Evolutionäre Referenzmodelle

Anforderungen an eine methodische Unterstützung zur systematischen Wiederverwendung und Weiterentwicklung von modellhaft aufbereitetem Wissen

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Abstract

Konzeptuelle Modelle sind zur Gestaltung und Steuerung von Informationssystemen ein akzeptiertes und weit verbreitetes Instrument. Sie werden sowohl zur Gestaltung der Organisationsstruktur als auch zur Entwicklung der unterstützenden IT-Systeme verwendet. Für diesen Aufgabenbereich existiert eine hohe Nachfrage nach externer Unterstützung, da spezifische Fachkenntnisse und Erfahrungen notwendig sind. In diesem Zusammenhang werden seit Jahrzehnten Ansätze zur Wiederverwendung in Wissenschaft und Praxis diskutiert. Die Akzeptanz und Verbreitung von explizit zur Wiederverwendung konstruierten Modellen (*Referenzmodelle*) bleiben jedoch deutlich hinter den Erwartungen zurück. Die vorliegende Arbeit trägt zur Untersuchung möglicher Ursachen für den ausbleibenden Erfolg von Referenzmodellen bei. Der Forschung liegt die Vermutung zugrunde, dass die Potentiale von Referenzmodellen nicht zufriedenstellend ausgeschöpft werden können, weil die existierenden bzw. verwendeten Modellierungsmethoden die theoretischen Anforderungen an die Wiederverwendung von modellhaft dargestellten Lösungen zur Unternehmensgestaltung nicht erfüllen.

Die vorliegende Arbeit fasst neun Einzelpublikationen zum Themenbereich Evolutionäre Referenzmodelle zu einer kumulativen Dissertation zusammen. Es werden in einem argumentativ-deduktiven Verfahren konstruktivistische Theorien zur systematischen Weiterentwicklung und Wiederverwendung konzeptueller Unternehmensmodelle untersucht. Die auf diese Weise resultierende Erweiterung der allgemeinen Modelltheorie wurde ihrerseits argumentativ-konzeptionell mit Hilfe von semiformalen Argumentationsmodellen aufbereitet. Im Ergebnis werden ein theoretisches Rahmenwerk zur evolutionären Referenzmodellierung präsentiert und 23 konzeptionelle Anforderungen definiert, die eine gezielte Methodenentwicklung für die evolutionäre Referenzmodellierung steuern sollen.

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Während meiner Tätigkeit als wissenschaftliche Mitarbeiterin an der Technischen Universität Dresden hatte ich Gelegenheit, das Forschungsfeld der Unternehmensmodellierung aus den unterschiedlichsten Blickwinkeln zu untersuchen und mitzugestalten. Ich möchte an dieser Stelle den vielen Kollegen, Studenten und Freunden danken, die mich auf diesem Weg begleitet haben und ohne deren vertrauensvolle und offene Zusammenarbeit, Mithilfe, Beistand und Diskussion diese Arbeit nicht hätte entstehen können.

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Teil I

Zusammenfassung der einzelnen Forschungsarbeiten

1 Einleitung

Konzeptuelle Modelle sind zur Gestaltung und Steuerung von Informationssystemen ein akzeptiertes und weit verbreitetes Instrument (siehe [DGR$^+$06] und [Fet09]). Sie werden sowohl zur Gestaltung der Organisationsstruktur[1] als auch zur Entwicklung der unterstützenden IT-Systeme[2] verwendet. Konzeptuelle Modelle unterstützen somit, insbesondere durch ihren integrierenden Charakter, die Forderung nach einer abgestimmten Gestaltung bzw. Verbesserung sowohl des sozialen als auch des technischen Aspekts von betrieblichen Informationssystemen[3]. Auch Ansätze zur Wiederverwendung werden seit Jahrzehnten in Wissenschaft und Praxis diskutiert (siehe z. B. [Fow97], [Gro74], [WBF$^+$09], [FL06]). Die Akzeptanz und Verbreitung von explizit zur Wiederverwendung konstruierten Modellen, im Weiteren als *Referenzmodelle* bezeichnet, bleiben jedoch deutlich hinter den Erwartungen zurück (siehe [KSF06]).

Die vorliegende Arbeit trägt zur Untersuchung möglicher Ursachen für den ausbleibenden Erfolg von Referenzmodellen bei. Der Forschung liegt die Vermutung zugrunde, dass die Potentiale von Referenzmodellen nicht zufriedenstellend ausgeschöpft werden können, weil die existierenden bzw. verwendeten Modellierungsmethoden die theoretischen Anforderungen an die Wiederverwendung von modellhaft dargestellten Lösungen zur Unternehmensgestaltung nicht erfüllen. Eine Analyse der entsprechenden Modelltheorien soll die Definition von adäquaten Anforderungen an die Methoden zur Referenzmodellierung ermöglichen und dazu beitragen, zum einen existierende Modellierungsmethoden hinsichtlich ihrer Eignung für die Referenzmodellierung zu bewerten bzw. weiterzuentwickeln und zum anderen die konzeptuellen Unzulänglichkeiten von Referenzmodellen zu beheben.

1.1 Forschungslücken

Auf dem deutschen Markt besteht eine hohe Nachfrage nach Unterstützung bei der Organisations- und Prozessgestaltung über alle Ebenen von der Strategie bis zur Informationstechnologie. Die Unternehmensberatungsbranche verzeichnet seit Jahren eine positive Umsatzentwicklung und konnte 2011 einen Branchenumsatz von 20,6 Milliarden Euro generieren (siehe [BDU12]). Die Idee der Referenzmodellierung, also die Verfügbarmachung guter existierender Lösungen für wiederkehrende Probleme, sollte daher große Potentiale bergen sowohl um die Effizienz bei der Generierung guter Lösungen zu steigern als auch die Qualität der Lösung zu

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[1] KOSIOL und NORDSIECK legten mit ihren Arbeiten (siehe z. B. [Kos76], [Nor36]) die Grundlagen für die systematische Organisationsgestaltung im Allgemeinen und für die Verwendung von diagrammatischen Abbildungen insbesondere.

[2] Die Modellierungssprachen der UML-Familie (siehe z. B. [Har87], [BRJ99], [OMG]) haben bspw. eine breite Akzeptanz und weite Verbreitung erreicht über die verschiedensten Anwendungsbereiche der Softwareentwicklung hinweg.

[3] Für Ausführungen zur Systemtheorie im Kontext von betrieblichen Informationssystemen und der Notwendigkeit der integrierten Gestaltung sowohl der sozialen als auch der technischen Aspekte siehe [TBNW13].

verbessern. Es existierten bereits Referenzmodelle zu den verschiedensten Problemen in unterschiedlichen Branchen (siehe z. B. [FL04b]). Deren Anwendung und der damit erhoffte Nutzen bleibt jedoch aus. Es ist dabei auffällig, dass die Referenzmodelle sich in der Außensicht nicht von den herkömmlichen individuellen konzeptuellen Modellen unterscheiden. Lediglich die Anpassung der Modellierungssprache zur Darstellung verschiedener Lösungsvarianten wird diskutiert (z. B. [BDK04], [RA07]). Für die vorliegende Arbeit wird somit die zentrale Frage definiert, ob Referenzmodelle spezifische Anforderungen an deren Beschreibung bzw. Handhabung stellen und diese somit entsprechend bei der Entwicklung von Referenzmodellierungs-Methoden berücksichtigt werden müssten.

Existierende Arbeiten zu Theorien der Referenzmodellierung leiten ihre Erkenntnisse argumentativ-deduktiv aus den allgemeinen Theorien zur konzeptuellen Modellierung her (siehe bspw. [BKKD01], [Fra07]). Aus diesem Grund stützt sich auch die vorliegende Arbeit auf die Theorien der konzeptuellen Modellierung, insbesondere auf das konstruktivistische Verständnis (siehe [Tho05]).

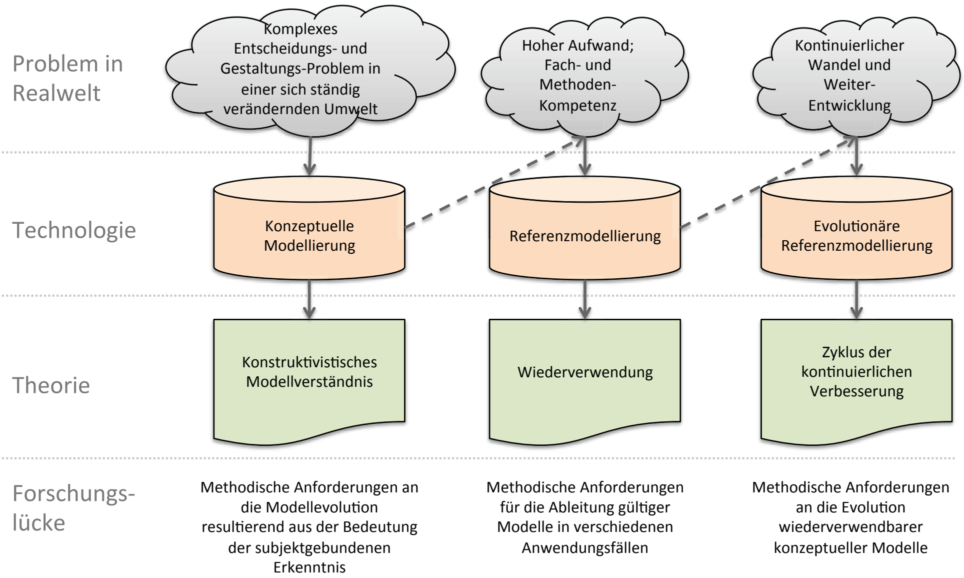

Abbildung 1: Identifizierte Forschungslücken für eine Theorie zur evolutionären Referenzmodellierung

Abbildung 1 stellt die definierten Forschungssäulen einschließlich der identifizierten Forschungslücken dar. Ausgangsbasis der Untersuchung sind reale Entscheidungs- und Gestaltungsprobleme hinsichtlich betrieblicher Informationssysteme. Methoden der konzeptuellen Modellierung stellen in diesem Zusammenhang ein zentrales Hilfsmittel bei der Aufgabendurchführung dar (siehe [DGR^{+}06], [Fet09]). Aus diesem Grund ist die konzeptuelle Modellierung bereits seit Jahrzehnten ein zentrales Forschungsgebiet der Wirtschaftsinformatik (siehe bspw. [WW02], [WKS^{+}09]). Insbesondere die Konsequenzen eines konstruktivistischen Paradigmas auf die Konstruktion eines konzeptuellen Modells werden diskutiert (siehe bspw. [Mol84], [Sch98], [Ham99], [Wol01]). Probleme der systematischen Weiterentwicklung des konzeptuellen Modells, im Sinne einer Evolution, sind in der bisherigen Forschung jedoch noch unzureichend erforscht. Der Lebenszyklus eines Modells wird zwar häufig als Kreislauf dargestellt (siehe bspw. [AHW03], [MH06]), die Besonderheiten bei der Weiterentwicklung gegenüber der initialen Konstruktion werden jedoch nur unzureichend thematisiert.

Da Modellierungsprojekte sehr aufwendig und riskant sind und eine hohe Fach- und Methodenkompetenz erfordern, sollen wiederverwendbare konzeptuelle Modelle (Referenzmodelle) einen signifikanten Beitrag zur Steigerung der Effizienz und Effektivität der Modellierungsleistung beitragen (siehe [Fra07]). Um konzeptuelle Modelle für die Wiederverwendung aufzubereiten, werden spezifische Konzepte für Modellierungssprachen diskutiert (bspw. [BDK04], [RA07]). Darüber hinaus wird die Notwendigkeit der Nachverfolgbarkeit der Ableitungsbeziehungen zwischen einem Referenzmodell und den zugehörigen individuellen Modellen hergeleitet (siehe [BEGW07]). Es bleibt jedoch unbeantwortet, welche Auswirkungen ein konstruktivistisches Paradigma auf Ansätze der systematischen Wiederverwendung hat. Insbesondere Fragestellungen der gemeinschaftlichen Konsensbildung und der Gültigkeitsbewertung bleiben weitgehend offen.

Referenzmodelle versprechen neben der Steigerung der Effizienz der Modellierungsleistung durch Wiederverwendung auch die Steigerung der Effektivität, im Sinne eines Qualitätsvorteils. Dazu müsste eine kontinuierliche Verbesserung der im Referenzmodell dargestellten Lösung unterstützt werden. Dieser Kreislauf-Gedanke wird in den akzeptierten Theorien zur Referenzmodellierung bereits propagiert (siehe z. B. [Sch98], S. 310ff.; [FL04a]). Es bleibt jedoch offen, wie die Evolution wiederverwendbarer bzw. wiederverwendeter konzeptueller Modelle systematisch unterstützt werden kann. Die diskutierten Ansätze bleiben weitgehend linear ausgerichtet und berücksichtigen nicht die iterative Entwicklung des Referenzmodells durch die Berücksichtigung und Einarbeitung von Nutzerinformationen hinsichtlich der empfundenen Nützlichkeit (bspw. in [Fra07]). Es existieren bereits theoretische Ansätze zur Bewertung des Nutzens individueller Unternehmensmodelle (siehe bspw. [Wol08]). Der potentielle Nutzen dieser individuellen Nutzenbewertung für die Weiterentwicklung der Referenzmodelle ist gleichfalls in der Modellierungstheorie anerkannt (siehe bspw. [Bra07]). Wie diese individuelle Nutzenbewertung für die Weiterentwicklung der Referenzmodelle systematisch genutzt werden kann, bleibt hingegen offen. Existierende Ansätze zur Evaluation von Referenzmodellen (siehe bspw. [Fra07], [FL03]) haben lediglich die Benennung einer Qualitätskennzahl als Ziel. Die evolutionäre Weiterentwicklung des Referenzmodells aufgrund der durchgeführten Evaluation wird in diesen Ansätzen nur unzureichend betrachtet. Auf der anderen Seite tragen Arbeiten zur prototypischen Entwicklung von spezifischen Evolutionstechniken (siehe bspw. [GRMR$^+$08]) kaum zur Erarbeitung einer allgemeinen und belastbaren Theorie der Evolutionären Referenzmodellierung bei, die grundsätzliche Normen für die Entwicklung von evolutionären Referenzmodellierungsmethoden definiert, unabhängig von den spezifischen Anforderungen des jeweiligen Anwendungsfalls.

1.2 Forschungskonzeption

Für die vorliegende Forschung wird die Position eines gemäßigten Konstruktivismus eingenommen[4] . Somit wird der subjektgebundenen Erkenntnis realer Phänomene sowie der subjektgebundenen Interpretation in Kommunikationsbeziehungen eine besondere Bedeutung beigemessen. Weiterhin wird eine offene ontische Position eingenommen. Als Wahrheitstheorie findet somit die Konsenstheorie bzw. die Kohärenztheorie Anwendung (siehe [Fra06]).

Die vorliegende Arbeit adressiert die in Kapitel 1.1 definierten Forschungslücken und definiert als übergeordnetes Forschungsziel die Systematisierung und Konzeptualisierung entscheidungsrelevanter Informationen für die systematische Evolution von Referenzmodellen. Es handelt sich dabei um ein Erkenntnisziel mit methodischem Auftrag (siehe [BNK04]). Zur Ausrichtung der einzelnen Forschungsschritte auf das definierte Forschungsziel werden folgende Forschungsfragen formuliert.

In einem ersten Schritt soll das konstruktivistische Verständnis des Begriffs *Referenzmodell* definiert werden. Damit werden die relevanten Theorien identifiziert, aus denen die jeweiligen Argumente zur Beantwortung der nachfolgenden Forschungsfragen abgeleitet werden.

Forschungsfrage 1. *Was kennzeichnet ein konzeptuelles Referenzmodell unter dem konstruktivistischen Paradigma?*

Die Forschungsfrage 2 adressiert die erste Forschungslücke hinsichtlich der systematischen Evolution von konzeptuellen Modellen. Die abgeleiteten Argumente bilden die allgemeinen Rahmenbedingungen für die weitere Untersuchung von wiederverwendbaren konzeptuellen Modellen (Referenzmodellen).

Forschungsfrage 2. *Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Evolution abgeleitet werden?*

Neben der Fragestellung nach der systematischen Evolution soll die Fragestellung der systematischen Wiederverwendung untersucht werden. Hier sind insbesondere Aspekte der Gültigkeit und der Bewertung von Referenzmodellen relevant.

Forschungsfrage 3. *Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Wiederverwendung abgeleitet werden?*

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[4] Für Ausführungen zur forschungsmethodischen Positionierung siehe [BNK04].

Schließlich sollen die Erkenntnisse zusammengeführt werden und die dritte Forschungslücke hinsichtlich einer systematischen Evolution von Referenzmodellen adressiert werden.

Forschungsfrage 4. *Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Evolution wiederverwendbarer/ wiederverwendeter konzeptueller Modelle abgeleitet werden?*

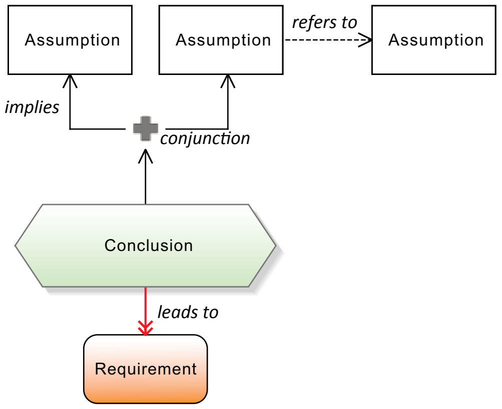

Abbildung 2: Zeichenerklärung der Argumentationsmodelle

Die Beantwortung der definierten Forschungsfragen erfolgt mit Hilfe einer theoriebasierten Exploration (siehe [BD09]). Es werden die Theorien der fach-konzeptionellen Modellierung im Allgemeinen und der Referenzmodellierung im Besonderen erweitert und ein Anforderungskatalog an die Entwicklung geeigneter Methoden zur evolutionären Referenzmodellierung abgeleitet. Der Forschungsbeitrag liegt somit im Zufluss neuer Hypothesen zum Bestand genereller Aussagen der Wissenschaftsdisziplin Wirtschaftsinformatik.[5] Die Theorie-Erweiterungen resultieren sowohl aus einer argumentativ-deduktiven als auch einer konzeptionell-deduktiven Analyse.[6] Die argumentativ-deduktive Analyse wird durch die Einzelpublikationen im Teil II repräsentiert. Die konzeptionell-deduktive Analyse wird dagegen durch die Modellierung der Argumentationsketten mit Hilfe von semiformalen Modellen durchgeführt. Die Modelle sind den jeweiligen Einzelpublikationen beigefügt. Die Legende zur Erläuterung der in den Argumentationsmodellen verwendeten Symbole wird in Abbildung 2 dargestellt.

Die Forschungsergebnisse in Form von definierten Anforderungen an eine Methode zur evolutionären Referenzmodellierung werden in den folgenden Kapiteln zusammenfassend präsentiert. Dazu werden die Schlussfolgerungen aus den Einzelpublikationen deskriptiv in ein übergeordnetes Framework für evolutionäre Referenzmodelle eingeordnet. Der Beitrag der Einzelpublikationen sowohl zum Framework als auch zum Anforderungskatalog wird überblicksartig im Kapitel 4 herausgearbeitet.

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[5] Zu Formen des wissenschaftlichen Fortschritts siehe [Chm94], Kapitel 352.

[6] Zu Inhalt und Verwendung der Forschungsmethoden siehe [WH07].

2 Evolutionäre Konzeptuelle Unternehmensmodelle

Ausgangspunkt der Forschung ist die konzeptuelle Unternehmensmodellierung. In einem ersten Schritt wurden konstruktivistische Theorien zur konzeptuellen Modellierung untersucht, um methodische Anforderungen an evolutionäre Unternehmensmodelle zu definieren. Diese Forschungsergebnisse bilden die theoretische Grundlage für die weiterführenden Forschungen zur Ableitung methodischer Anforderungen an evolutionäre Referenzmodelle.

In der vorliegenden Arbeit werden konzeptuelle Unternehmensmodelle wie folgt definiert (siehe [EL13]).

Definition 1. *Ein konzeptuelles Unternehmensmodell ist eine Repräsentation eines wahrgenommenen Phänomens hinsichtlich der Gestaltung und des Managements von betrieblichen Informationssystemen. Es ist das Ergebnis einer subjektiven Konstruktionsleistung und wird durch die zugrundeliegenden Modellierungsziele bestimmt. Es wird für eine spezifische Nutzergruppe und einen bestimmten Zeitraum definiert.*

Das in Abbildung 3 dargestellte Framework zur argumentations-basierten Evolution von konzeptuellen Unternehmensmodellen wurde in dem Artikel [Leh13a] entwickelt und greift dabei auf die Erkenntnisse der Artikel [LE08] und [EL09] zurück. Die Abbildung 3 stellt drei Phasen der evolutionären Unternehmensmodellierung dar. In der Konstruktionsphase (*Model Construction in* t_n) wird das konzeptuelle Unternehmensmodell (*Conceptual Model-Layer*) entsprechend den zugrundeliegenden Zielen, der Annahmen und der Argumentation (*Argumentation-Layer*) erstellt. Die Gültigkeit der zugrundeliegenden Annahmen und Argumentation sowie die

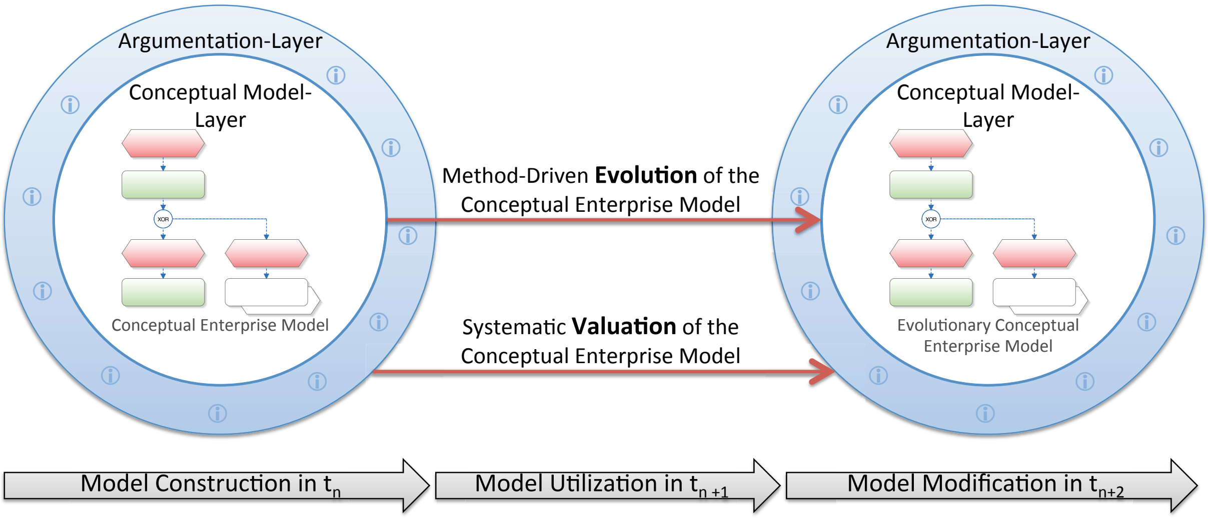

Abbildung 3: Methodengestützte Evolution von Konzeptuellen Unternehmensmodellen [Leh13a]

tatsächliche Zielerreichung können ausschließlich durch die Nutzung des konzeptuellen Unternehmensmodells (*Model Utilization in* t_{n+1}) und einer adäquaten Bewertung verifiziert bzw. falsifiziert werden.

Anforderung 1. *Für eine methodische Unterstützung der Modellevolution ist eine systematische Bewertungsmethode für konzeptuelle Unternehmensmodelle notwendig (siehe Anforderung 1 in Abbildung 12).*

Um die dem Modellentwurf zugrundeliegende Argumentation persistent und auswertbar zur Verfügung zu stellen, wird für evolutionäre Unternehmensmodelle die Anpassung der Modellierungssprache um diesen Begründungs- und Bewertungsaspekt empfohlen.

