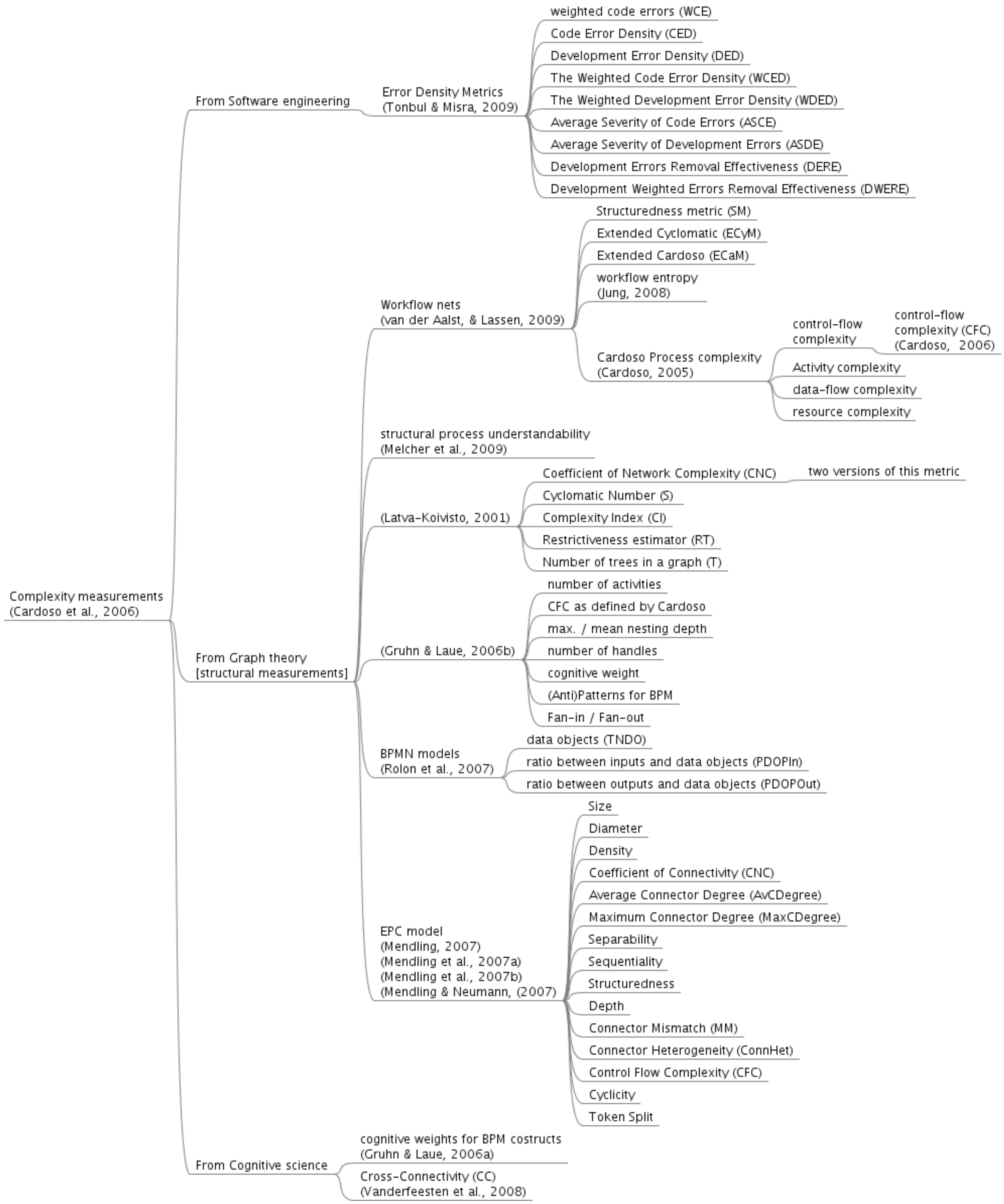
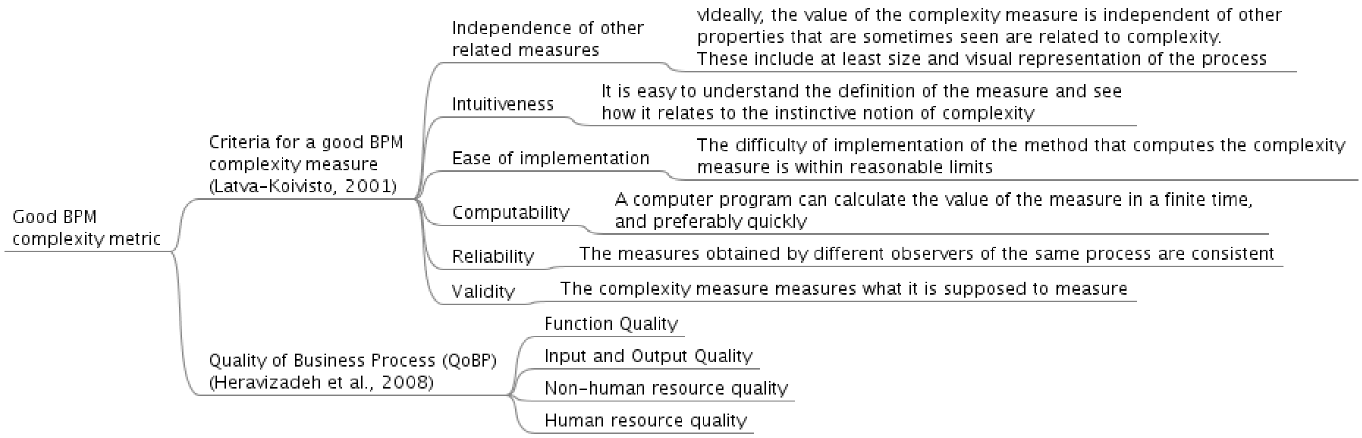
Appendix A – BPM complexity metrics





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