Anforderung 2. *Eine Modellierungssprache für evolutionäre konzeptuelle Modelle muss Konzepte zur Darstellung von Argumentations- und Bewertungsaspekten zur Verfügung stellen (siehe Anforderung 4 in Abbildung 12).*

Die Notwendigkeit, die dem Modellentwurf zugrundeliegende Argumentation zu veröffentlichen, wird in dem Artikel [LE08] hergeleitet. Die Abbildung 11 auf Seite 36 stellt dazu die Argumentationskette modellhaft dar. Ausgehend von einem moderaten Konstruktivismus ist der Modellierungsprozess auf die Erreichung eines Konsens unter den beteiligten Modell-Stakeholdern ausgerichtet. Infolge der subjektiven Wahrnehmung und Strukturierung realweltlicher Phänomene ist es notwendig, die dem Modell zugrunde liegenden Annahmen und Ziele zu externalisieren. Modellnutzer, die nicht am Konstruktionsprozess (d. h. an der Konsensfindung) beteiligt waren, sind ohne diese Meta-Informationen nicht in der Lage, das Modell adäquat zu interpretieren und zu bewerten.

Anforderung 3. *Die argumentative Begründung für einen Modellentwurf muss externalisiert werden (siehe Anforderung 1 in Abbildung 11, Anforderung 2 in Abbildung 13, Anforderung 1 in Abbildung 24).*

Insbesondere für die Übertragung der in dem konzeptuellen Modell dargestellten Lösung in einen anderen Kontext, wie es bei der Wiederverwendung der Fall ist, sind diese Meta-Informationen notwendig, um die Gültigkeit der Aussagen beurteilen zu können.

Anforderung 4. *Referenzmodelle müssen zusätzliche Hintergrundinformationen zu der dargestellten Modelllösung anbieten (siehe Anforderung 2 in Abbildung 11).*

Der Artikel [LE08] geht insbesondere darauf ein, dass die Externalisierung der argumentativen Begründung nicht nur für den dargestellten Modellinhalt, sondern auch für die verwendete Modellierungssprache notwendig ist.

Die Weiterentwicklung bzw. die Evolution des konzeptuellen Modells kann durch organisationale Erfahrungen wie die unzureichende Zielerreichung ausgelöst werden. Die Gründe für eine unzureichende Zielerreichung können dabei vielfältig sein. Veränderte Umweltbedingungen, ein geändertes Zielsystem oder fehlerhafte Annahmen und Erwartungen bei der Modellkonstruktion sind häufige Ursachen. Der Artikel [EL09] untersucht die betriebliche Prozessverbesserung aufgrund organisationaler Erfahrungen. Es können daraus folgende Anforderungen für die methodische Unterstützung einer systematischen Modell-Evolution aufgrund organisationaler Erfahrungen abgeleitet werden (siehe Argumentationsmodell in Abbildung 15 auf Seite 65).

Anforderung 5. *Für die erfahrungsbasierte Evolution von Unternehmensmodellen ist ein explizites Werte- und Sensoren-System für die Unternehmung zu definieren (siehe Anforderung 1 in Abbildung 15, Anforderung 5 in Abbildung 14).*

Anforderung 6. *Evolutionäre Unternehmensmodelle müssen die organisationalen Erfahrungen systematisch bewerten und dokumentieren (siehe Anforderung 2 in Abbildung 15).*

Der Artikel [Leh13a] greift die Ideen zur Bewertung der organisationalen Erfahrungen auf und erweitert sie um die Entwicklung innovativer Lösungen, die u. U. zu einer Evolution des konzeptuellen Unternehmensmodells (*Model Modification in* $tn + 2$) führen können. Unter der Annahme der ständigen Umweltveränderung, kontinuierlicher Verbesserungsbestrebungen und organisationaler Erfahrungen hinsichtlich der Nützlichkeit der modellhaft entwickelten Lösungen, sollten evolutionäre Unternehmensmodelle auch die Diskussion innovativer Ideen während der Modellnutzung berücksichtigen.

Anforderung 7. *Ein evolutionäres Unternehmensmodell sollte innovative Ideen und ihre Argumentation erfassen (siehe Anforderung 3 in Abbildung 13).*

Es lässt sich zusammenfassend feststellen, dass evolutionäre Unternehmensmodelle (auswertbare) Meta-Informationen bezüglich der Modellkonstruktion zugrundeliegenden Argumentation zur Verfügung stellen müssen. Auf Basis von definierten Zielen, Annahmen, Argumenten und Sensoren (im Sinne von organisationaler Wahrnehmung) kann eine systematische Bewertung des Modellnutzens und damit eine gezielte Evolution des Unternehmensmodells und seiner Modellierungssprache erfolgen.

3 Evolutionäre Referenzmodelle

Im Rahmen dieser Arbeit wird der Begriff *Referenzmodell* wie folgt definiert (siehe [Leh13c]).

Definition 2. *Ein Referenzmodell ist ein spezifisches konzeptuelles Modell, welches explizit für die Wiederverwendung entworfen und bereits zur Konstruktion von neuen konzeptuellen Modellen wiederverwendet wurde.*

Da es sich bei einem Referenzmodell um ein spezifisches konzeptuelles Modell handelt, werden die konstruktivistischen Theorien zur konzeptuellen Modellierung (siehe Kapitel 2) zugrunde gelegt. Darüber hinaus fokussiert die vorliegende Arbeit auf konzeptuelle Modelle der Fachebene, die zur Gestaltung und Steuerung von betrieblichen Informationssystemen verwendet werden. Das allgemeine Modellierungsobjekt ist somit ein sozio-technisches System aus Wirtschaft und Verwaltung.

Ausgangspunkt für die theoriebasierte Exploration von Anforderungen an evolutionäre Referenzmodelle ist die spezifische Kommunikationssituation bei der Konstruktion und Verwendung der Referenzmodelle, die in Abbildung 4 dargestellt ist.

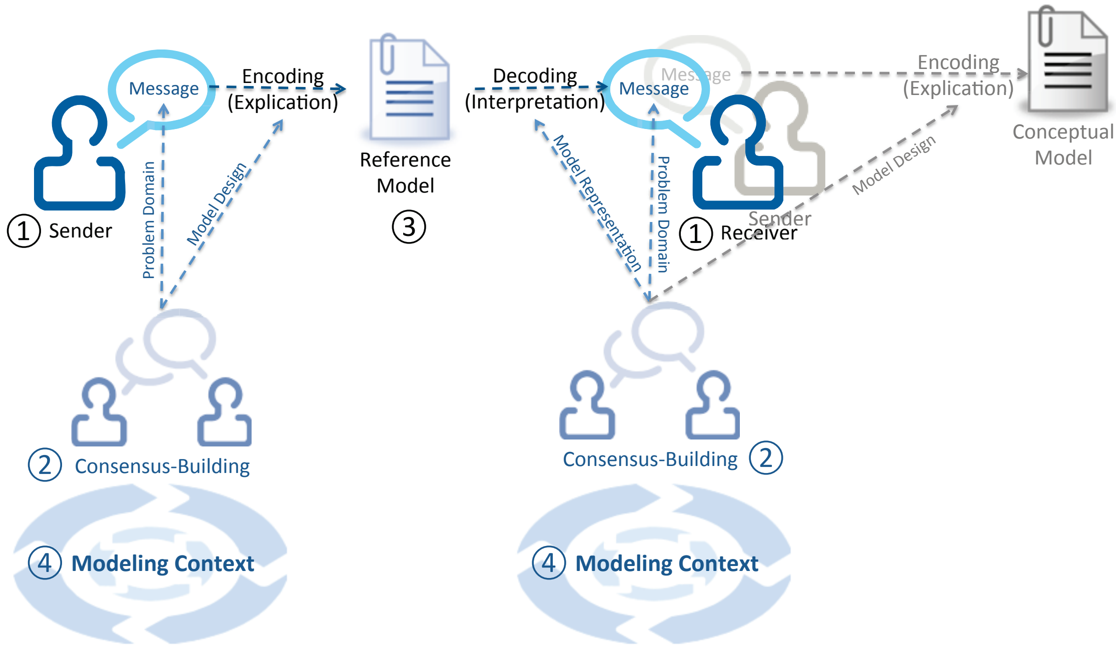

Abbildung 4: Kommunikationssituation in der Referenzmodellierung [Leh13b]

Das Referenzmodell (siehe ③ in Abbildung 4) dient als Kommunikationsmittel zwischen Modellersteller (siehe ① *Sender* in Abbildung 4) und Modellnutzer (siehe ① *Receiver* in Abbildung 4). Der Nutzer des Referenzmodells verwendet das Referenzmodell seinerseits zur Erstellung eines individuellen Modells und nimmt in diesem Konstruktionsprozess die Rolle des Modellerstellers (*Sender*) ein. Diese Ebene beinhaltet die bekannten Herausforderungen einer Sender-Empfänger-Kommunikation (siehe [SW98]). Darüber hinaus ist zu berücksichtigen, dass es sich sowohl beim Modellersteller als auch beim Modellnutzer nicht um Einzelpersonen handelt, sondern um Personengruppen (*Stakeholder*), die sich zielorientiert und kontextabhängig auf die Interpretation der Modellaussagen einigen (siehe ② und ④ in Abbildung 4).

Die Konsensbildung als wahrheitsprüfendes Kriterium im gemäßigten Konstruktivismus wurde als zentraler Einflussfaktor bei der Ableitung methodischer Anforderungen an eine evolutionäre Referenzmodellierung identifiziert. Die Diskussion der Wahrnehmung und Interpretation der realweltlichen Phänomene ist sowohl bei der Konstruktion als auch bei der Anwendung des Referenzmodells zwischen den Stakeholdern notwendig. Um die Konsensbildung nachvollziehen und damit das Referenzmodell im intendierten Sinne interpretieren zu können, ist die zugrundeliegende Argumentation und Entscheidungsfindung zu dokumentieren.

Anforderung 8. *Um die intendierte Interpretation des Referenzmodells durch den Modellnutzer zu unterstützen, ist die zugrundeliegende Argumentation offenzulegen (siehe Anforderung 1 in Abbildung 16, Anforderung 2 in Abbildung 20, Anforderung 1 in Abbildung 18, Anforderung 1 in Abbildung 24).*

Dabei sollten Kommunikationsmittel verwendet werden, die die besondere Kommunikationssituation zwischen Referenzmodell-Ersteller und Referenzmodell-Anwender berücksichtigen.

Anforderung 9. *Referenzmodellierungs-Methoden müssen die Kommunikation zwischen Ersteller und Nutzer hinsichtlich der Eignung und Gültigkeit des Referenzmodells unterstützen (siehe Anforderung 3 in Abbildung 10, Anforderung 1 in Abbildung 16, Anforderung 3 in Abbildung 25).*

Um die Gültigkeit der Aussagen im Referenzmodell bzw. in dessen Argumentation bewerten zu können, benötigt der Referenzmodell-Nutzer Informationen zum Kontext des Referenzmodellierungs-Projekts.

Anforderung 10. *Der Kontext des wiederverwendeten Modells und die aktuelle Modellierungssituation müssen auf Vergleichbarkeit geprüft werden (siehe Anforderung 1 in Abbildung 20).*

Da das Referenzmodell explizit zur Wiederverwendung entworfen worden ist, sollte es den Kontextvergleich unterstützen. Der Ausweis des angenommenen Gültigkeitsbereichs ermöglicht eine gezielte Suche nach geeigneten Referenzmodellen für ein spezifiziertes Modellierungsproblem.

Anforderung 11. *Das Referenzmodell muss Kontextparameter zur Verfügung stellen, um die Gültigkeit der dargestellten Lösung bewerten zu können (siehe Anforderung 2 in Abbildung 18).*

Um die abgeleiteten individuellen Modelle als Informationsquelle für eine systematische Evolution des Referenzmodells wiederverwenden zu können, müssen auch diese ihren Erstellungs- bzw. Anwendungskontext entsprechend offenlegen.

Anforderung 12. *Sowohl der Kontext des Referenzmodells als auch des individuellen konzeptuellen Modells müssen dokumentiert und bewertbar sein (siehe Anforderung 4 in Abbildung 21).*

Da das Referenzmodell explizit die Wiederverwendung unterstützen soll, werden spezifische Methodenfragmente benötigt, die die Ableitung valider individueller Modelle ermöglichen.

Anforderung 13. *Referenzmodelle müssen entsprechend ihrer zugrundeliegenden Zielstellung sowie der jeweiligen Modellierungssituation geeignete Konstruktionstechniken, Ableitungsoperatoren und Sprachkonzepte anbieten, die die Ableitung gültiger neuer konzeptueller Modelle unterstützen (siehe Anforderung 1 und 2 in Abbildung 10, Anforderung 5 in Abbildung 21).*

In Abhängigkeit von der Zielstellung des jeweiligen Referenzmodells und der zur Verfügung stehenden Nutzer-Unterstützung bei dessen Anwendung sowie Weiterentwicklung können Referenzmodelle unterschiedlichen Reifestufen zugeordnet werden (siehe [EL12]). Referenzmodelle, die die oben definierten Anforderungen erfüllen, erreichen die Reifestufe 3 des im Artikel [EL12] entwickelten Reifegradmodells (siehe Abbildung 5). Sie können bei entsprechender Eignung als Entwurfsvorlage für ein spezifisches Modellierungsproblem herangezogen werden. Wird jedoch eine Bewertung des Nutzens des Referenzmodells bzw. eine systematische Verbesserung der darin beschriebenen Lösung angestrebt, sind weitere Voraussetzungen zu erfüllen. Voraussetzung für eine systematische Verbesserung ist dabei die Implementierung der definierten Lösung und deren Erfolgsmessung. Dazu muss ein organisationales Wahrnehmungssystem entwickelt werden, das den Erfolg bzw. die Unzulänglichkeiten der definierten Lösung erfasst und diese Informationen in geeigneter Form für eine weitere Analyse zur Verfügung stellen kann.

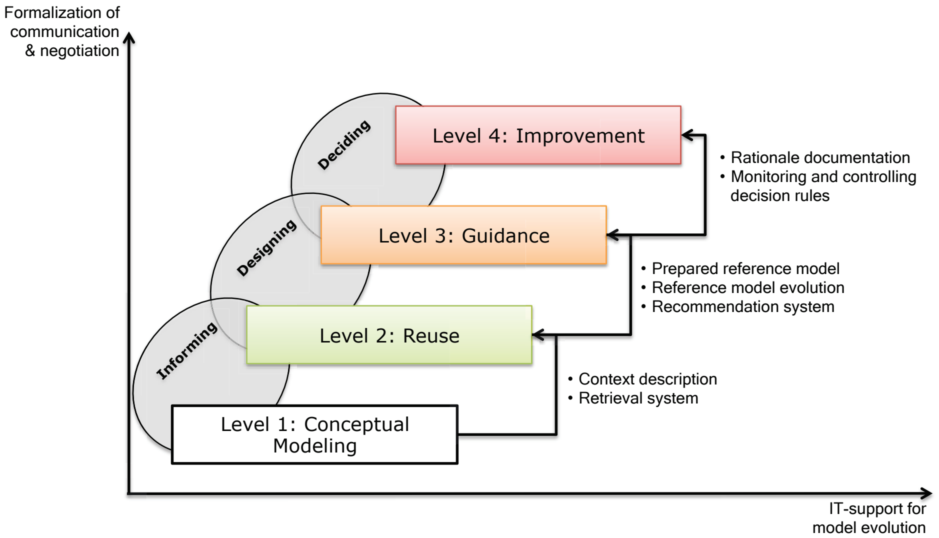

Abbildung 5: Reifegrade von Referenzmodellen [EL12]

Anforderung 14. *Die Gültigkeit und der Wert eines Referenzmodells müssen an seinen Anwendungen gemessen werden (siehe Anforderung 3 in Abbildung 18 und Abbildung 19).*

Anforderung 15. *Es wird ein systematisches Erfahrungs-Management-System zur Erfassung und Bewertung von organisationalen Erfahrungen benötigt (siehe Anforderung 1 in Abbildung 22, Anforderung 2 in Abbildung 15, Anforderung 4 in Abbildung 25).*

Da die Anwendung eines Referenzmodells die Konstruktion eines individuellen konzeptuellen Modells darstellt, müssen die Beziehungen zwischen dem Referenzmodell und dem zugehörigen individuellen konzeptuellen Modell erfasst und verwaltet werden, um den Erfahrungsraum geeignet zuordnen und auswerten zu können.

Anforderung 16. *Methoden zur evolutionären Referenzmodellierung müssen die Verfolgbarkeit der Ableitungen individueller Modelle aus dem Referenzmodell sicherstellen (siehe Anforderung 6 in Abbildung 21, Anforderung 4 in Abbildung 23).*

Die so erfassten Erfahrungen hinsichtlich der Anwendung des Referenzmodells können zum einen als Bewertungskriterium für die initiale Suche nach geeigneten Referenzmodellen herangezogen werden. Zum anderen können sie als Steuerungsgröße genutzt werden, um eine gezielte und systematische Weiterentwicklung des Referenzmodells zu unterstützen und dessen Nutzenbeitrag damit zu steigern. Referenzmodelle, die diese Eigenschaften aufweisen, sind der Reifestufe 4 des im Artikel [EL12] definierten Reifegradmodells zuzuordnen.

Anforderung 17. *Eine Methode zur evolutionären Referenzmodellierung muss ein Controlling-Verfahren definieren, das die Bewertung der Gültigkeit und des Nutzens des Referenzmodells ermöglicht und dessen Weiterentwicklung gezielt steuert (siehe Anforderung 7 in Abbildung 21, Anforderung 5 in Abbildung 19, Anforderung 5 in Abbildung 25).*

Die oben definierten Anforderungen für evolutionäre Referenzmodelle lassen sich in einem Schalenmodell zusammenfassen (siehe Abbildung 6). Der Kern des Schalenmodells repräsentiert das Referenzmodell (*Conceptual Model-Layer*). Dieses stellt eine zur Wiederverwendung aufbereitete Lösung dar und nutzt dabei erweiterte Modellierungssprachen zur Abbildung geeigneter Ableitungsregeln (z. B. siehe [RA07]). Um die im Referenzmodell dargestellte Lösung im intendierten Sinne interpretieren und verwenden zu können, muss die zugrundeliegende Argumentation einschließlich der Entscheidungskriterien und ihrer Gewichtung nachvollziehbar dokumentiert sein[7]. Diese Informationen bilden den *Argumentation-Layer* und repräsentieren den während der Modellkonstruktion erreichten Konsens zwischen den beteiligten Partnern.

Um die Reichweite bzw. die Gültigkeit des Referenzmodells zu definieren bzw. bewerten zu können, werden Informationen benötigt, die den Kontext der Modellerstellung bzw. den Kontext

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[7] Die theoretischen Grundlagen bilden die Arbeiten zum Design Rationale, z. B. [DMMP06], [RRLT04]

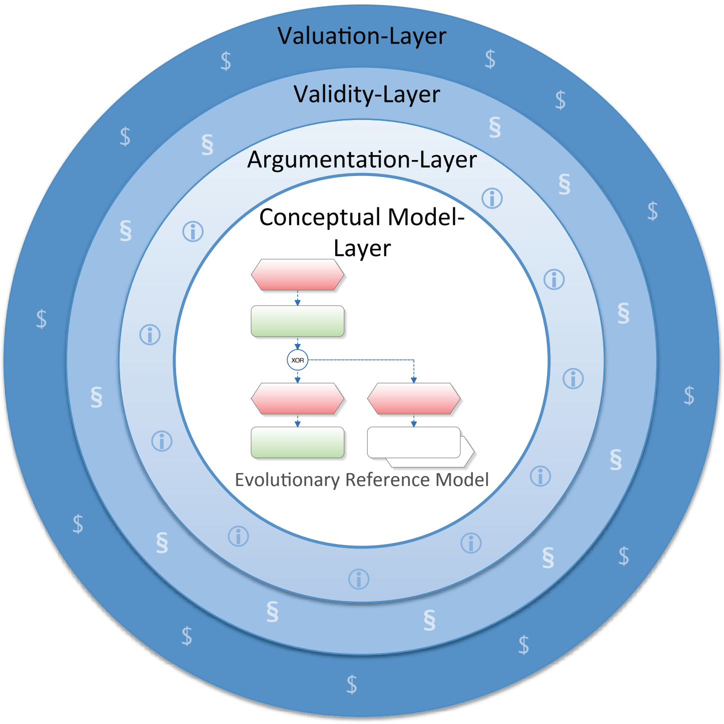


Abbildung 6: Schalenmodell eines evolutionären Referenzmodells

der (intendierten) Anwendung näher charakterisieren. Diese Informationen bilden den *Validity-Layer*. Informationen bezüglich des Modellierungsprojekts (z. B. beteiligte Modellierungs- bzw. Fachexperten, Erhebungs- und Entscheidungsmethoden, rechtliche Bindung etc.), in dem das Referenzmodell entstanden ist, sind notwendig, um die Gültigkeit bzw. die Eignung des Referenzmodells für das vorliegende spezifische Modellierungsproblem beurteilen zu können.

Die dritte Ebene (*Valuation-Layer*) repräsentiert die Qualitätsbeurteilung des Referenzmodells. Wobei hier die Beurteilung des Nutzens für den Anwender im Vordergrund steht. Der Nutzen wird dabei in zweierlei Hinsicht bewertet. Zum einen sind die Erfahrungen der Nutzer bei der Ableitung valider individueller konzeptueller Modelle relevant. Zum anderen wird der Erfolg der implementierten Lösung gemessen, die von den abgeleiteten individuellen konzeptuellen Modellen repräsentiert wird. Beide Erfahrungsklassen werden zur Qualitätsbewertung des Referenzmodells herangezogen.

Die bisher definierten Anforderungen werden in Tabelle 1 dem in Abbildung 6 dargestellten Schalenmodell zugeordnet. Das Schalenmodell in Abbildung 6 repräsentiert lediglich den statischen Aspekt evolutionärer Referenzmodelle. Referenzmodelle, die geeignete Informationen auf allen vier Ebenen zur Verfügung stellen, müssen keine evolutionären Referenzmodelle sein. Erst die systematische Weiterentwicklung der Modellinhalte aufgrund von Feedback Informationen aus der Modellnutzung erfüllt den Anspruch eines evolutionären Vorgehens. Aus diesem Grund sind die oben definierten Anforderungen zu den statischen Aspekten evolutionärer Re-

Tabelle 1: Zuordnung der definierten Anforderungen zu dem Schalenmodell eines evolutionären Referenzmodells

Informationsebene des evolutionären Referenzmodells	**Anforderung**
Conceptual Model-Layer	Anforderung 2 Anforderung 7 Anforderung 13
Argumentation-Layer	Anforderung 2 Anforderung 3 Anforderung 4 Anforderung 5 Anforderung 7 Anforderung 8 Anforderung 14 Anforderung 15
Validity-Layer	Anforderung 4 Anforderung 5 Anforderung 9 Anforderung 10 Anforderung 11 Anforderung 12 Anforderung 16
Valuation-Layer	Anforderung 1 Anforderung 4 Anforderung 5 Anforderung 6 Anforderung 14 Anforderung 15 Anforderung 17

ferenzmodelle um Anforderungen hinsichtlich der dynamischen Aspekte eines evolutionären Vorgehens zu ergänzen. Die Definition des Begriffs *Referenzmodell* wird für die vorliegende Arbeit um den Aspekt der evolutionären Entwicklung wie folgt erweitert [Leh13b].

Definition 3. *Ein evolutionäres Referenzmodell ist ein Referenzmodell, welches in einem evolutionären Entwicklungsprozess um die Erkenntnisse bei der Modellanwendung erweitert und entsprechend angepasst wird.*

Das Zustandsübergangsdiagramm in [Leh13b] (siehe Abbildung 7) beschreibt den dynamischen Aspekt der evolutionären Referenzmodellierung näher. Es greift existierende Beschreibungen des Lebenszyklusses von Referenzmodellen auf (siehe [Sch98], [RS07]) und erweitert es explizit um die systematische Evaluation und Weiterentwicklung des respektiven Referenzmodells. Die bereits definierten Anforderungen an eine methodische Evolution von Referenzmodellen (siehe Tabelle 1) wurden in Aktionen, Aktivitäten und bedingten Zustandsübergängen berücksichtigt. Die Erfassung des Konstruktionskontexts sowie die Definition von relevanten Kontextparametern soll die Auswahl und die Bewertung eines Referenzmodells für einen bestimmten Anwendungsfall unterstützen. Die Definition von zielorientierten Sensorkonzepten und die Implementierung eines zugehörigen Steuerungssystems ermöglicht sowohl die Überwachung der Gültigkeit zugrundeliegender Argumentationen als auch die Initiierung notwendiger Entwicklungsaufgaben. Somit soll eine zyklische Weiterentwicklung des Referenzmodells gewährleistet werden.

Aus den im Zustandsdiagramm (Abbildung 7) beschriebenen Evolutionsaktivitäten können weitere Anforderungen an eine methodische Unterstützung abgeleitet werden. Die folgenden Anforderungen wurden insbesondere bei der Diskussion von für die Evolution relevanter Erfahrungssituationen (siehe [ELS10b]) identifiziert. Zusätzlich wurden Rahmenbedingungen resultierend aus der asynchronen Kommunikationssituation und dem konstruktivistischen Modellverständnis (siehe Abbildung 4) berücksichtigt. Entsprechend der Definition 3 ist die Erfassung und Analyse der Erkenntnisse aus der Modellanwendung von zentraler Bedeutung für die Modellevolution.

Anforderung 18. *Eine Methode zur evolutionären Referenzmodellierung muss Feedback Informationen sowohl aus der Nutzung des Referenzmodells als auch aus der Nutzung der abgeleiteten individuellen Modelle systematisch erfassen und auswerten (siehe Anforderung 2 in Abbildung 17, Anforderung 3 in Abbildung 20, Anforderung 4 in Abbildung 25).*

Um die Analyse der Feedback Informationen systematisch zu unterstützen, sind die als notwendig definierten Informationsarten zu berücksichtigen (siehe Schalenmodell in Abbildung 6).

Anforderung 19. *Es wird ein Änderungsprotokoll benötigt, das die Änderungen der individuellen konzeptuellen Modelle zusammen mit deren Kontext und ihrer Begründung erfasst (siehe Anforderung 4 in Abbildung 19).*

Um die Evolution des Referenzmodells systematisch zu unterstützen, muss eine methodische Erfassung und Auswertung der Feedback Informationen erfolgen. Im Sinne der Kybernetik

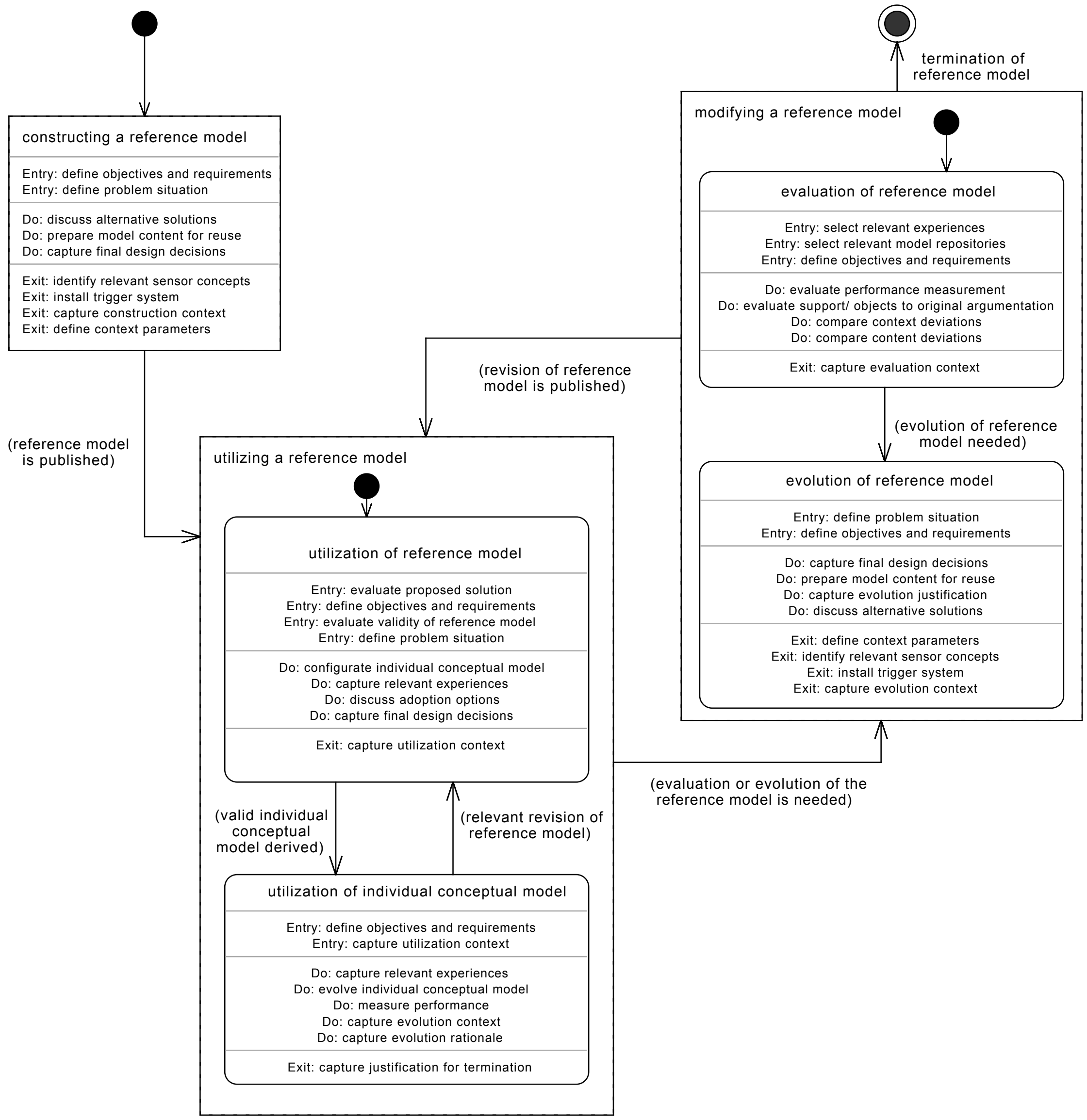


Abbildung 7: Zustandsübergangsmodell der Evolutionären Referenzmodellierung [Leh13b]

sollten Evaluations- bzw. Evolutionsaktivitäten ausgelöst werden, sobald definierte Grenzwerte (bspw. Zielabweichungen, Verwendungshäufigkeit, Häufigkeit von Modelländerungen) überschritten werden.

Anforderung 20. *Eine Methode zur systematischen Evolution von Referenzmodellen muss ein entsprechendes Regel- und Steuerungssystem einschließlich geeigneter Sensoren zur Verfügung stellen (siehe Anforderung 2 in Abbildung 24).*

Da die Änderung der Modellaussagen lediglich die Konsequenz einer Erfahrung repräsentiert, jedoch nicht die Erfahrung selbst (d. h. Erfahrungssubjekt, Erfahrungskontext und Erfahrungsurteil), müssen Konzepte zur Abbildung der organisationalen Erfahrung entwickelt werden. Werden die Erfahrungen nicht geeignet aufbereitet und dokumentiert, ist der Evolutionsprozess des Referenzmodells (im Sinne eines spezifischen Konstruktionsprozesses) nicht mehr transparent (siehe Anforderung 8).

Anforderung 21. *Methoden zur erfahrungsbasierten Evolution von Referenzmodellen müssen Konzepte zur Abbildung der organisationalen Erfahrung beinhalten (siehe Anforderung 2 in Abbildung 22).*

Die eigentliche Weiterentwicklung des Referenzmodells (siehe Abbildung 7: Do-Activity *prepare model content for reuse* im Zustand *evolution of reference model*) umfasst nicht nur die Änderung der Modellaussagen, sondern ggf. auch die Änderung der Modellierungssprache, wenn die Erfahrungen bei der Anwendung des Referenzmodells eine unzureichende Sprachmächtigkeit nachgewiesen haben.

Anforderung 22. *Eine Methode zur evolutionären Referenzmodellierung muss Konzepte zur erfahrungsbasierten (Weiter-)Entwicklung der Referenzmodellierungs-Sprache zur Verfügung stellen (siehe Anforderung 3 in Abbildung 23).*

Anforderung 23. *Eine Methode zur evolutionären Referenzmodellierung muss Konzepte zur erfahrungsbasierten (Weiter-)Entwicklung der Referenzmodell-Inhalte zur Verfügung stellen (siehe Anforderung 5 in Abbildung 23).*

Abbildung 8 fasst die Erkenntnisse aus Kapitel 2 und Kapitel 3 zusammen. Der obere Teil der Abbildung stellt die Konstruktion und Evolution des Referenzmodells dar, einschließlich der relevanten Informationsarten (siehe Schalenmodell in Abbildung 6). Der untere Bereich der Abbildung 8 stellt dagegen die Ableitung eines individuellen Modells aus dem Referenzmodell sowie dessen Anwendung und Evolution dar. Die Feedback-Informationen aus dem Lebenszyklus des individuellen konzeptuellen Modells werden wiederum für die systematische Evolution des Referenzmodells verwendet. Dieses gedankliche Rahmenwerk zur erfahrungsbasierten Evolution von Referenzmodellen dient im Kapitel 4 der Einordnung der Einzelpublikationen und damit der Auszeichnung des jeweiligen Forschungsbeitrags.

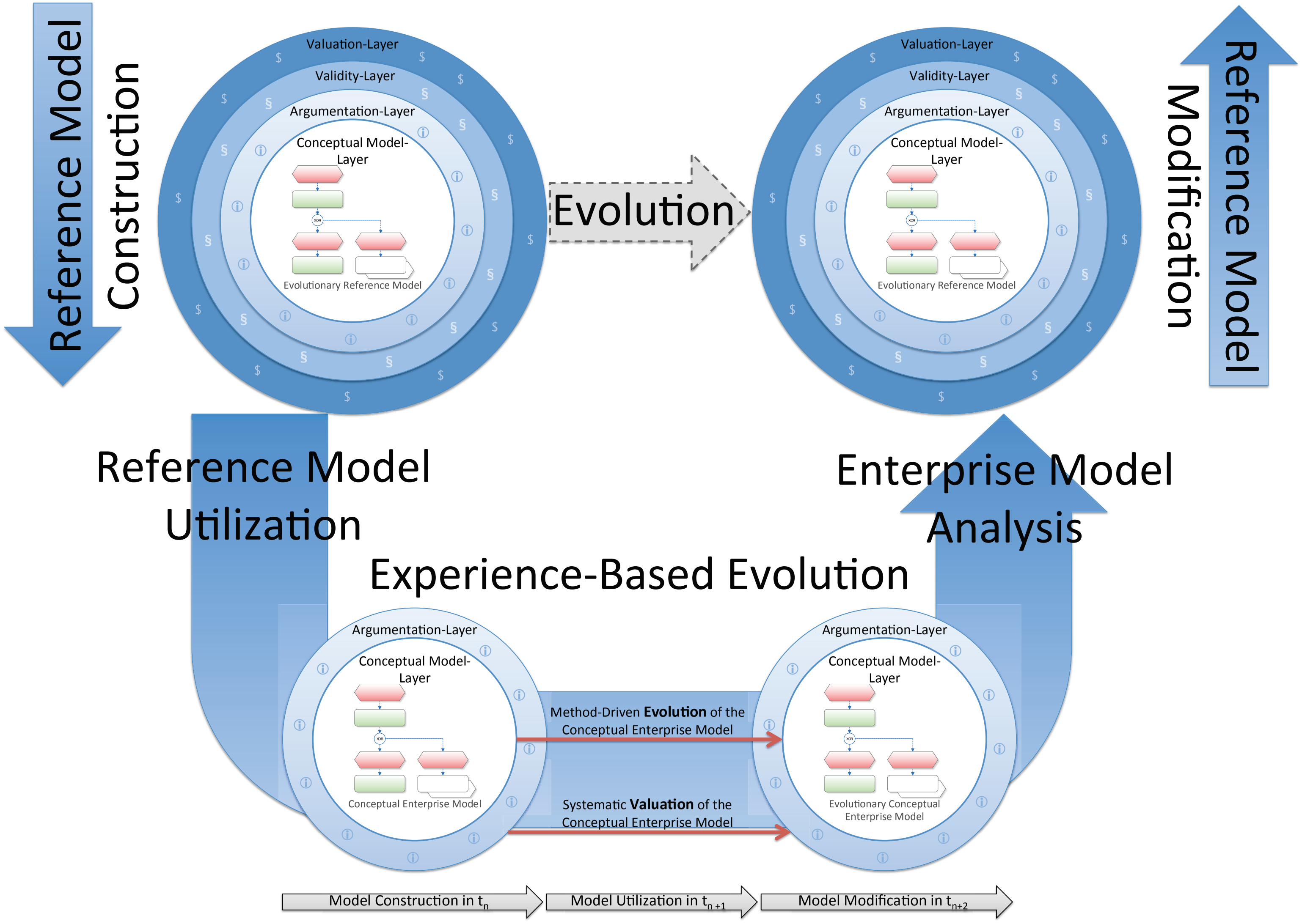


Abbildung 8: Erfahrungsbasierte Evolution eines Referenzmodells

4 Zusammenfassung

Die vorliegende Arbeit trägt zur Erweiterung der allgemeinen Modelltheorie, insbesondere der Referenzmodellierungs-Theorie bei. Das entwickelte Rahmenwerk zur evolutionären Referenzmodellierung definiert Anforderungen an die methodische Wiederverwendung und Weiterentwicklung modellhaft aufbereiteten Wissens im Bereich des Business Engineering. Es adressiert die in Kapitel 1 identifizierten Forschungslücken bezüglich der methodischen Evolution von konzeptuellen Modellen im Allgemeinen und von Referenzmodellen insbesondere.

Im Ergebnis wurde in den Kapiteln 2 und 3 ein Anforderungskatalog abgeleitet, der die Entwicklung geeigneter Methoden zur evolutionären Referenzmodellierung gezielt unterstützt. Die Anforderungen sind aus den Einzelpublikationen argumentativ-konzeptionell abgeleitet und als Argumentationsmodelle abgebildet worden (siehe Teil II). In den jeweiligen Einzelpublikationen werden die in Kapitel 1 aufgestellten Forschungsfragen argumentativ-deduktiv untersucht und akzentuiert beantwortet. In Tabelle 2 wird der Beitrag der Einzelpublikationen zur Beantwortung der Forschungsfragen dargestellt.

Das allgemeine Rahmenwerk zur evolutionären Referenzmodellierung (siehe Abbildung 8) basiert auf theoretischen Schlussfolgerungen und identifiziert kritische Einflussfaktoren bei der Wiederverwendung konzeptueller Modelle und deren systematischen Weiterentwicklung. Es abstrahiert bewusst von konkreten Anwendungsfällen, um einen allgemeinen Beitrag zur Modelltheorie zu leisten. Die Entwicklung geeigneter Modellierungssprachen für spezifische Anwendungsfälle sollte demnach neben den konkreten Anforderungen des jeweiligen Modellierungsprojekts die allgemeinen aus der Modelltheorie abgeleiteten Anforderungen berücksichtigen. Die definierten Anforderungen wurden mit Hilfe eines Schalenmodells (siehe Abbildung 6) strukturiert und deren Abhängigkeiten aufgezeigt. Die Erfüllung der Anforderungen der inneren Schalen bildet dabei die Voraussetzung für die Erfüllung der Anforderungen der äußeren Schalen. So ist das Verständnis des Referenzmodells Grundvoraussetzung für dessen sinnvolle Anwendung. Aufgrund der besonderen Kommunikationssituation in der Referenzmodellierung (siehe Abbildung 4) ist der Konstruktionsprozess einschließlich der relevanten Entwurfsentscheidungen zu dokumentieren. Auch wenn die Argumentation für den Modellentwurf nachvollziehbar ist (Erfüllung der Anforderungen aus dem Argumentation-Level), so ist sie nur für einen bestimmten Anwendungsfall-Typ bzw. Kontext gültig. Anforderungen an die Gültigkeitsprüfung von Referenzmodellen werden im Validity-Layer definiert. Auf der dritten Ebene, dem Valuation-Level, werden Anforderungen zur Bewertung des Referenzmodells definiert. Die Bewertung hinsichtlich der Nützlichkeit kann wiederum vom jeweiligen Anwendungsfall-Typ bzw. Kontext (Gültigkeitsbereich des Referenzmodells) abhängig sein. Demzufolge sollte eine systematische Evolution von Referenzmodellen diese unterschiedlichen Untersuchungsaspekte und deren Abhängigkeiten berücksichtigen und gezielt mit geeigneten Methoden umsetzen. Die

Tabelle 2: Forschungsbeitrag der Einzelpublikationen zur Beantwortung der Forschungsfragen

Forschungsfrage	Artikel	Beitrag
Forschungsfrage 1: Was kennzeichnet ein konzeptuelles Referenzmodell unter dem konstruktivistischen Paradigma?	[ELS10a]	*Begriffsdefinition*: Konsensorientierte und asynchrone Kommunikationssituation
	[LE08]	*Auswirkungen der Subjektivität*: Dokumentation der Modellbegründung und Trennung der Modellbegründung hinsichtlich Fragestellungen bezüglich der Fachdomäne und bezüglich der Modellierungsmethode
Forschungsfrage 2: Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Evolution abgeleitet werden?	[Leh13a]	*Evolution konzeptueller Unternehmensmodelle*: theoretische Grundlagen und dreiteiliges Framework mit den Dimensionen Konzeptuelles Modell, Modellbegründung, Modelländerung
	[EL09]	*Erfahrungsbasierte Prozessverbesserung*: Bewertungsmodell für organisationale Erfahrungen
Forschungsfrage 3: Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Wiederverwendung abgeleitet werden?	[EL13]	*Argumentations-Ebene*: theoretische Herleitung der Ebenen Artefakt, Modell-Lösung, Argumentation
	[Leh13c]	*Gültigkeit von Referenzmodellen*: theoretische Herleitung der Notwendigkeit des Vergleichs und der Analyse sowohl des Modellinhalts als auch der Modellkontexte
	[EL12]	*Klassifikation von Referenzmodellen*: Reifegradmodell für die Referenzmodellierung
Forschungsfrage 4: Welche Anforderungen können aus der konstruktivistischen Modelltheorie hinsichtlich einer systematischen Evolution wiederverwendbarer/ wiederverwendeter konzeptueller Modelle abgeleitet werden?	[ELS10b]	*Erfahrungsbasierte Evolution von Referenzmodellen*: Identifikation von Erfahrungssituationen bei der Referenzmodellierung und Definition von Potentialstufen organisationaler Erfahrungen
	[Leh13b]	*Statische und Dynamische Aspekte der Referenzmodellevolution*: Identifikation der Haupteinflussfaktoren während der jeweiligen Lebensphasen und Entwicklung eines Zustandsübergangsmodell für Evolutionäre Referenzmodelle

Zuordnung der definierten Anforderungen zu den relevanten Einzelpublikationen stellt Tabelle 3 dar.

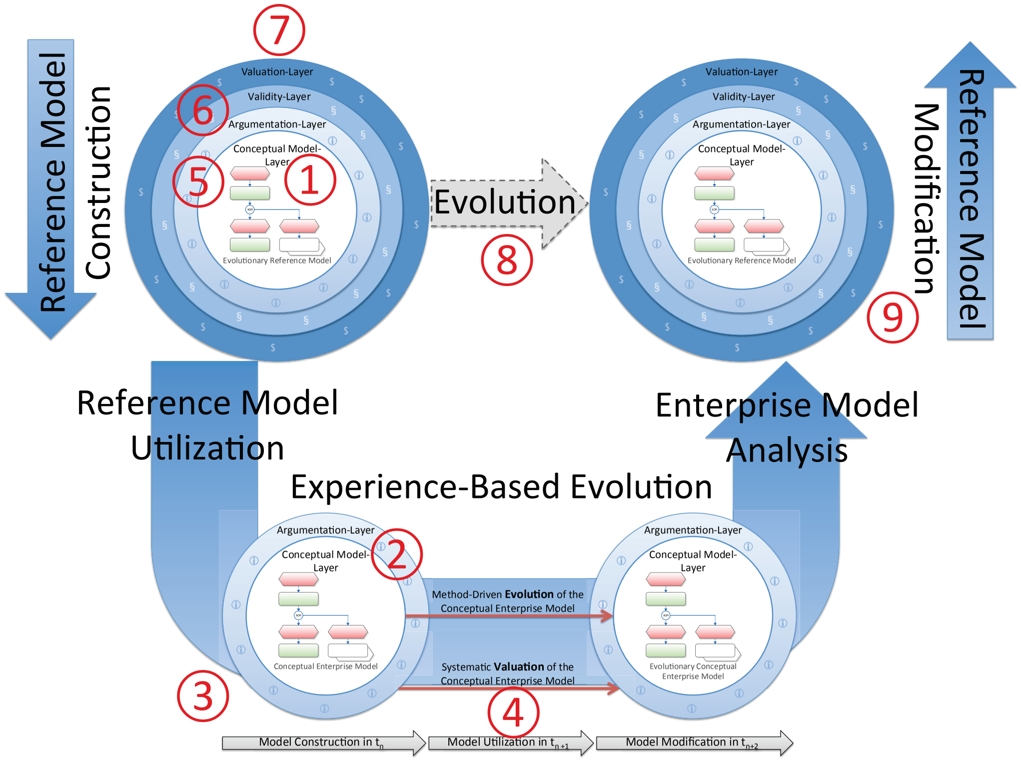
Tabelle 3: Zuordnung der definierten Anforderungen zu den Einzelpublikationen

Anforderung Artikel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
[EsLe09]					x										x								
[EsLe12]								x		x		x	x			x	x	x					
[EsLe13]								x	x									x					
[Ess+10a]									x				x										
[Ess+10b]															x						x	x	x
[LeEs08]			x	x																			
[Lehr13a]	x	x	x		x	x	x																
[Lehr13b]								x	x						x		x	x		x			
[Lehr13c]								x			x			x			x		x				

Die definierten Anforderungen und das abgeleitete Schalenmodell repräsentieren ein allgemeines und abstraktes Rahmenwerk für evolutionäre Referenzmodelle. In Abhängigkeit von der jeweiligen Domäne bzw. des Anwendungsbereichs müssen diese allgemeingültigen Anforderungen in konkrete Methodenfragmente überführt werden. Ein erster konzeptueller Entwurf für die Definition von entsprechenden Evaluationskriterien wurde bspw. in [Fra07] definiert. Ob diese Kriterien jedoch hinreichend die Anforderungen aus dem oben definierten Rahmenwerk für evolutionäre Referenzmodelle erfüllen, ist individuell für den vorliegenden Anwendungsfall zu bewerten.

In diesem Bereich liegt der Ausgangspunkt für weitere Forschung. Die vorliegenden Forschungsergebnisse bedürfen einer empirischen Evaluation bspw. mit Hilfe von repräsentativen Fallstudien und einem Design-Science-orientierten Forschungsansatz (siehe bspw. [HMP04], [PTRC07]). Insbesondere die Analyse empirischer Forschungsergebnisse verspricht die Möglichkeit, die definierten Methodenanforderungen weiter zu spezifizieren und an den Bedürfnissen konkreter Anwendungsfall-Typen auszurichten.

Im folgenden Teil II werden die Einzelpublikationen einschließlich ihrer Argumentationsmodelle zur Verfügung gestellt. Wie die Einzelpublikationen in das in Abbildung 8 dargestellte Rahmenwerk einzuordnen sind, wird in Abbildung 9 dargestellt.



Evolutionäre Referenzmodelle

1. Begriffsdefinition:	[Ess+10a]
5. Argumentations-Ebene:	[EsLe13]
6. Gültigkeit von Referenzmodellen:	[Lehr13c]
7. Klassifikation von Referenzmodellen:	[EsLe12]
8. Erfahrungsbasierte Evolution von Referenzmodellen:	[Ess+10b]
9. Statische und Dynamische Aspekte der Referenzmodellevolution:	[Lehr13b]

Evolutionäre Unternehmensmodelle

3. Evolution Konzeptueller Unternehmensmodelle:	[Lehr13a]
4. Erfahrungsbasierte Prozessverbesserung:	[EsLe09]
2. Auswirkungen der Subjektivität:	[LeEs08]

Abbildung 9: Einordnung der einzelnen Artikel-Beiträge

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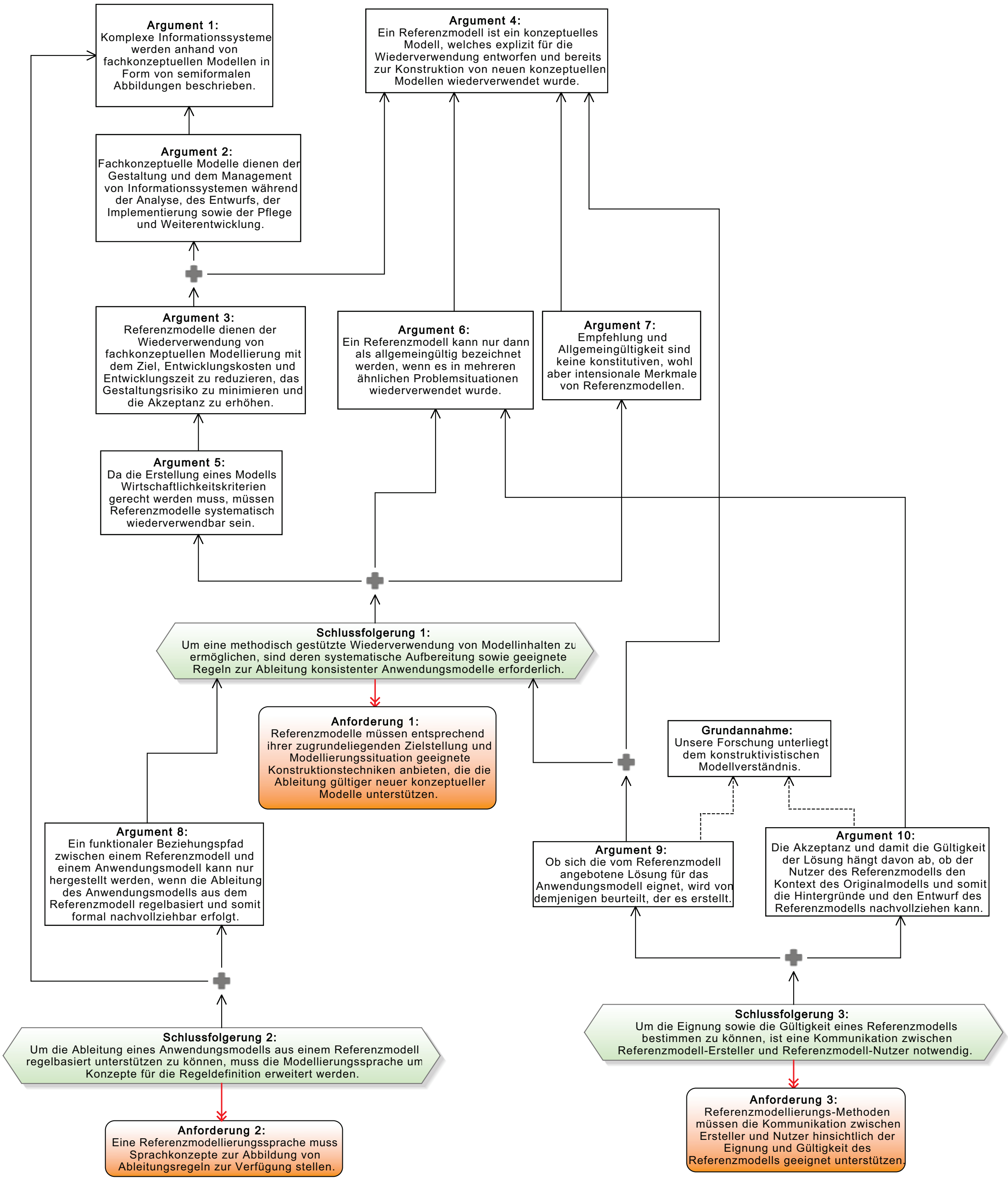
Teil II

Einzelpublikationen

5 Begriffsdefinition: [ELS10a]

Tabelle 4: Beitrag der Koautoren zum Artikel [ELS10a]

Titel	Referenzmodelle		
Autor(en)	Werner Esswein, Sina Lehrmann, Hannes Schlieter		
Publikation in	Das Wirtschaftsstudium, 39(3), S. 371-375, 2010.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	33%
		Sina Lehrmann	33%
		Hannes Schlieter	33%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	40%
		Hannes Schlieter	40%
	Argumentative Analyse	Werner Esswein	20%
		Sina Lehrmann	40%
		Hannes Schlieter	40%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	45%
		Hannes Schlieter	45%
	Kritische Prüfung des Manuskripts	Werner Esswein	50%
		Sina Lehrmann	25%
		Hannes Schlieter	25%



Argument 1:
Komplexe Informationssysteme werden anhand von fachkonzeptuellen Modellen in Form von semiformalen Abbildungen beschrieben.

Argument 4:
Ein Referenzmodell ist ein konzeptuelles Modell, welches explizit für die Wiederverwendung entworfen und bereits zur Konstruktion von neuen konzeptuellen Modellen wiederverwendet wurde.

Argument 2:
Fachkonzeptuelle Modelle dienen der Gestaltung und dem Management von Informationssystemen während der Analyse, des Entwurfs, der Implementierung sowie der Pflege und Weiterentwicklung.

Argument 3:
Referenzmodelle dienen der Wiederverwendung von fachkonzeptuellen Modellierung mit dem Ziel, Entwicklungskosten und Entwicklungszeit zu reduzieren, das Gestaltungsrisiko zu minimieren und die Akzeptanz zu erhöhen.

Argument 6:
Ein Referenzmodell kann nur dann als allgemeingültig bezeichnet werden, wenn es in mehreren ähnlichen Problemsituationen wiederverwendet wurde.

Argument 7:
Empfehlung und Allgemeingültigkeit sind keine konstitutiven, wohl aber intensionale Merkmale von Referenzmodellen.

Argument 5:
Da die Erstellung eines Modells Wirtschaftlichkeitskriterien gerecht werden muss, müssen Referenzmodelle systematisch wiederverwendbar sein.

Schlussfolgerung 1:
Um eine methodisch gestützte Wiederverwendung von Modellinhalten zu ermöglichen, sind deren systematische Aufbereitung sowie geeignete Regeln zur Ableitung konsistenter Anwendungsmodelle erforderlich.

Anforderung 1:
Referenzmodelle müssen entsprechend ihrer zugrundeliegenden Zielstellung und Modellierungssituation geeignete Konstruktionstechniken anbieten, die die Ableitung gültiger neuer konzeptueller Modelle unterstützen.

Grundannahme:
Unsere Forschung unterliegt dem konstruktivistischen Modellverständnis.

Argument 8:
Ein funktionaler Beziehungspfad zwischen einem Referenzmodell und einem Anwendungsmodell kann nur hergestellt werden, wenn die Ableitung des Anwendungsmodells aus dem Referenzmodell regelbasiert und somit formal nachvollziehbar erfolgt.

Argument 9:
Ob sich die vom Referenzmodell angebotene Lösung für das Anwendungsmodell eignet, wird von demjenigen beurteilt, der es erstellt.

Argument 10:
Die Akzeptanz und damit die Gültigkeit der Lösung hängt davon ab, ob der Nutzer des Referenzmodells den Kontext des Originalmodells und somit die Hintergründe und den Entwurf des Referenzmodells nachvollziehen kann.

Schlussfolgerung 2:
Um die Ableitung eines Anwendungsmodells aus einem Referenzmodell regelbasiert unterstützen zu können, muss die Modellierungssprache um Konzepte für die Regeldefinition erweitert werden.

Schlussfolgerung 3:
Um die Eignung sowie die Gültigkeit eines Referenzmodells bestimmen zu können, ist eine Kommunikation zwischen Referenzmodell-Ersteller und Referenzmodell-Nutzer notwendig.

Anforderung 2:
Eine Referenzmodellierungssprache muss Sprachkonzepte zur Abbildung von Ableitungsregeln zur Verfügung stellen.

Anforderung 3:
Referenzmodellierungs-Methoden müssen die Kommunikation zwischen Ersteller und Nutzer hinsichtlich der Eignung und Gültigkeit des Referenzmodells geeignet unterstützen.

Abbildung 10: Argumentationsmodell für Publikation [ELS10a]

6 Auswirkungen der Subjektivität im Modellierungsprozess: [LE08]

Tabelle 5: Beitrag der Koautoren zum Artikel [LE08]

Titel	Rationale Models for Conceptual Modeling		
Autor(en)	Sina Lehrmann, Werner Esswein		
Publikation in	PREISACH, C.; BURKHARDT, H.; SCHMIDT-THIEME, L.; DECKER, R. (Hrsg.): Data Analysis, Machine Learning and Applications, Springer-Verlag, Studies in Classification, Data Analysis, and Knowledge Organization, S. 155-162, 2008.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	30%
		Sina Lehrmann	70%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	80%
	Argumentative Analyse	Werner Esswein	10%
		Sina Lehrmann	90%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	90%
	Kritische Prüfung des Manuskripts	Werner Esswein	40%
		Sina Lehrmann	60%

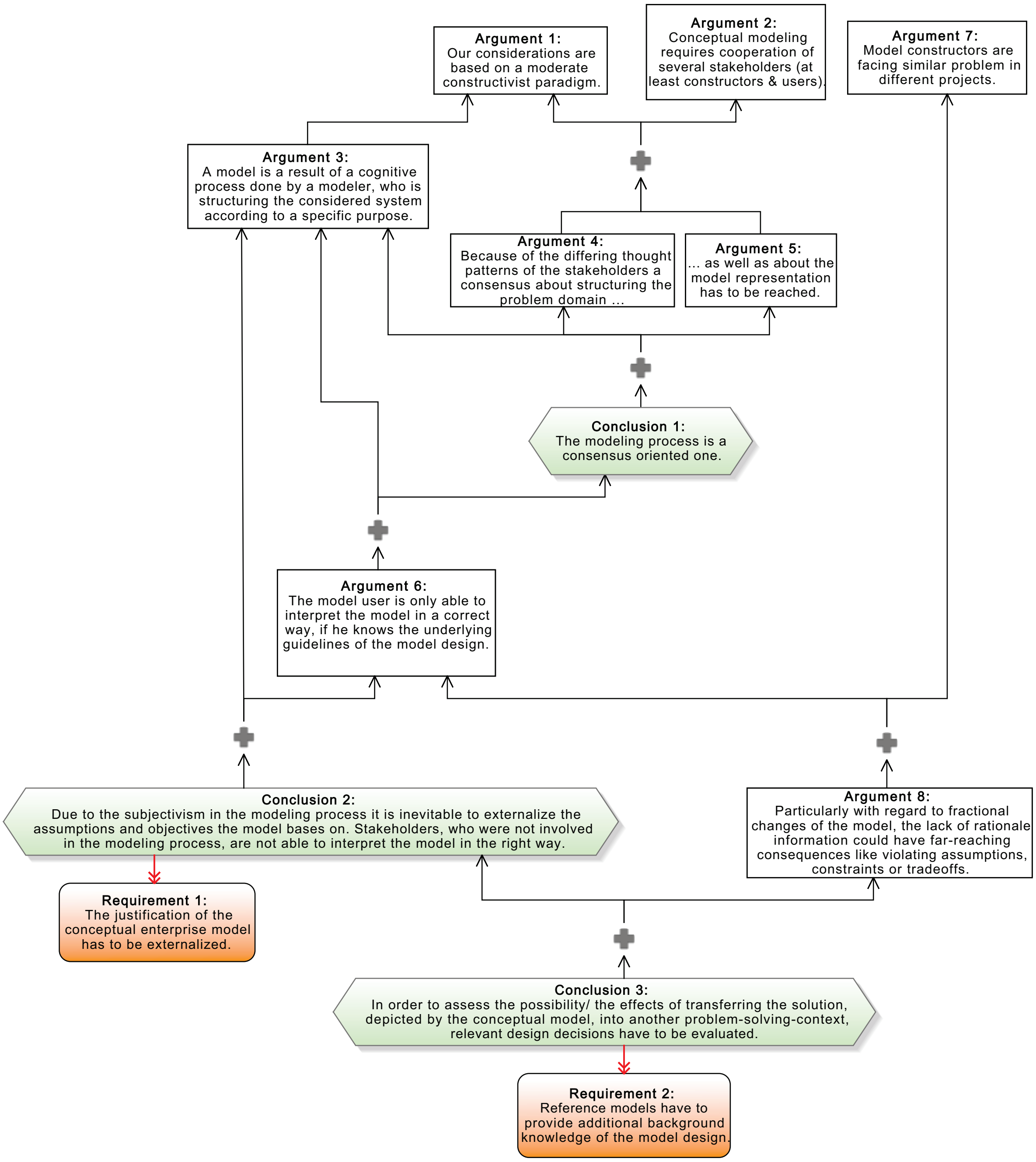


Abbildung 11: Argumentationsmodell für Publikation [LE08]

7 Evolution Konzeptueller Unternehmensmodelle: [Leh13a]

Tabelle 6: Beitrag der Koautoren zum Artikel [Leh13a]

Titel	Evolutionary Conceptual Enterprise Models		
Autor(en)	Sina Lehrmann		
Publikation in	Unveröffentlicht, 2013.		
Beitrag der Autoren	Forschungskonzeption	Sina Lehrmann	100%
	Identifikation der Theorien	Sina Lehrmann	100%
	Argumentative Analyse	Sina Lehrmann	100%
	Formulierung des Manuskripts	Sina Lehrmann	100%
	Kritische Prüfung des Manuskripts	Sina Lehrmann	100%

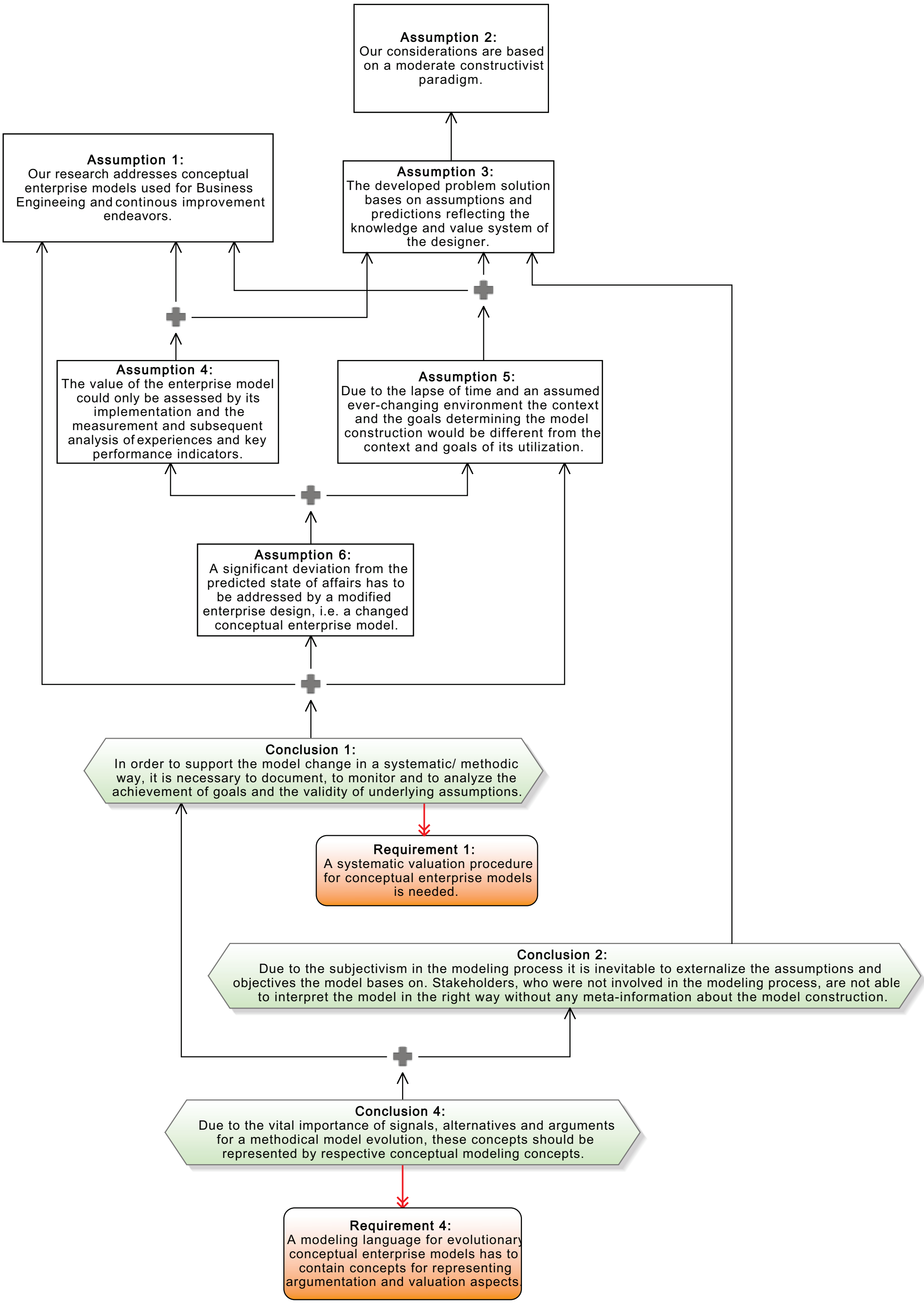


Abbildung 12: Argumentationsmodell 1 für Publikation [Leh13a]

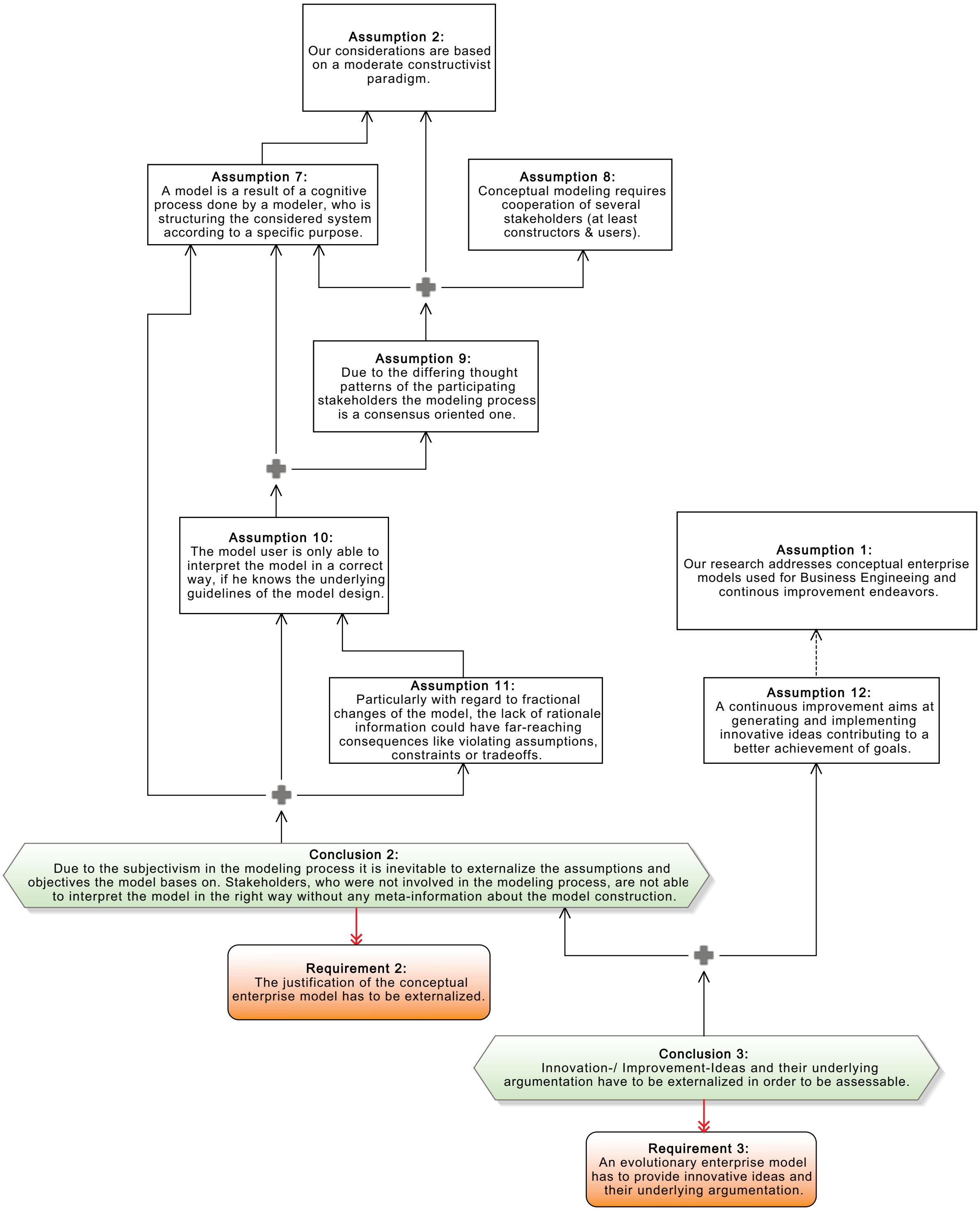


Abbildung 13: Argumentationsmodell 2 für Publikation [Leh13a]

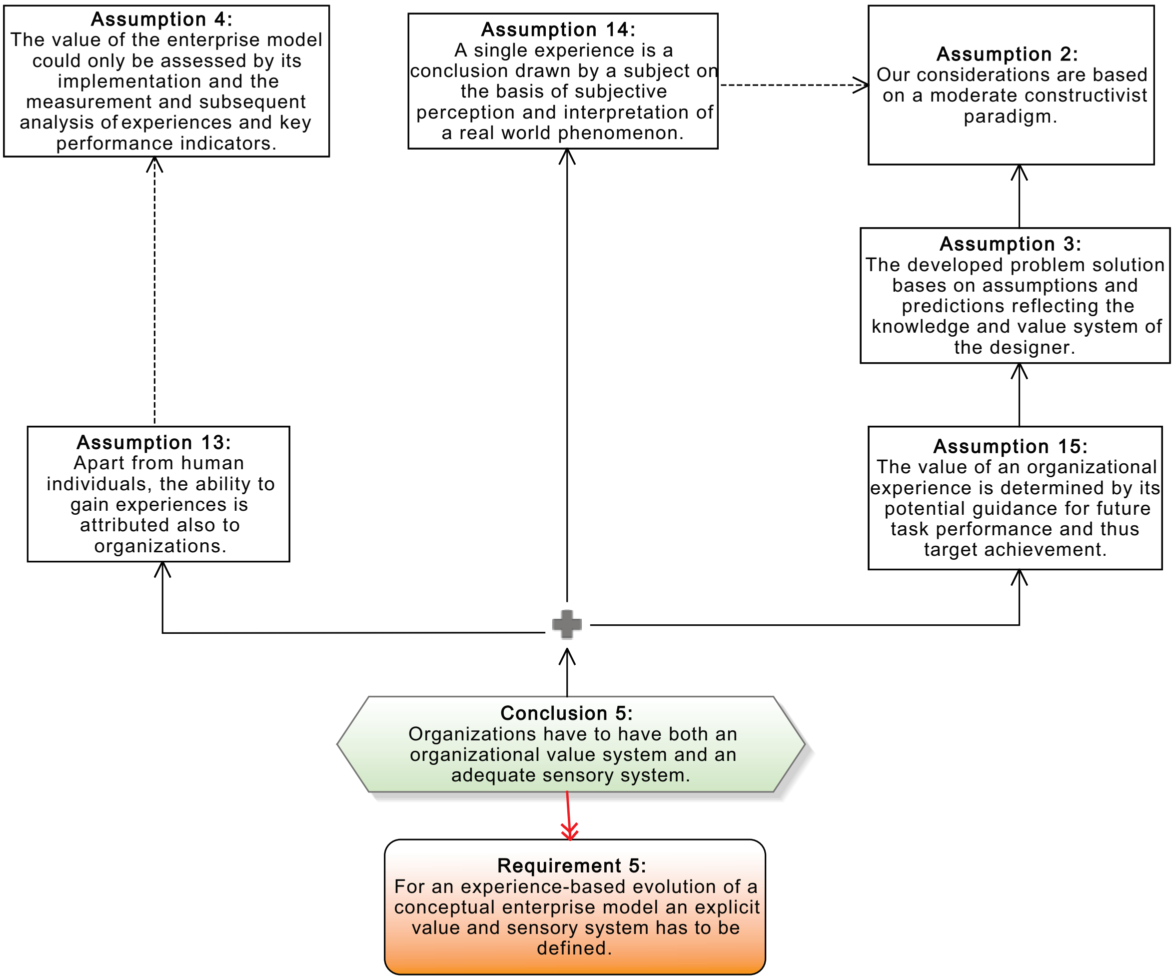


Abbildung 14: Argumentationsmodell 3 für Publikation [Leh13a]

Evolutionary Conceptual Enterprise Models

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Abstract: Conceptual enterprise models are means for various tasks within business management. They particularly fulfill an outstanding function in business engineering and business improvement. For these use cases evolutionary conceptual enterprise models are inevitable. But a systematic evolution of a conceptual enterprise model requires the disclosure of its underlying assumptions, goals and predictions. Challenging, monitoring and evaluating the model justification serve as information source for the improvement of the respective enterprise design. Due to the lack of existing modeling approaches in supporting a systematic model evolution, the paper presents a conceptual tripartite framework for conceptual enterprise model evolution basing on conventional management approaches for business process improvement. On the basis of an argumentative exploration of both conventional theories in management science and information systems, basic requirements for adequate method engineering are defined. The discussed ideas are illustrated by two case studies.

1 Introduction

Business Engineering is used as a collective term for core principles of corporate (re-)organization following an engineering approach and is widely accepted within both academia and practice (cf. [FL04], [ÖB04]). The central idea within Business Engineering is the alignment between corporate strategy and its defined goal system, its business processes and its information technology. The related issues are key research questions in the information systems discipline (cf. [HMP04]).

Especially theories in *conceptual modeling* and the respective modeling methods contribute to this interdisciplinary research between business management and information technology (cf. [Fet09a], [WW02]). In this context, conceptual models are diagrammatic representations of static and dynamic phenomena in the domain of business and administration. They are often used for design, documentation and training purposes, but also for endeavors towards improvement and innovation (cf. [DGR$^+$06]). In particular the two latter issues reveal that Business Engineering should not be understood as a onetime task, but as a continuous planning and control procedure in which conceptual models should be utilized as an essential tool.

Figure 1 illustrates the deployment of conceptual models to contribute to a continuous improvement procedure. In general, conceptual models reflect specific business solutions

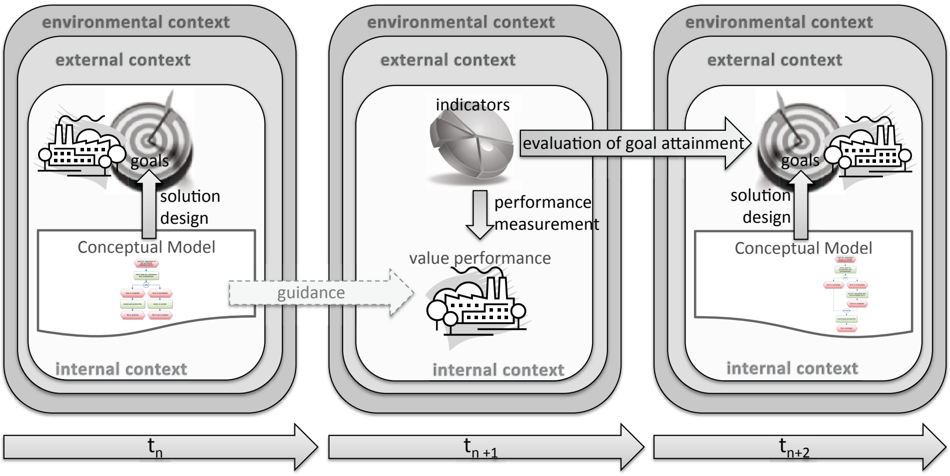

Figure 1: Contextual and Performance Based Impacts on Conceptual Enterprise Models

deliberately designed for the achievement of defined organizational goals and objectives and they are used as communication means between the various stakeholders of the organization. Figure 1 especially depicts the issue that due to the lapse of time and an assumed ever-changing environment the context and the goals determining the model construction could be different from the context and goals of its utilization. The left part of figure 1 (t_n) illustrates the construction of a conceptual enterprise model aligned to the corporate goals and determined by different context factors. The resulting conceptual model guides the value performance of the company due to its function as a blueprint for organizational structures and procedures (central part of figure 1; t_{n+1}). In the meantime, the context of the organization and thus its goals could have been changed. The value of the conceptual model is assessed by its implementation and a measurement and subsequent analysis of key performance indicators. A perceived underperformance could originate in an inadequate design of the conceptual model or in a changed context-situation. A significant deviation from the predicted state of affairs has to be addressed by a modified enterprise design, i.e. a changed conceptual enterprise model (right part of figure 1; t_{n+2}). To support this task, the historical development of the respective solution should be considered. It could be a main source of information for analyzing the strengths and weaknesses of the current socio-technical system.
We conclude that conceptual enterprise models are essential and accepted tools for Business Engineering. Since Business Engineering is understood as a continuous improvement approach, it requires modeling methods considering the evolutionary character of the task.

A Priori Assumption. *The implementation of a systematic continuous improvement approach (in the sense of business engineering) requires evolutionary conceptual enterprise models.*

The idea of an evolutionary development of conceptual enterprise models is reflected by an assumed cyclic business process lifecycle (cf. [vdAHB03]). Even though the analysis

and goal-oriented redesign of the respective business process is emphasized, only little methodical support for diagnosis tasks is provided (cf. [vdAHB03]). In recent years, increasing research on analytic approaches have been conducted in order to support the process analysis- and process design-phase (e.g. [vdA11]). But this kind of analysis focuses on problems inherent to the process definition, like avoiding deadlocks. Problems regarding the degree of target fulfillment are almost disregarded[1]. But the alignment of the organizational structure and processes to the corporate strategy and organizational objectives is a core principle of Business Engineering[2] .
Relevant studies (cf. [DGR$^+$06], [Fet09a]) on modeling practice show that traditional modeling languages like *entitiy-relationship-model*, *event-driven-process-chain*, *unified modeling language* and *data flow diagram* are most frequently used in practice. But none of these language specifications include concepts for making the justification and/or value of the conceptual model tangible and analyzable. Although expressive and powerful goal modeling languages (esp. the i$*$-framework [Yu11] or the design rationale approaches [DMMP06a]) has been developed for requirements engineering, an integration of this kind of conceptual modeling to the general engineering process still has to be defined (c.f. [Fra12]). In particular, there is a need to develop theories and methods for an integrated design and mutual evolution of the goal system, the organization and the information technology. No existing modeling method provides specific support to the incremental evolution of conceptual enterprise models as an essential element of the corporate performance measurement system[3] .

Research Gap. *Existing conceptual modeling methods disregard requirements of an evolutionary construction of conceptual enterprise models.*

This gap in research and method engineering motivates our investigations. The research goal is the definition of basic requirements on methods for evolutionary enterprise modeling.

Research Question. *What does an evolutionary construction of conceptual enterprise models require of provided modeling methods?*

For defining convincing requirements we conducted a theory-based exploration. Our research bases on a moderate constructivist paradigm (c.f. [SR98], [Tho05]) and is guided by both conventional theories of conceptual modeling and conventional management theories of continuous improvement. We illustrated our findings by two case studies.
The remainder of this paper is structured as follows. In section 2 we analyze the construction, utilization and evolution of conceptual enterprise models from the external perspective of business engineering. In section 3 we investigate the issue of evolutionary enterprise models by analyzing modeling theories and the resulting conditions. In order to illustrate our findings by an example, we outline two case studies in section 4. The gained

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[1] E.g., in [vdAHB03] the activity of business process design is referred to as the early phase of business process management. Within the characterization of the remaining lifecycle-phases no dependencies to (strategic) organizational decisions are addressed.

[2] In business management research, methods for supporting a systematic management cycle are referred to as *performance measurement systems*.

[3] For an overview of performance measurement systems and their use in practice see [Grü02]

insights are summed up and consolidated in section 5. The paper ends with a conclusion and implications for future research.

2 Conceptual Enterprise Models as Means for Business Engineering

Conceptual enterprise models have a long history of supporting business organization and management (for a detailed survey on the use of conceptual enterprise modeling see [Fet09a]). They are instruments for high-level abstraction and a multi view approach (c.f. [Fra02]). These two inherent features of conceptual enterprise models facilitate the reduction of the tremendous complexity of the task, the creation of transparency, the communication among stakeholders and the integration of various perspectives on Business Engineering within the organization.

Since we define Business Engineering as the methodical design of corporate structures and information system aligned with the strategic goals (cf. [ÖB04]), the starting point of our investigation is the general management cycle considering corporate planning and control activities. Within management science respective theories and methods are subsumed under the term *performance measurement systems* (for a detailed study on performance measurement systems and their use in practice see [Grü02]).

One of the core principles of this kind of management approach is the idea of organizational learning (cf. [Grü02], p. 209 et seqq.). Therefor a continuous development and improvement approach has to be implemented. A prominent approach for this kind of continuous improvement is the DEMING-cycle [Dem92]. Its content provides the basis for our further research.

The DEMING-cycle describes an infinite cyclic process of business management composed of the four successive phases PLAN, DO, CHECK and ACT. Its basic structure is forming the fundamental idea for our framework for systematic enterprise model evolution. As first step, we integrated the lifecycle of conceptual enterprise models into the DEMING-cycle (see figure 2). The left side of figure 2 (*Business Management*) depicts a modification of the original DEMING-cycle. The modifications have to become necessary due to the explicit consideration and integration of conceptual enterprise modeling. The access point to the depicted lifecycle is the planning phase. We distinguish between the strategic planning and the operative planning. The former one defines the overall corporate goals whereas the latter one derives operative goals and objectives to govern the performance of day-to-day business. Both planning activities are influenced by individual objectives, knowledge and predictions of the involved stakeholders.

Basing on the defined goals an adequate organizational structure has to be defined and explicated within conceptual enterprise models. The lifecycle of the respective conceptual enterprise model is depicted on the right side of figure 2 (*Conceptual Enterprise Modeling*). First, the conceptual enterprise model is initially constructed aligned to the organizational goals defined within the planning activities (business management). It comprises different abstraction levels of enterprise structures and integrates the requirements resulting from the superior level with the solutions of the subordinated level (e.g. for theoretical frameworks and related modeling methods see [KVB$^+$06]; [JLQ$^+$11]; [Yu09]).

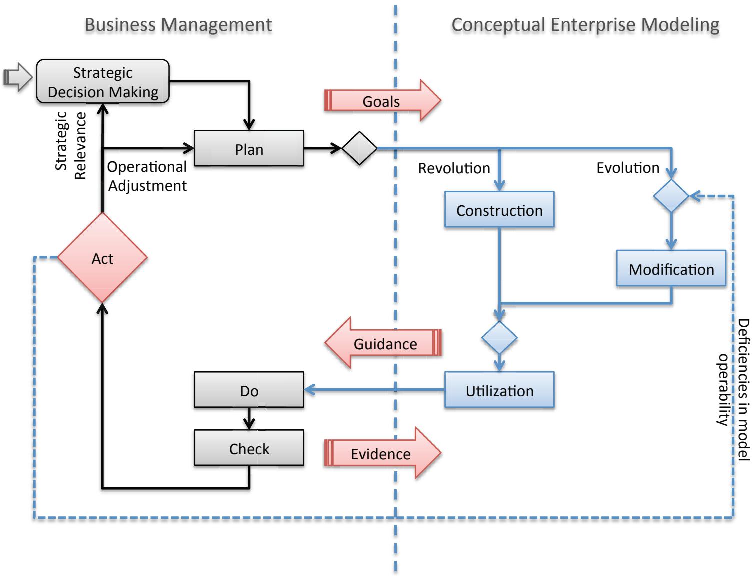

Figure 2: Integration of Enterprise Model Lifecycle and PDCA-Cycle

The implementation of the designed problem solution is carried out during the DO-phase by utilizing the conceptual enterprise model. The conceptual enterprise model guides the organizational value performance due to its function as a blueprint for organizational structures and procedures.

Within the DO-phase, the expected results have to be monitored and predefined key performance indicators have to be measured. Beyond that, problems and unexpected observations, relevant to the deliberately designed organizational structures, have to be documented. These information form the basis for the subsequent analysis of goal attainment (CHECK-phase). Gathered experiences have to be compared to the assumptions and predictions of the planning-phase. The analysis results could trigger in turn a replanning of enterprise structures by adapting the underlying assumptions, goals and predictions. Dependent on the scope of the revealed deviation a strategic or operational planning is triggered.

We changed the ACT-Phase into a decision node due to the fact that a standardization of the planned solution already took place by conceptual modeling. A modification of the solution could only be triggered by a changed goal system or by the detection of deficiencies in model operability. The former one implies a new cycle within the business management process (DEMING-cycle). Dependent on the impact of the changed goal system a modification of an existing conceptual enterprise model (evolution) or a construction of a new conceptual enterprise model (revolution) takes place. In case of deficiencies in conceptual modeling, an evolution of the conceptual enterprise model is a matter of organizational learning regarding methodology of conceptual enterprise modeling. Both the captured experiences during the DO-phase and the statistics from the CHECK-phase of the prior cycle serve as evidence for the justification of the actual model design. Figure 3 summarizes the

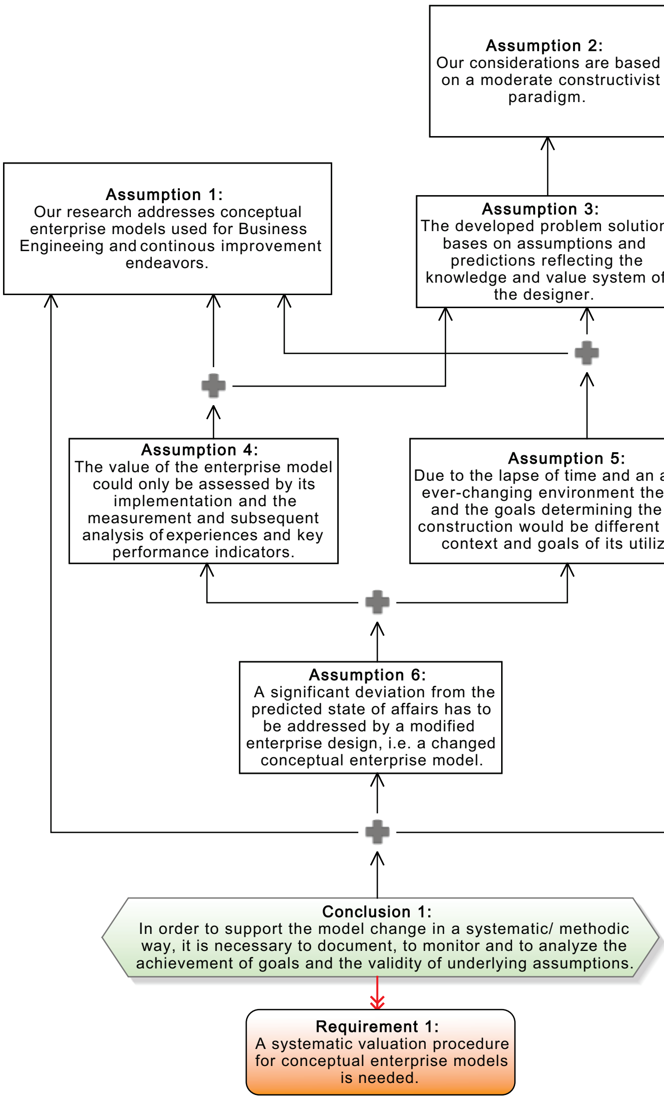

Figure 3: Argumentation for a Systematic Valuation Procedure

presented key arguments for the need of a systematic valuation procedure in order to assure a systematic evolution of the conceptual enterprise model. In short, the design of the conceptual enterprise model is determined by the assumptions, predictions and goals of the involved stakeholders (illustrated by *Goals*-arrow in figure 2). Whether the expectations could have been met, has to be assessed by the implementation of the respective conceptual model and the measurement of adequate key performance indicators (illustrated by *Evidence*-arrow in figure 2). A significant deviation from the predicted state of affairs has to be addressed by a changed conceptual enterprise model. Thus, a systematic valuation procedure supports the methodical evolution of conceptual enterprise models.

Requirement 1. *A systematic valuation procedure for conceptual enterprise models is needed.*

After revealing the need for evolutionary conceptual enterprise models, we will discuss the nature of conceptual enterprise models in section 3. The analysis of existing modeling theories should support the identification of further requirements on evolutionary conceptual enterprise models.

3 Evolutionary Enterprise Modeling

For conceptual modeling a constructivist understanding is widely accepted within European research community ([SR98]; [Wol01]; [Geh07]). According to that a conceptual enterprise model is an artefact formulated in a conceptual modeling language representing a vital structure of an information system perceived and interpreted by humans. Due to the essential influence of the subjective interpretation and cost-effectiveness considerations done by model constructors, the design of a conceptual model is determined by both its context and its underlying assumptions and objectives. Thus, besides the syntactic and semantic aspects the pragmatic aspect is a key criterion for assessing the quality of conceptual models (c.f. [LSS94]; [KSJ06]).

The construction and evolution of conceptual enterprise models are cooperative tasks at least due to the need of modeling experts and domain experts (c.f. [Geh07], [Bra07]). Within a moderate constructivist philosophy, the construction of conceptual enterprise models (in the sense of epistemological principle) is consensus-oriented (c.f. [BHKN03]). Therefore, the conceptual enterprise model represents the results of various discussions among involved stakeholders which may form alliance in order to strengthen their attitude and goals (c.f. [RS05]).

In summary, we defined following determinants of the model construction. First, the modeling project is primarily defined by its contexts as budget and organizational anchoring (*internal context*), as market situation and relevant competitors (*external context*) and as culture and legal system (*environmental context*)(see figure 5). Second, the organizational goals defined by the corporate management are basic conditions for designing an appropriate solution (see discussion in section 2). Third, the solution design bases on the individual assumptions, predictions, knowledge and values of the designer (we refer to the underlying philosophy of moderate constructivism). Fourth, the construction of a conceptual enterprise model involves various stakeholders whose several points of opinions have to be negotiated. Finally, a consensus on the final design of the conceptual enterprise model has to be reached among the relevant stakeholders (see truth claim in moderate constructivism philosophy).

On the basis of the above described arguments, we assume that a conceptual enterprise model could only be interpreted in the correct way, if the underlying conditions and argumentation is known (c.f. [Ham99]; [Wol01]). An undeliberated transfer of the conceptual enterprise model into a different context or undeliberated modifications of the conceptual enterprise model could cause defects in the represented solution[4]. Thus, we conclude that the externalization of the underlying assumptions and the argumentation are inevitable for a long-term use and evolution of a conceptual enterprise model (see figure 4 for our logical chain of reasoning).

Requirement 2. *The justification of the conceptual enterprise model has to be externalized.*

Beyond the construction-oriented aspects of conceptual enterprise modeling, implications of the continuous improvement approach have to be considered. A continuous improvement approach as described in section 2 thrives on frequent innovative ideas and weighing up their potential. But as argued before, the actual benefit of an innovation could only be assessed by its implementation. Hence, an evolution method for conceptual enterprise models should consider the assumed benefits of an innovation and their justifications along with the actual experiences of an implemented solution. Thus, the valuation of current and alternative solutions requires the comparison of the competing ideas and their underlying argumentation.

Requirement 3. *An evolutionary enterprise model has to provide innovative ideas and their underlying argumentation.*

Most of the papers addressing the reflective design (e.g. [SFHK12], [RRLT04]) propose semiformal methods to support human decision finding (i.e. construction of conceptual models), but a holistic modeling approach for continuous improvement and systematic evolution of the model content along with its accompanying justification is missing. Solely the technical aspects of managing model versions and variants are discussed by formalizing configuration management principles (e.g. [EGK02]; [TDL08]).
The documentation of the argumentation and justification of current and previous versions of the respective conceptual enterprise model has two benefits. First, a methodical validation and valuation of the conceptual model are feasible. Second, alternative solutions could be developed, assessed and/or rejected efficiently by considering the history of the conceptual model including earlier discussions, negotiations and argumentation. In this way, repeating earlier discussions without any new insights could be avoided.
Against this background, we defined a framework for managing the justification and changes of conceptual enterprise models (see figure 5). It consists of three abstraction levels characterizing the evolution of conceptual enterprise models. The integrated enterprise model lifecycle shows that, beyond the pure model content (documentation of corporate structures), a systematic model evolution has also to consider the context of the original decision situation (goals, assumptions, etc.), experiences of model use (failure, success, unforeseen events) and innovations. Thus, we conclude a tripartite division from the general discussion of an enterprise model lifecycle within a PDCA-cycle. The first and obvious

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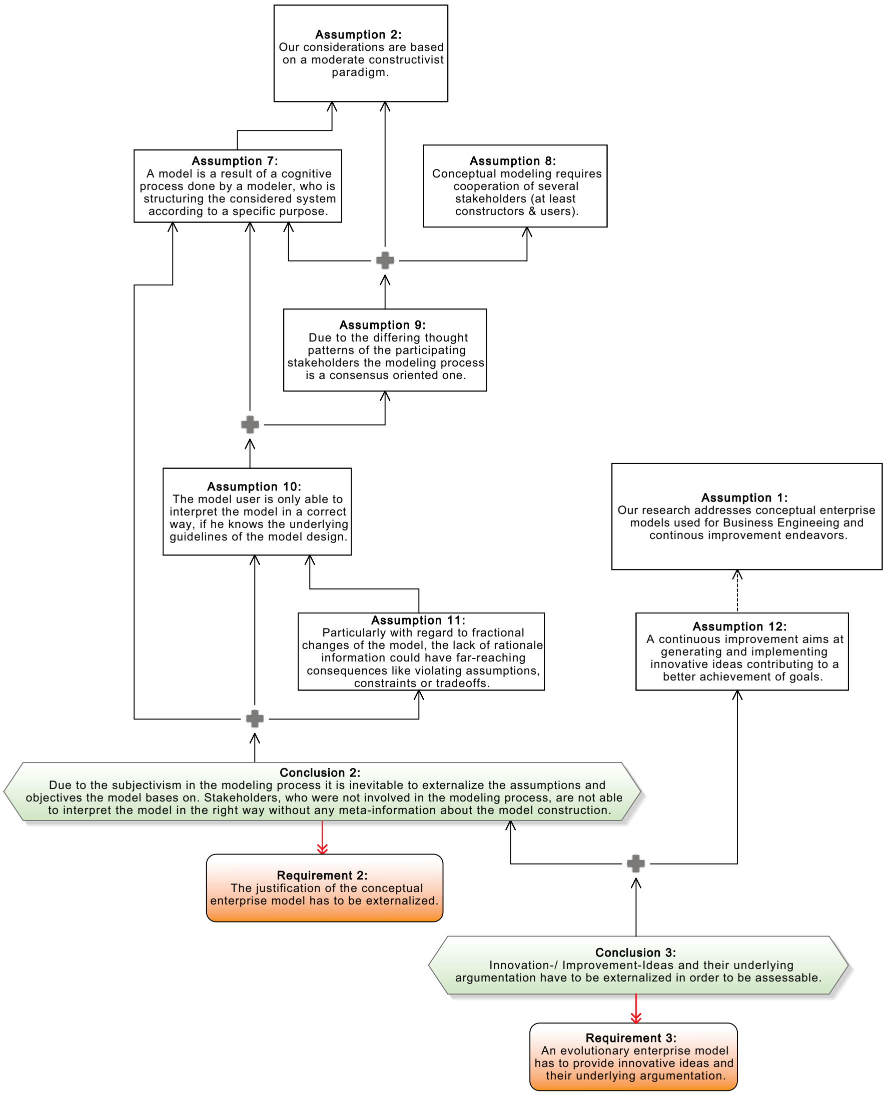
[4] For further information we refer to literature on design rationale (e.g. [RRLT04]).



Assumption 2: Our considerations are based on a moderate constructivist paradigm.

Assumption 7: A model is a result of a cognitive process done by a modeler, who is structuring the considered system according to a specific purpose.

Assumption 8: Conceptual modeling requires cooperation of several stakeholders (at least constructors & users).

Assumption 9: Due to the differing thought patterns of the participating stakeholders the modeling process is a consensus oriented one.

Assumption 10: The model user is only able to interpret the model in a correct way, if he knows the underlying guidelines of the model design.

Assumption 1: Our research addresses conceptual enterprise models used for Business Engineering and continous improvement endeavors.

Assumption 11: Particularly with regard to fractional changes of the model, the lack of rationale information could have far-reaching consequences like violating assumptions, constraints or tradeoffs.

Assumption 12: A continuous improvement aims at generating and implementing innovative ideas contributing to a better achievement of goals.

Conclusion 2: Due to the subjectivism in the modeling process it is inevitable to externalize the assumptions and objectives the model bases on. Stakeholders, who were not involved in the modeling process, are not able to interpret the model in the right way without any meta-information about the model construction.

Requirement 2: The justification of the conceptual enterprise model has to be externalized.

Conclusion 3: Innovation-/ Improvement-Ideas and their underlying argumentation have to be externalized in order to be assessable.

Requirement 3: An evolutionary enterprise model has to provide innovative ideas and their underlying argumentation.

Figure 4: Argumentation for the Need of Documenting Underlying Argumentation

perspective, *conceptual enterprise model*, is the content of the enterprise model (including alternative solutions) describing the perceived, interpreted and designed structures of the respective enterprise. For this purpose various general and domain specific modeling languages are developed (e.g. a study of process modeling grammars is presented in [RRIG06]).

Considering the impact of subjectivity and prediction within conceptual modeling we

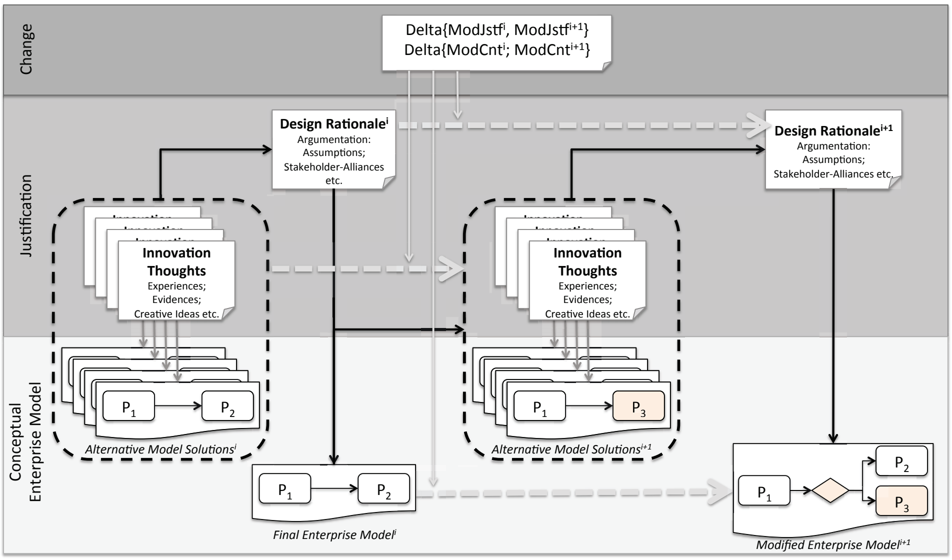


Figure 5: Framework for Managing the Justification and Changes of Conceptual Enterprise Models

claim for a *justification* level (see requirement 2). Concepts of this level contain argumentation, assumptions, objectives, predictions and all other information relevant for the decision-making on design alternatives. We distinguish between innovation thoughts and design rationale. The former ones are deliberations regarding one specific innovation idea, whereas the latter one captures the discussion and weighing of all available alternatives regarding context, assumptions, superordinated goals and so on. This approach constrains the enterprise designers to be aware of their assumptions, predictions and problem interpretation. Beyond that, decision criteria relevant for the choice of alternative design proposals could be designated and monitored. In the case of falsification of relevant assumptions a targeted model modification could be triggered. Otherwise a confirmation of the underlying assumptions or predictions could be assumed. In addition, an instrument is hereby given to capture innovation ideas which could only be implemented in the future owing to actual unfavorable conditions.

The third perspective, *change*, results from the lifecycle consideration. A model evolution implicates a modification of the respective model content and the model justification, respectively. A combined consideration could be useful for an accumulative analysis of changes within the model justification. Most of the goals and assumptions are weighted and intertwined. On that account it is conceivable that a model modification is not caused by a deviation of a single argument but possibly by an aggregated argument or by a limit value. Beyond that, an analysis of the history of argumentation for a conceptual enterprise design could avoid the recurrence of already discarded solutions or reveal obsolete arguments.

The execution of the described approach by means of both adequate modeling concepts and a sophisticated configuration management system would constitute a helical integration of modeling goals, the related enterprise design, the evaluated usefulness and the deduced model evolution. The principles of horizontal and vertical integration[5] have to be implemented on the level of conceptual enterprise modeling. The change level integrates the sequenced model versions along with its primary argumentation and its experiences and performance measurements. The main impacts on conventional conceptual modeling methods are illustrated by two case studies in section 4.

4 Illustrating Example

Summarizing the findings of the former sections, we define the following logical chain for a systematic evolution of conceptual enterprise models. First, the value of the conceptual model is assessed by its implementation and a methodical performance measurement. We interpret the measurement results as received signals from an organizational sensory system. These signals have to be processed in order to reach a decision on (dis-)satisfaction with the level of goal attainment. Second, innovative alternative design solutions are developed for various reasons. These ideas could be inspired by feedback information from employees or customers, by changed market conditions, by management consultants and so on. Consequently, the third step is the evaluation of the alternatives and a reasoned decision about changes of the conceptual enterprise model. In this chapter we outline case studies illustrating the above described steps in model evolution.

4.1 Confirming and Refuting Enterprise Designs

Our first case study was a business process reengineering project within a German administration agency due to the introduction of a new ERP solution. Conceptual models have been used as main tools for designing and documenting innovative business process solutions. The novel business process structures have been represented by BPMN-models[6] as depicted in figure 6.

Before implementing the designed process structures, a realistic simulation of the process flow has been performed by processing typical cases and involving relevant key users. This preliminary valuation of the business process (see requirement 1) revealed that some model fragments are perceived as significant improvements, as impractical or improvable. The valuation results have been captured by specific modeling concepts representing positive or negative experiences (green, red, yellow rectangles at the bottom of figure 6). Additional explanations like experience reports or test logs could be linked by these concepts. Negative test results have been resulted in reconfiguration-activities of the respective software, modifications of the business processes or temporary solutions until further conditions have been met. Positive test results in turn have been discussed for transferring the respective solution to similar problem situations. Beyond that, it becomes obvious which

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[5] Vertical integration comprises different abstraction levels like in [JLQ$^+$11]. Whereas horizontal integration comprises different modeling perspectives like in [Fra02].

[6] For a specification of the primary conceptual modeling language we refer to [OMG].

model fragments have not been questioned at all.

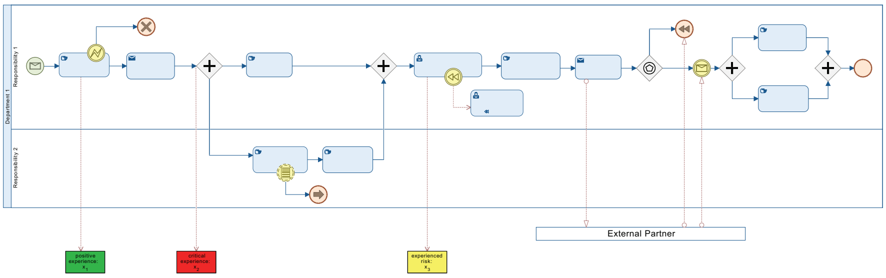

Figure 6: Example of Conceptual Enterprise Model Enriched by Assessment Results

This specific enhancement of a conventional BPMN-model could have following benefits for a systematic and traceable model evolution. It is possible to tag those model elements which are objects of organizational experiences. Confirmed, refuted and challenged model fragments could be easily (and tool supported) identified. In the case of changing positive confirmed model fragments, a corresponding alert may appear. Unsatisfactory solutions could in turn be documented along with relevant experience reports. This simple mechanism could significantly contribute to an efficient model evolution since the repetition of errors or imperfections as well as the modification of successful solutions could be avoided.

4.2 Develop Innovative Alternative Enterprise Designs

The second case study was a longtime student project within the formula student competition (see [For]). The projects specificity is found in the annual challenge of constructing a racing car under the condition of a high level of fluctuation among the team members. Conceptual enterprise models have been used for standardizing project processing and to facilitate a knowledge transfer. A domain specific modeling language has been developed according to the requirements defined by the current project team. Besides the conventional modeling concepts for representing static and dynamic aspects of the perceived system, we defined modeling concepts for integrating alternative solutions into the respective conceptual enterprise model. For this purpose an innovation view[7] was added. This innovation view comprises all relevant alternative solutions. The modeling concept *innovation region* was added in order to interrelate the actual defined structures with the alternative solutions. Figure 7 illustrates the use of this concept.
One of the key issues within the project was sponsorship acquisition. A constant shortage of funding often causes the substitute of planned innovative construction ideas by conventional construction concepts. This practice compromises their chances for winning the cup. The enterprise model has been included among others the document structure and the

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[7] We understand conceptual enterprise models as multi-perspective models as characterized in [Fra02].

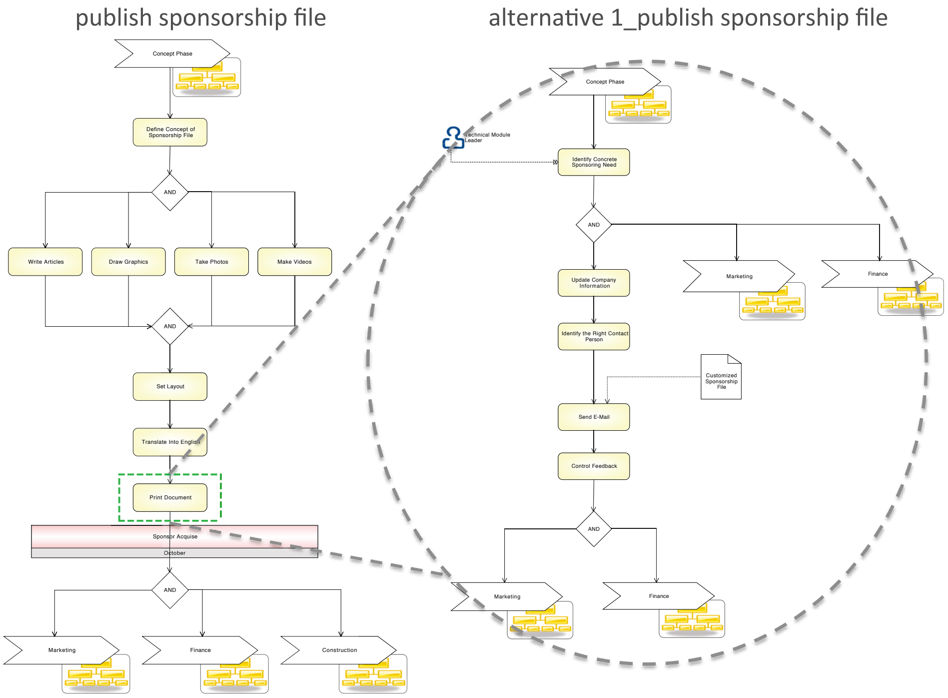


Figure 7: Proposed Process Innovation for Publishing the Sponsorship File

publishing process of the sponsorship file. A causal analysis revealed the standardization of the sponsorship file as possible key problem. An uniform printed document is used for all marketing activities regardless of industry or interests of the addressed sponsor or the targeted sponsorship deal. The customization of the sponsorship file has been identified as promising solution, but a change of organizational structures during the season has been defeated by the team due to the actual workload and the shortage of manpower and expertise. The need for improved structures and procedures should be discussed in its entirety at the end of the present season and at the beginning of the subsequent season, respectively. For documenting the identified innovation potential we extended the conceptual enterprise model by an innovation view.

We designed an alternative document structure of a customized sponsorship file. But this alternative design required in turn a modified publishing process. Figure 7 illustrates the integration of the alternative publishing process into the current valid conceptual enterprise model. The left process model outlines the publishing process of the standardized sponsorship file. The disputable activity, *print document*, is tagged by a green dotted line indicating an existing innovation idea. The concept (*innovation region*) links the current valid enterprise model fragment to its alternative solution (right process model).

This simple enhancement of the conceptual modeling language facilitates the capturing of innovative ideas outside the defined improvement routines. Relevant model fragments could be tagged as improvable. But contrary to the above described example of valuation concepts, this concept presents concrete proposals for alternative solutions (see requirement 3). By this means, improvement routines could be effectively supported due to the facility to capture innovative ideas when they are generated (e.g. outside the improvement routines) and to document them where they are needed (when reviewing the conceptual enterprise model).

4.3 Decide for the Most Promising Solution

Following the improvement cycle described in section 2, the conceptual enterprise model evolves due to unexpected experiences (e.g. dissatisfaction with the level of goal attainment), changed context factors, changed organizational goal system and so on. After the need for improvement has been recognized, innovative solutions have to be constructed (e.g. by means of modeling concepts as described in section 4.2).

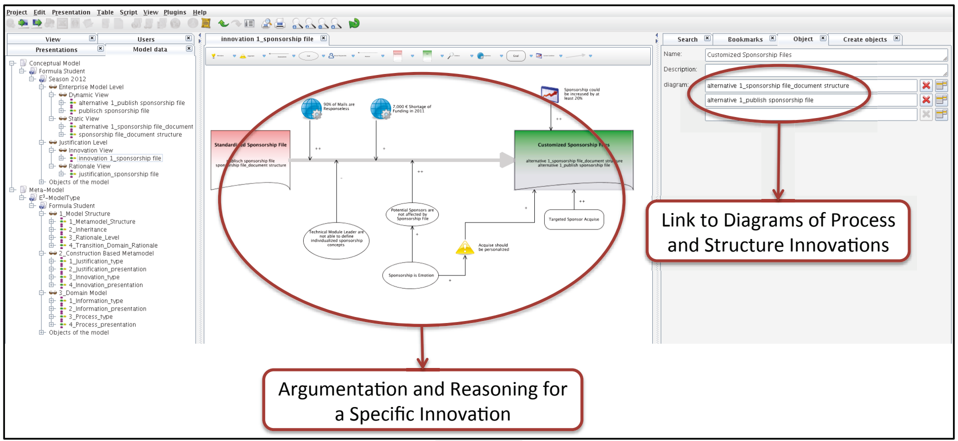
As we aim at a systematic and methodical evolution of the conceptual enterprise model, we claim for a rational decision on alternative solutions (see justification-level in figure 5). Within the case study of the formula student project we met this requirement by defining an additional justification view containing both the justification of a specific innovation idea and the rationale for the final decision on the design of the conceptual enterprise model. The former one includes predictions with regard to the potential benefit of the respective innovation. The latter one includes argumentation for a final design decision based on defined criteria. These crucial decision criteria should in turn serve as a basis for deriving powerful organizational sensors (e.g. performance indicators).

Figure 8 outlines the implementation of a justification view for the support of a traceable evolution of conceptual enterprise models. The upper part of figure 8 depicts an *innovation map*. We defined modeling concepts from scratch for representing the idea and the assumed benefits of a specific innovation (here the individualized sponsorship file). The innovation map could be linked to several diagrams of the innovation view (here the alternative document structure of the sponsorship file and the correspondent publishing process).

The lower part of figure 8 depicts a *justification map*. Concepts of this diagram are derived from design rationale methods (c.f. [RRLT04], [DMMP06b]). The captured innovation thoughts along with experiences from model use, changed context factors or goals are discussed and argumentatively investigated. The decision making could be supported by an algorithmic approach (e.g. a weighting procedure) or just by making complex dependencies and crucial influencing variables transparent and traceable. This justification map could be linked by respective region-concepts (as described in section 4.2) to the correspondent fragment of the actual conceptual enterprise model. Dependent on the used modeling tool, an automated evaluation of the changes of both the model content and the justification could support a systematic model evolution significantly.

For the case study of the formula student team the innovation idea of individualized sponsorship files was rejected for the actual season due to manpower shortage, lack of competencies and predicted increased workload. But the idea itself has been approved and should be discussed within the concept exploration phase of the next season. In this way the integrated enterprise model along with its innovation and justification thoughts is a value source for knowledge and experience transfer into the new engineering team.

a) Innovation Map



Name: Customized Sponsorship Files

Description:

diagram: alternative 1_sponsorship file_document structure

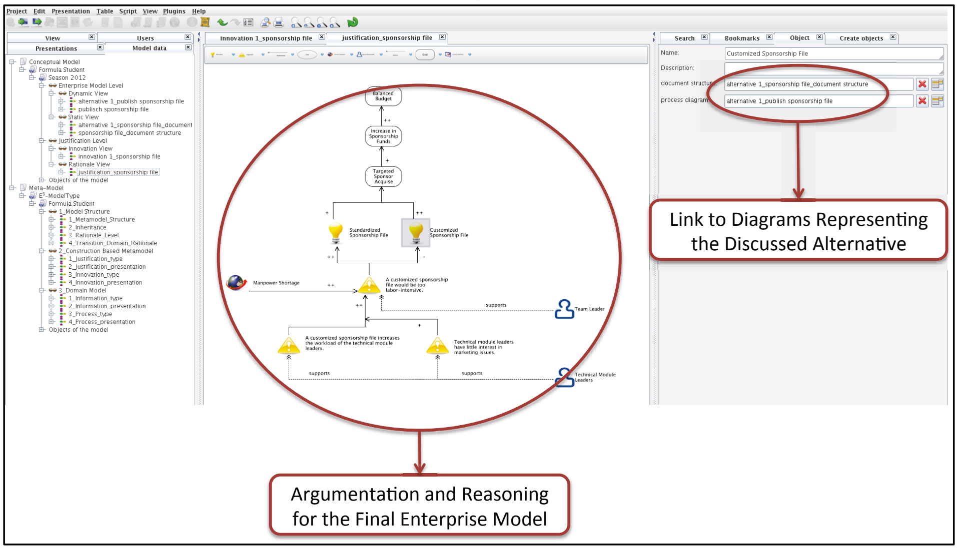
alternative 1_publish sponsorship file

Link to Diagrams of Process and Structure Innovations

Argumentation and Reasoning for a Specific Innovation

Innovation Maps as Input for a Comprehensive Decision (represented by Rationale Maps)

b) Justification Map



Name: Customized Sponsorship File

Description:

document structure: alternative 1_sponsorship file_document structure

process diagram: alternative 1_publish sponsorship file

Link to Diagrams Representing the Discussed Alternative

Argumentation and Reasoning for the Final Enterprise Model

Figure 8: Justification for the Retention or Evolution of an Enterprise Model

4.4 Extensions of the Conceptual Modeling Language

Summarizing the two case studies, we defined several conceptual enhancements of both conventional and domain specific modeling languages in order to support a systematic and methodical evolution of conceptual enterprise models. First, we defined concepts for capturing organizational experiences like unexpected success or unforeseen disruptions in the process. These concepts should represent the results of the valuation process (see requirement 1) in the corresponding sections of the conceptual enterprise model. In this way, these concepts represent the organizational sensory system.

Second, we defined concepts for defining and documenting alternative/ innovative solutions (see requirement 3). These concepts are needed to support the organizational creative performance independent from the state of the improvement cycle. We use the means of conceptual modeling for documenting and communicating innovative ideas due to their commonly accepted benefits (c.f. [Fra02]).

Third, we defined modeling concepts for justifying innovative ideas and rationalizing the conscious decision for the final conceptual enterprise model (see requirement 2). Especially the deployment of the region-concept allows for tagging model fragments and connecting them to documentations of argumentation and/or valuation aspects. This part of the evolutionary conceptual enterprise model represents the organizational rationality. Rationale maps are used to document and communicate the underlying argumentation of the conceptual enterprise model. By this means the validity of the underlying assumptions becomes traceable and analyzable. The identification of need for improvement could be supported by appropriate features of the respective modeling tool.

The signals received from the organizational sensory system serve as arguments within reasoning for the final design decision. The crucial decision criteria serve in turn as a basis for the design of the organizational sensory system. Due to the vital importance of signals, alternatives and arguments for a methodical model evolution, we conclude from the presented case studies that these concepts should be represented by respective conceptual modeling concepts.

Requirement 4. *A modeling language for evolutionary conceptual enterprise models has to contain concepts for representing argumentation and valuation aspects.*

5 Experience-Based Evolution of Conceptual Enterprise Models

In order to consolidate the defined requirements on evolutionary conceptual enterprise models, the research gap defined in section 1 should be revisited. Starting point of our research was the identified lack of methodical support for the evolutionary development of conceptual enterprise models. Existing conceptual modeling languages represent only perceived elements of the respective enterprise (investigated as socio-technical system) but disregard requirements of an evolutionary development approach. The widely accepted assumption of evolutionary conceptual enterprise models was demonstrated by referencing respective research results regarding the deployment of conceptual enterprise models for improvement endeavors (e.g. [DGR+06]; [Fet09b]) and the abstract lifecycle of concep-

tual enterprise models (e.g. [vdAHB03]). Our research is only the first step to close this gap in research by defining basic requirements on methods for evolutionary conceptual enterprise models. Our findings bases on a moderate constructivist paradigm on the one side and on conventional management theories for continuous improvement (like performance measurement systems) on the other side.
Two main insights have been gained by discussing conceptual enterprise models within this context. First, a systematic and continuous improvement is realized by a cyclic approach of defining goals and target values, implementing the planned solution, analyze the actual results and compare them with expected results and derive improvements based on the preceding analysis. Second, a moderate constructivist paradigm of conceptual modeling claims for a consensus theory of truth. This means that the relevant stakeholders of the conceptual enterprise model have to reach a consensus about the underlying goal system and the usefulness of the defined and implemented solution (represented by the conceptual enterprise model). Therefore the rationale and the valuation of a conceptual enterprise model represent the organizational value system rather than the value system of a single person.

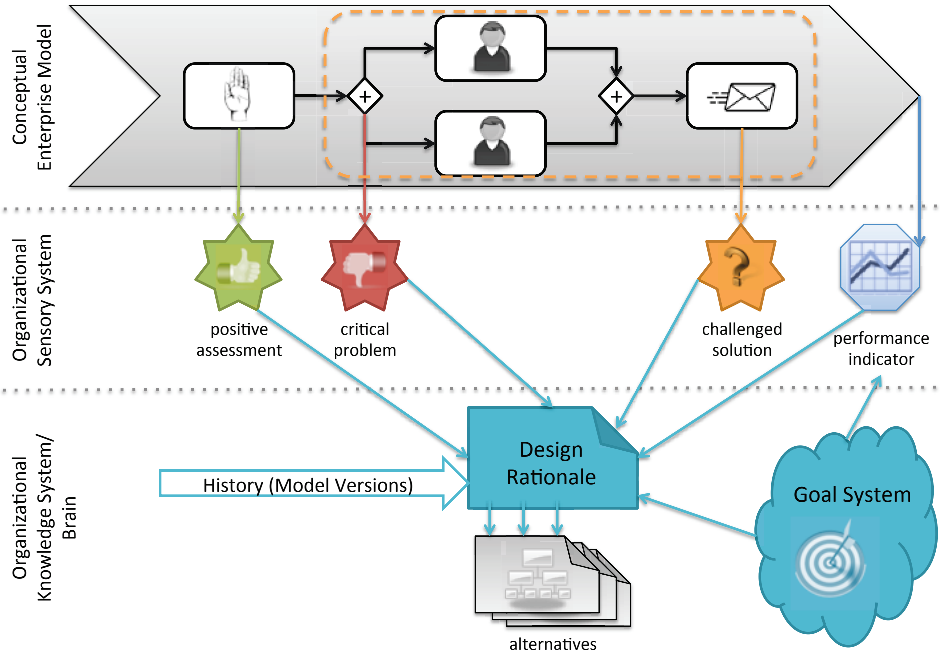


Figure 9: Organizational Valuation of Conceptual Enterprise Models

Figure 9 represents our conclusions from the above described insights. In the upper third of the figure a conventional conceptual enterprise model is depicted. In contrast the lower third of the figure represents the organizational knowledge system including assumptions, predictions and experiences. The organizational knowledge base (in the sense of a consensus among involved stakeholders) determines the argumentation for the final model design. Since the value of a conceptual enterprise model could only be assessed by its implementation and an adequate performance measurement (see argumentation in section 2), some kind of sensory system is needed. We defined two kinds of sensors. First, we defined performance indicators (depicted as octagon in figure 9) based on the methods of performance measurement systems. Sensors of this type are derived from the underlying (organizational) goal system and could be systematically monitored. Their potential impact on model evolution could be derived from the explicated design rationale (see requirement 2). The second type of sensors are experiences (depicted as stars in figure 9) gained by implementing the conceptual enterprise model. Sensors of this type are not systematically monitored but perceived and captured by humans (employees, project teams and so on).

We define an experience as a conclusion drawn by a subject on the basis of subjective perception and interpretation of a real world phenomenon[8]. For the issue of evolutionary conceptual enterprise models, only experiences with reference to the organizational performance are relevant rather than the individual experience of a single person. Thus, we defined this kind of experience as organizational experience. Particularly these experiences are most valuable from which potential options for action could be derived. In this context both confirming and unexpected experiences are of value. The conscious perception of confirming experiences could be used for strengthen the argumentation for a particular solution. Whereas negative experiences (in the sense of unexpected) could initiate a reanalysis of the particular model fragment.

Figure 10 represents our argumentation. We conclude that an organization has to have both an organizational value system and an adequate sensory system. Thus, the definition of the organizational value and sensory system is a prerequisite for a systematic evolution of the conceptual enterprise model.

Requirement 5. *For an experience-based evolution of a conceptual enterprise model, an explicit value and sensory system has to be defined.*

In figure 11 the insights from our research are consolidate. The arrows in the bottom part of figure 11 represent the lifecycle-phases of an evolutionary conceptual enterprise model. The conceptual enterprise model is initially constructed based on the organizational goal and knowledge system and determined by various contextual factors. Due to the underlying constructivist paradigm we claim that the particular solution represented by the conceptual enterprise model is gained by a consensus agreement among relevant stakeholders. In order to communicate the defined solution in a traceable and understandable way, the underlying argumentation should be externalized (see requirement 2 - represented as argumentation-layer in figure 11).

The middle part of figure 11 represents the subsequent utilization of the conceptual enterprise model as blueprint for organizational structures and processes. Since the value of a conceptual enterprise model is measured by its contribution to the business performance, a systematic value procedure (see requirement 1) has to assure both the monitoring of crucial performance indicators and the capturing of any relevant experiences.

The need for improvement could be derived from an analysis of the organizational value

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[8] For a philosophic discussion on the nature of experiences we refer to [Ham97]

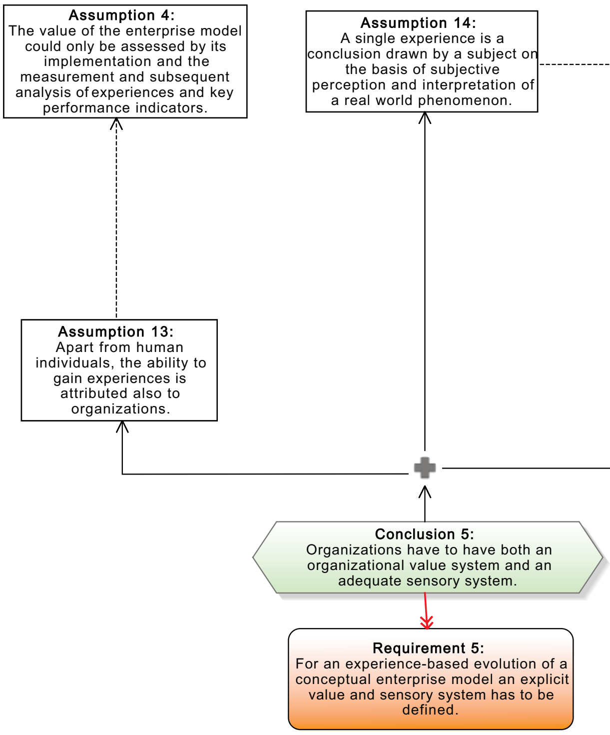

Figure 10: Argumentation for the Need of an Organizational Value and Sensory System

system (documented as design rationale of the conceptual enterprise model) and the respective information gained by the organizational sensory system (performance indicators and organizational experiences). Since both the organizational value system and the organizational sensory system are developed by consensus agreements among relevant stakeholders, they have to be specified in detail (see requirement 5). As we identified conceptual models as suitable communication means for complex issues, we claim for suitably enriched conceptual modeling languages (see requirement 4).
The evolution of the conceptual enterprise model is depicted in the right part of figure 11. If the analysis of the primary argumentation and the perceived experiences has revealed the need for improvement, alternative solutions (innovations) and their related argumentation has to be developed (see requirement 3). The decision for a particular modification of the conceptual enterprise model is finalized on the discussion of the (changed) organizational goal and knowledge system, the (changed) context factors and the gained experiences. The final decision also has to be externalized (represented as argumentation-layer in figure 11). The delta (change) of the design rationale of the evolutionary conceptual enterprise model could be regarded as organizational learning. Finally, we conclude that the development of adequate evolutionary modeling methods will determine to what extend the organizational

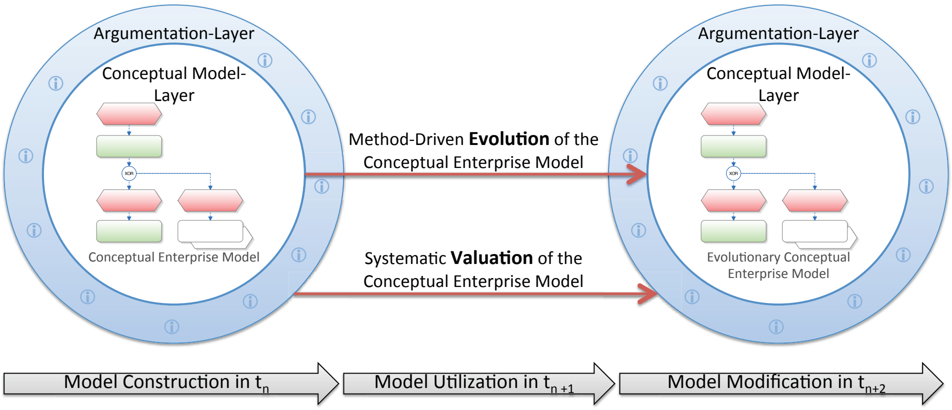

Figure 11: Evolutionary Conceptual Enterprise Model

capability to evolve systematically could be established.

6 Conclusion

Our research bases on the assumption that a systematic continuous improvement of organizational structures and processes requires evolutionary conceptual enterprise models. We motivated our research by the fact that conventional conceptual modeling methods provide insufficient support for an evolutionary development of conceptual enterprise models. The argumentative exploration of theories in both management science and information systems has made the following contributions.

First, the lifecycle of the evolutionary conceptual enterprise model has been integrated into the business management cycle based on performance measurement. Crucial influencing factors like goals and empirical evidences have been identified. In addition situations relevant for the model evolution have been described and characterized. This procedural understanding of model evolution forms a basis for defining a framework in which appropriate methods for evolutionary conceptual enterprise models should be developed.

The presented tripartite framework for managing the justification and changes of conceptual enterprise models is the second contribution of the paper. A differentiation between the representation of the perceived system (represented by conventional conceptual models) and the argumentation for a specific solution design has been made. Due to the fact that the underlying goal and value system is gained by a consensus agreement among the involved stakeholders, it should be specified in detail and persistently documented. The documented argumentation is a main source of information for a systematic model evolution. It facilitates the methodical analysis of goal attainment and validity of underlying assumptions. The changes in both the conceptual enterprise model and its argumentation represent the organizational learning. On condition that the respective versions of the conceptual enterprise model and their rationale are coherently presented, the organizational

learning process becomes traceable and manageable.
Finally, the paper contributes to the enhancement of constructivist model theory by defining basic requirements for the development of adequate methods for evolutionary conceptual enterprise models. In essence we claim for a further modeling view in the sense of a construction-based metamodel. By this means, a coherent presentation of underlying assumptions, arguments, evidences and so on could be assured. We have illustrated these requirements by the description of two case studies.
We have avoided to present a specific modeling method for evolutionary conceptual enterprise model. This is due to the fact that the specific design of a conceptual modeling method depends on the management-task at hand. And it seems to be impossible to standardize the wide range of corporate improvement projects. But future research on evolutionary conceptual enterprise models may reveal further restrictions and guidelines for respective method engineering.
Our future work will focus on the tool supported evaluation of changes within both the enterprise model level and the justification level. Therefor we will develop a domain specific modeling language consisting of both modeling concepts representing elements of the perceived system and modeling concepts representing the organizational knowledge system as well as the organizational learning process.
The potential for a systematic evolution of reference models will be of particular interest. Issues of method engineering for evolutionary reference models along with the support of communities of practice will be the main object of future research. Therefor we aspire a long-term research project for investigating the repeatedly pass through the improvement-cycle.

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8 Erfahrungsbasierte Prozessverbesserung: [EL09]

Tabelle 7: Beitrag der Koautoren zum Artikel [EL09]

Titel	Erfahrungsbasierte Prozessverbesserung		
Autor(en)	Werner Esswein, Sina Lehrmann		
Publikation in	ERP Management, 5(2), S. 44–46, 2009.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	20%
		Sina Lehrmann	80%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	80%
	Argumentative Analyse	Werner Esswein	10%
		Sina Lehrmann	90%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	90%
	Kritische Prüfung des Manuskripts	Werner Esswein	40%
		Sina Lehrmann	60%

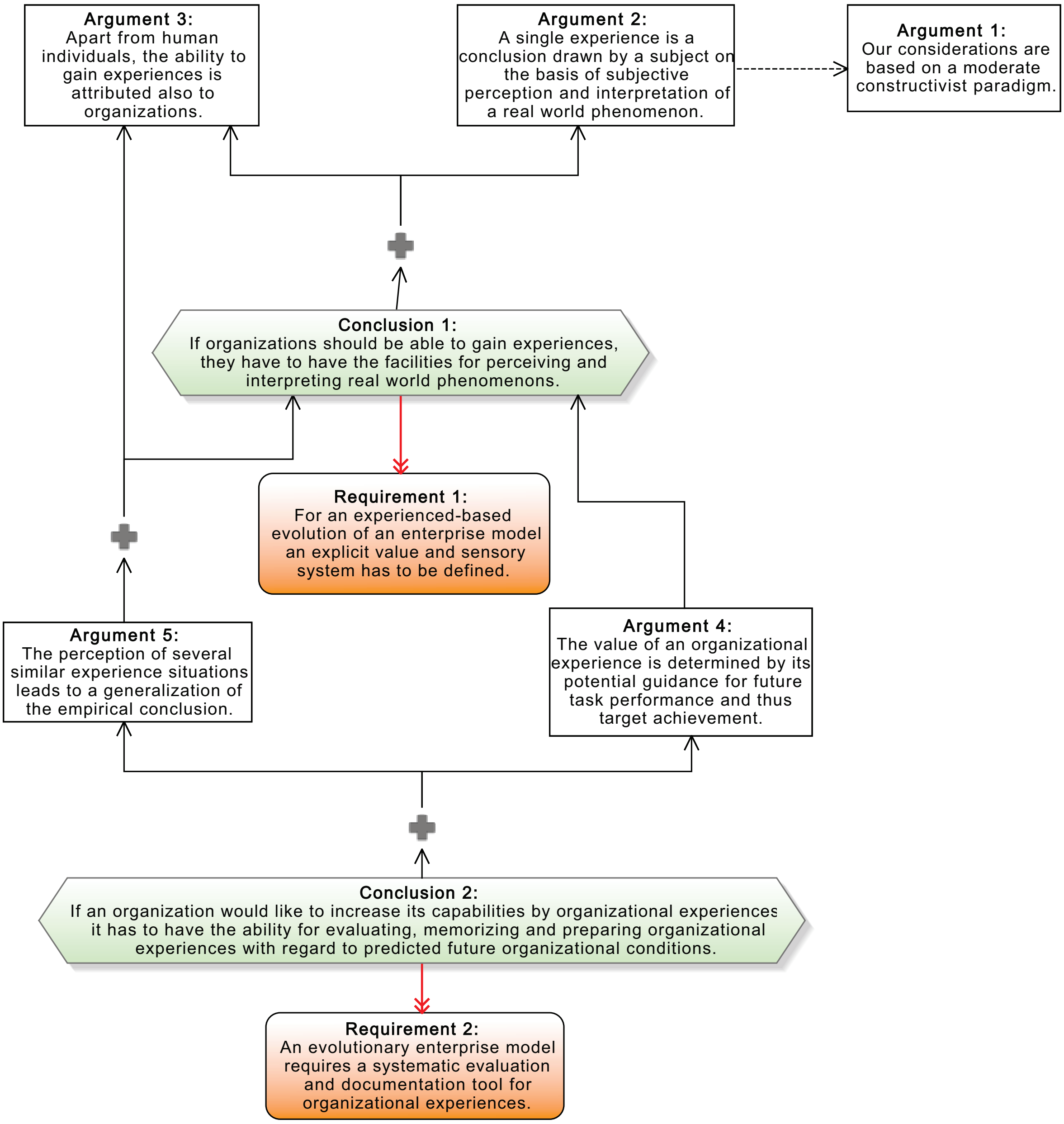
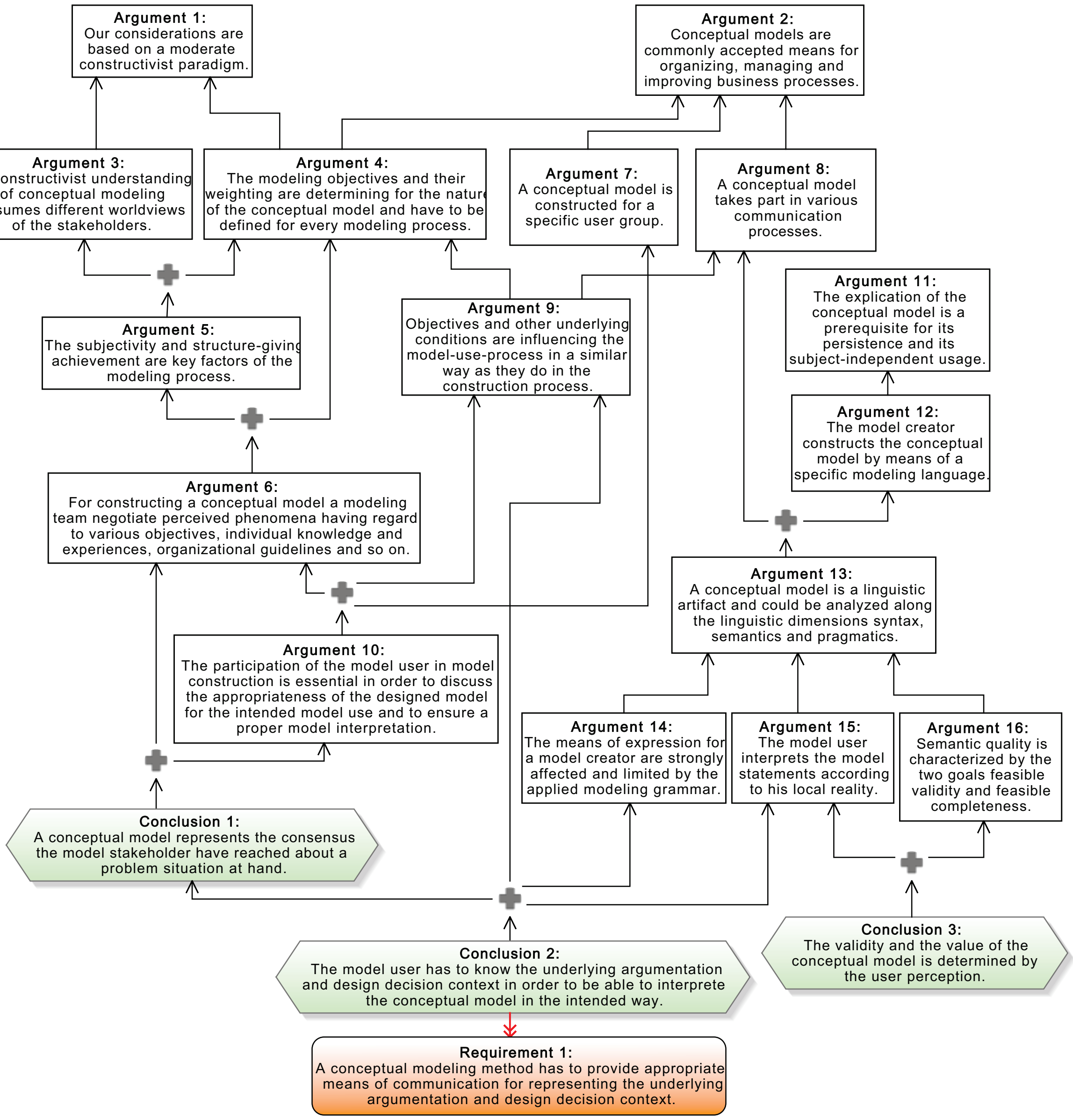


Abbildung 15: Argumentationsmodell für Publikation [EL09]

9 Argumentations-Ebene: [EL13]

Tabelle 8: Beitrag der Koautoren zum Artikel [EL13]

Titel	About the Need for Semantically Enriched Reference Models		
Autor(en)	Werner Esswein, Sina Lehrmann		
Publikation in	Proceedings of the Nineteenth Americas Conference on Information Systems, Chicago, Illinois, August 15-17, 2013.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	20%
		Sina Lehrmann	80%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	80%
	Argumentative Analyse	Werner Esswein	10%
		Sina Lehrmann	90%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	90%
	Kritische Prüfung des Manuskripts	Werner Esswein	40%
		Sina Lehrmann	60%



Argument 1:
Our considerations are based on a moderate constructivist paradigm.

Argument 2:
Conceptual models are commonly accepted means for organizing, managing and improving business processes.

Argument 3:
A constructivist understanding of conceptual modeling assumes different worldviews of the stakeholders.

Argument 4:
The modeling objectives and their weighting are determining for the natur of the conceptual model and have to be defined for every modeling process.

Argument 7:
A conceptual model is constructed for a specific user group.

Argument 8:
A conceptual model takes part in various communication processes.

Argument 5:
The subjectivity and structure-giving achievement are key factors of the modeling process.

Argument 9:
Objectives and other underlying conditions are influencing the model-use-process in a similar way as they do in the construction process.

Argument 11:
The explication of the conceptual model is a prerequisite for its persistence and its subject-independent usage.

Argument 12:
The model creator constructs the conceptual model by means of a specific modeling language.

Argument 6:
For constructing a conceptual model a modeling team negotiate perceived phenomena having regard to various objectives, individual knowledge and experiences, organizational guidelines and so on.

Argument 13:
A conceptual model is a linguistic artifact and could be analyzed along the linguistic dimensions syntax, semantics and pragmatics.

Argument 10:
The participation of the model user in model construction is essential in order to discuss the appropriateness of the designed model for the intended model use and to ensure a proper model interpretation.

Argument 14:
The means of expression for a model creator are strongly affected and limited by the applied modeling grammar.

Argument 15:
The model user interprets the model statements according to his local reality.

Argument 16:
Semantic quality is characterized by the two goals feasible validity and feasible completeness.

Conclusion 1:
A conceptual model represents the consensus the model stakeholder have reached about a problem situation at hand.

Conclusion 2:
The model user has to know the underlying argumentation and design decision context in order to be able to interprete the conceptual model in the intended way.

Conclusion 3:
The validity and the value of the conceptual model is determined by the user perception.

Requirement 1:
A conceptual modeling method has to provide appropriate means of communication for representing the underlying argumentation and design decision context.

Abbildung 16: Argumentationsmodell 1 für Publikation [EL13]

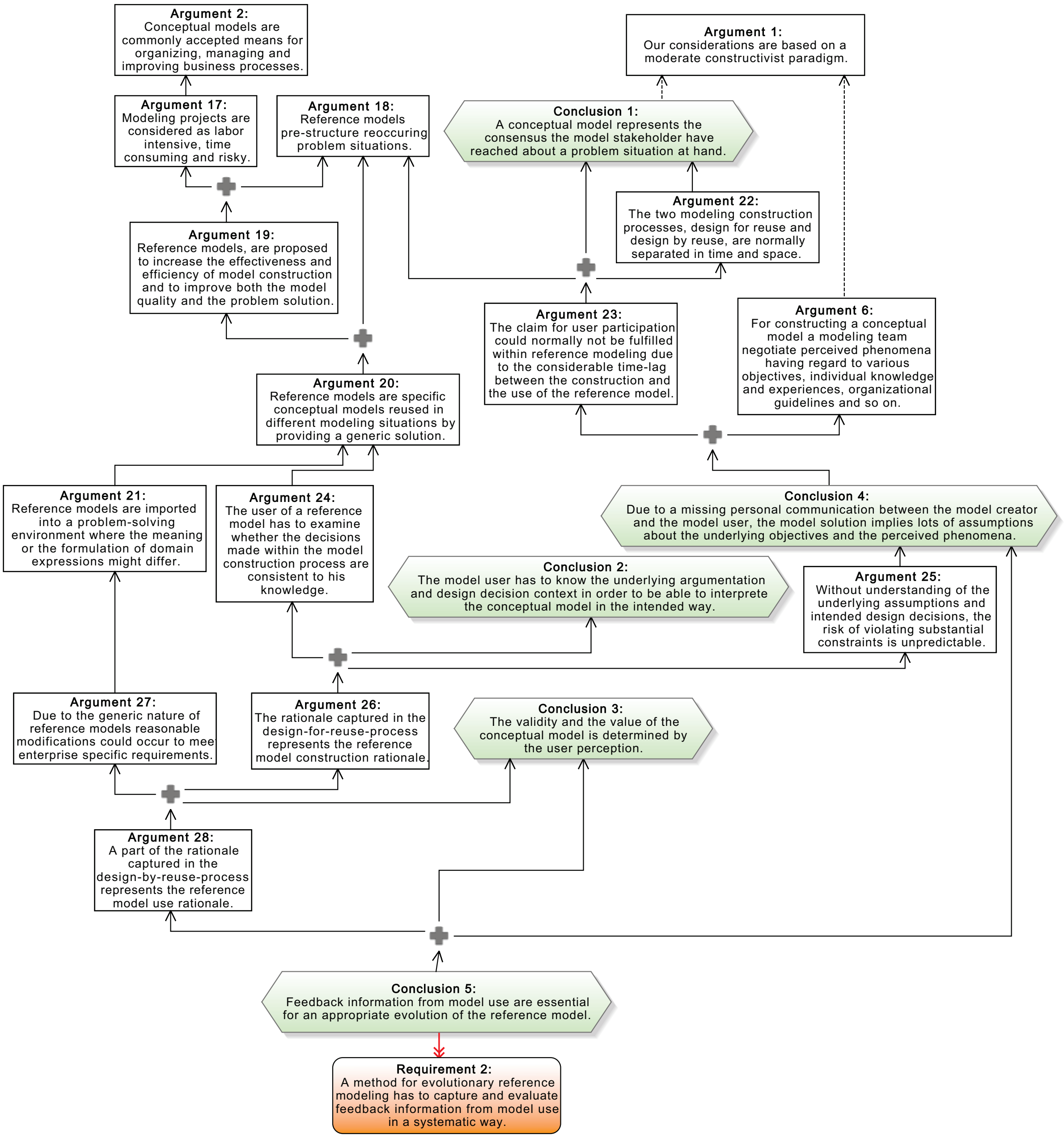


Abbildung 17: Argumentationsmodell 2 für Publikation [EL13]

10 Gültigkeit von Referenzmodellen: [Leh13c]

Tabelle 9: Beitrag der Koautoren zum Artikel [Leh13c]

Titel	How to Develop Valid Reference Models by Mining Individual Information Models?		
Autor(en)	Sina Lehrmann		
Publikation in	Unveröffentlicht, 2013.		
Beitrag der Autoren	Forschungskonzeption	Sina Lehrmann	100%
	Identifikation der Theorien	Sina Lehrmann	100%
	Argumentative Analyse	Sina Lehrmann	100%
	Formulierung des Manuskripts	Sina Lehrmann	100%
	Kritische Prüfung des Manuskripts	Sina Lehrmann	100%

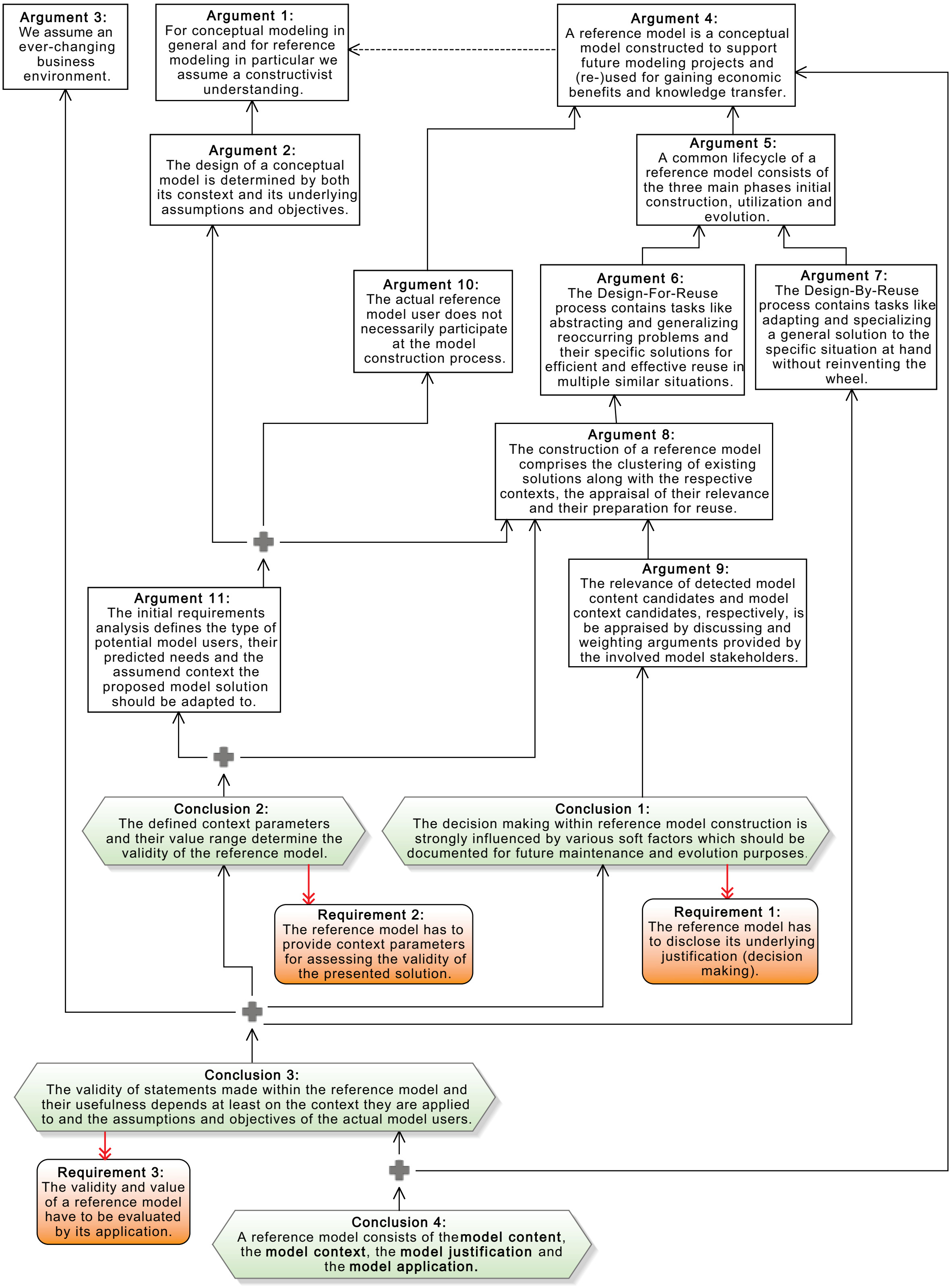


Abbildung 18: Argumentationsmodell 1 für Publikation [Leh13c]

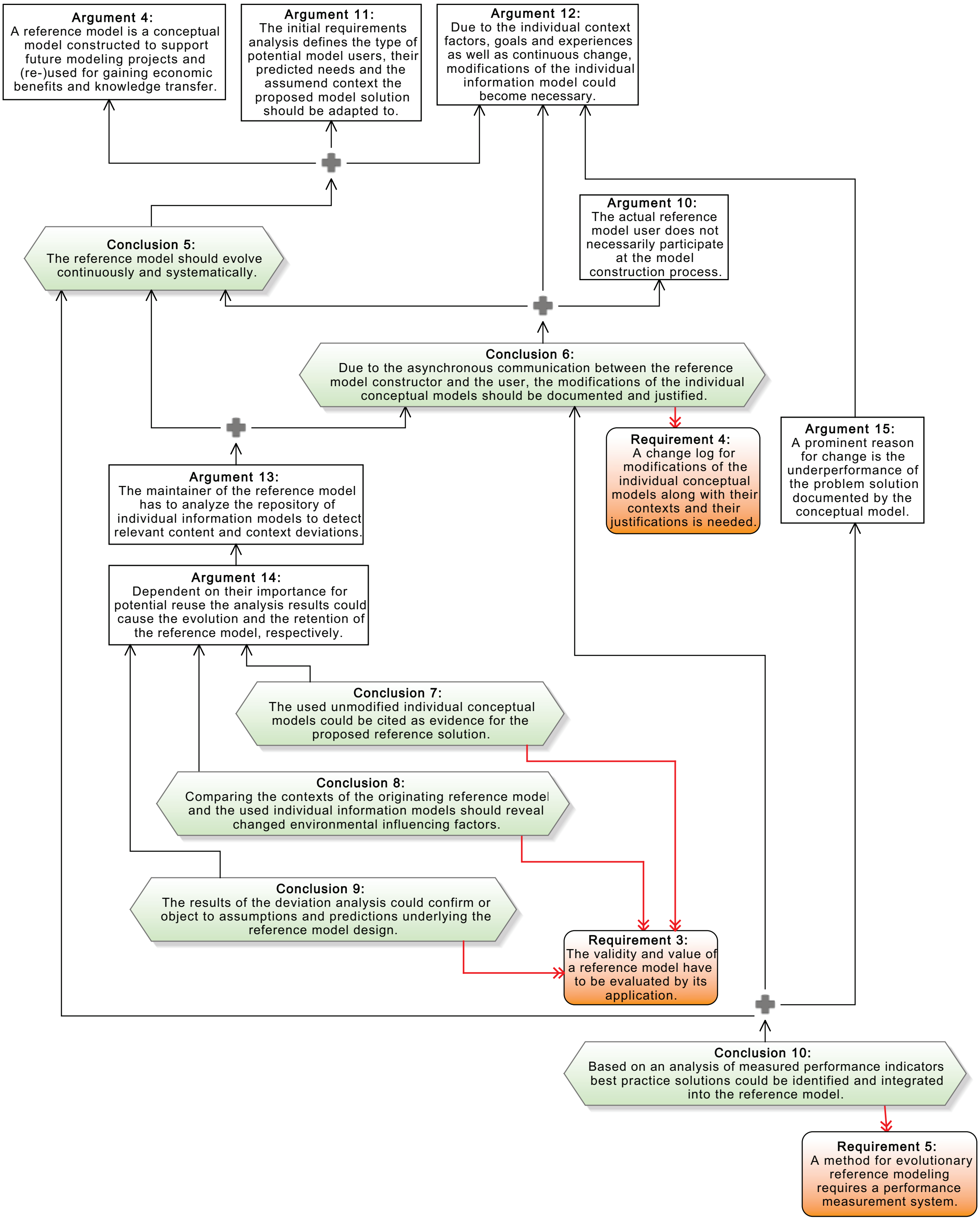


Abbildung 19: Argumentationsmodell 2 für Publikation [Leh13c]

How to Develop Valid Reference Models by Mining Individual Information Models?

Sina Lehrmann

Technische Universität Dresden

Abstract. Reference models are accepted means for various tasks within information systems management. Whereas a comprehensive theoretical framework for design principles exists, general scenarios and related modeling operations for an evolutionary development are almost uninvestigated. This paper proposes to extend the existing body of research by studying different kinds of trigger for the retention or evolution of a reference model. Basing on a lifecycle consideration we identify key situations for mining individual information models for justifying and evolving the design of reference models systematically.

Key words: Reference Modeling, Reference Model Lifecycle, Contextawareness, Evolutionary Development

1 Introduction

Reference Models as powerful means for information systems management are discussed within academia since decades (e.g. [20], [22], [11]). Specific reference modeling techniques have been developed and implemented in modeling tools (e.g. [7], [16]). This leads to an increased acceptance of their practical relevance for various tasks within information systems management in various industries (e.g. [1], [2]). But even if a variety of modeling concepts and operations exist for supporting the construction of reference models, their specific requirements for maintenance and evolution are almost unsolved. Especially the pragmatic aspect of conceptual modeling [14] is unconsidered so far within reference modeling research.

This paper presents a general framework for evolutionary reference modeling. For this we discuss prerequisites and determining influencing factors of the development of valid reference models. On the basis of a lifecycle consideration we identify key situations for mining adaptation and change logs of individual information models. The analysis results are used for justifying and evolving the design of reference models systematically.

In the remainder, we first provide a motivating example to clearly position what drives our research. Then we discuss related work on reference modeling and model evolution in order to introduce a useful definition and understanding of context in the environment of evolutionary reference modeling. Third, we introduce our framework by discussing the construction and utilization of reference models and their relationship towards related individual information models. Finally, we conclude the paper and outline future research.

2 Motivating Example

Business process improvement is one of the main application areas of conceptual modeling [8]. Due to cost saving aspects and a collaborative improvement of the problem solution an exchange of existing process models among cooperative companies are common in practice (e.g. [19]). But an unreflected adoption of borrowed process models involves the danger of missing the corporate targets. Figure 1 depicts two alternative process designs for handling an incomplete claim form by different branches of an insurance company. Alternative A recommends the return of the incomplete form to sender. Alternative B recommends adding the missing values by clerk. The central reference modeling issue here is how to aggregate these proposals to an useful blueprint for reoccurring problem situations. The first and obvious solution is the description of the problem situation by relevant context factors. These context factors could originate from the business aspect like type of company, corporate guidelines or business network as well as from the modeling project like model stakeholders and their knowledge and experiences in insurance domain and conceptual modeling, respectively. On the basis of calculating similarity scores for multiple context descriptions a ranked recommendation of alternative process designs could be derived.

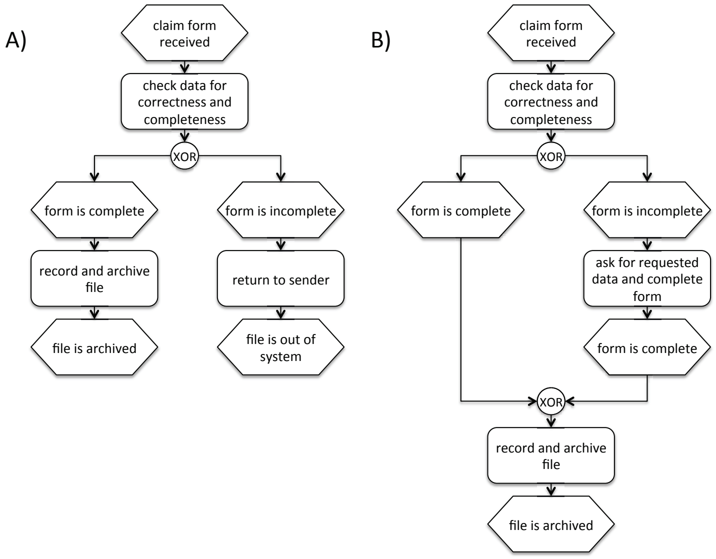


Fig. 1. Alternative Sample Processes for Handling Incomplete Claim Forms

3 Background and Theory

A reference model is a conceptual model constructed to support future modeling projects and (re-)used for gaining economic benefits and knowledge transfer. Basically within reference modeling research two different kinds of conceptual modeling have to be distinguished, the *Design for Reuse* and the *Design by Reuse* [6]. The former one contains tasks like abstracting and generalizing reoccurring problems and their specific solutions for efficient and effective reuse in multiple similar situations. The latter one contains tasks like adapting and specializing a general solution to the specific situation at hand without reinventing the wheel.

For conceptual modeling in general and for reference modeling in particular we assume a constructivist understanding ([21], [15]). According to that a conceptual model is an artifact formulated in a conceptual modeling language representing a vital structure of an information system perceived and interpreted by humans. Due to the essential influence of the subjective interpretation and cost-effectiveness considerations done by model constructors, the design of a conceptual model is determined by both its context and its underlying assumptions and objectives. Thus, besides the syntactic and semantic aspect the pragmatic aspect is a key criterion for assessing the quality of conceptual models ([14], [13]).

For a further analysis of key factors within refernce modeling we consider a common lifecycle of a reference model consisting of the three main phases, initial construction, utilization and evolution (cf. [5]). Starting point for the lifecycle of a reference model is its deliberate construction for well defined purposes. The initial requirements analysis defines the type of potential model users, their needs and the context the proposed model solution should be adapted to. As reference models should serve as support for multiple future modeling projects, the actual reference model user does not necessarily participate at the model construction process. Thus, representatives of potential model users are included in the model construction process and a lot of assumptions and predictions are made. The validity of statements made within the reference model and their usefulness depends at least on the context they are applied to and the assumptions and objectives of the actual model users. Thus, the context description attached to the model content states the predicted scope of the reference model but only its actual application and the related context confirm its validity. As we assume an ever-changing business environment, the reference model should evolve continuously and systematically too. For this purpose information about the adaptations of the reference model for constructing individual information models and their subsequent modifications are relevant. Summarizing, following essential properties of reference models could be stated.

Defintion 1 (Reference Model) *A reference model RM = (ModCnt, ModCtxt, ModJstf, ModAppl) consists of the model content ModCnt, the model context ModCtxt, the model justification ModJstf and the model application ModAppl.*

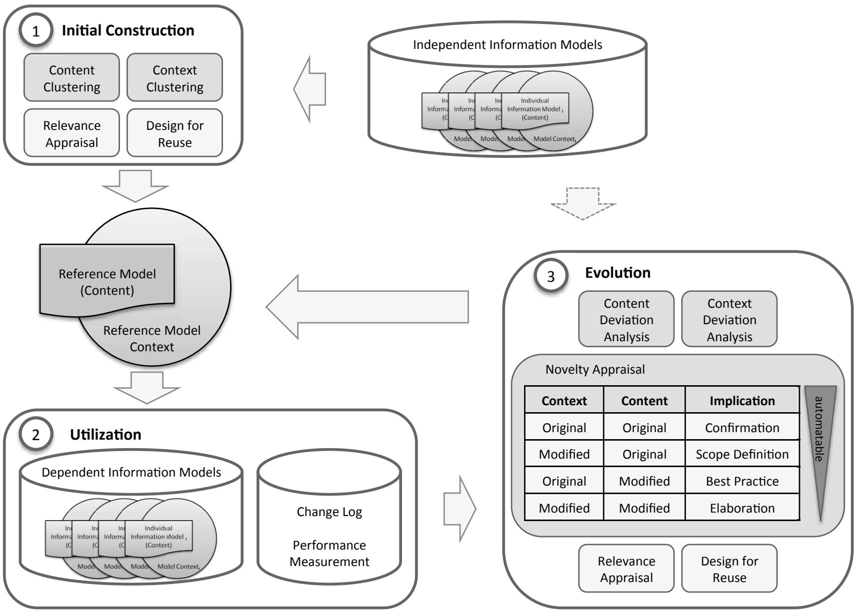
Most of theoretical work is done to formalize modeling principles how to declare the content of reference models and to operationalize their derivation and adaption for specific problem situations at hand (e.g. [4], [7]). Especially the syntactic and semantic aspects of reference modeling are objects of research (e.g. [16], [10]). The impact of contextual influencing factors (e.g. [17], [23]) or underlying objectives (for aspects of goal modeling see [9], [25]) plus the weighting of arguments (e.g. [18]) on the design of conceptual models and their perceived valueness is increasingly recognized within research. But no systematic translations of these considerations to reference modeling theory has been occured. Some innovative approaches are tailored to specific use cases and focus mainly on mining execution and change logs of workflow systems (e.g. [3], [12], [24]). These approaches however neglect the underlying argumentation and discontinuity of goals. But to document the justification for the design of the reference model is all the more important because of the missing involvement of the model user in the construction process. Only on the basis of assessing the underlying argumentation a potential model user can decide whether to accept the provided solution or not. Thus, our paper contributes to the development of a holistic framework for evolutionary reference modeling by complementing reflections about social aspects of reference modeling.

4 Constructing Valid Reference Models

We assume that the initial reference model is deliberately formed and geared towards the support of deriving individual information models. To what extend existing individual information models could be (automatically) analyzed and generalized depends on their accessibility, their coding and their provision of supplement information like goal orientation and performance indicators. When a reference model is constructed and published, it could be used as a blueprint for constructing individual information models geared to the specific situation at hand. Due to the individual context factors, goals and experiences as well as the continuous change, modifications of the individual information model could become necessary and should be documented and justified within a change log. Beyond that, a prominent reason for change is the underperformance of the problem solution documented by the conceptual model. Thus, the measured performance indicators should be documented and analyzed systematically for continuous improvement of both the individual information model and the reference model. This lifecycle of a reference model is depicted in figure 2. The framework gives room for multiple automatable and manual approaches analyzing hard and soft factors of reference modeling. In the following sections we will have a closer look to them.

4.1 Initial Construction

The initial construction is the first *design for reuse* process within the lifecycle of a reference model. The goal is to identify a good solution for a common problem and to guide potential users how to adapt it. In order to effect this purpose four



Context	Content	Implication
Original	Original	Confirmation
Modified	Original	Scope Definition
Original	Modified	Best Practice
Modified	Modified	Elaboration

Fig. 2. Outline of Reference Model Analysis

main tasks have to be fulfiled, *content clustering*, *context clustering*, *relevance appraisal* and *design for reuse*.

The first task of reference modeling is the definition of the goals. Modeling by objectives enables the systematic definition of both the model content (ModCnt) and the model context (ModCtxt). Within reference modeling various individual problem situations have be considered, generalized and clustered in order to construct the reference model as a helpful instrument for reuse. Whereas the definition of model content is object of various research within conceptual modeling, the context description is almost disregarded. But a significant context description for defining the scope of the potential reference model is needed. The defined context parameters and their value range determine the validity of the reference model.

To appraise the relevance of detected model content candidates and model context candidates, respectively, an argumentation of pros and cons is necessary. The discussed arguments and their weighting depend on the involved model stakeholders and their knowledge, experiences and culture. Considering goal conflicts or corporate guidelines could influence the decision for or against a certain reference model design as well as considerations of impact, cause-effects-relations and the gauge of scope. These soft factors are influencing the decision making to a great extend and should be documented for future maintenance and evolution purposes (ModJstf).

Concluding, the defined model content and its associated model context have to be prepared for potential reuse situations. To support this, various modeling principles, techniques and language concepts already exists (e.g. [7], [16], [4]).

Referring to the introductory example (see figure 3), alternative B has been chosen as a blueprint for all branches of an insurance company. The reference model should ensure that all branches pursue the strategic goal of customer orientation and implement the respective corporate guideline. For supporting succeeding maintenance tasks, sensor concepts are defined to monitor the validity of the underlying argumentation.

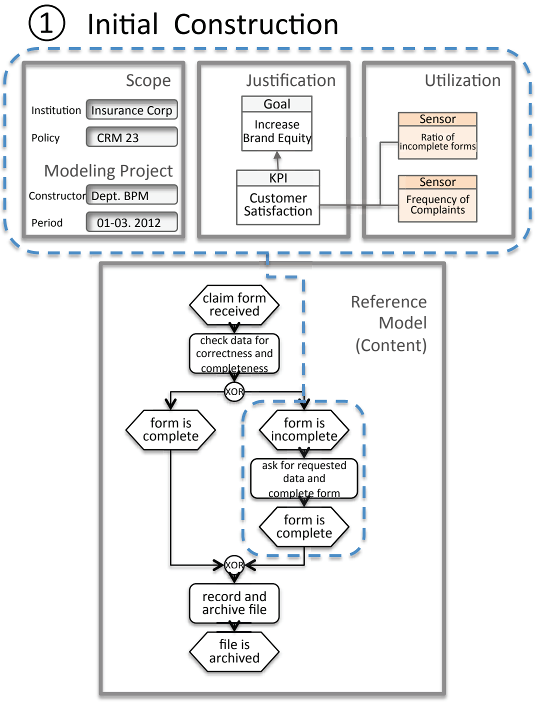


Fig. 3. Example for Initial Reference Model and Partial Context Description

4.2 Utilization

The reference model is used to derive an individual information model adapted and customized for the specific requirements of the situation at hand. A comparison of the context description of the reference model and the situation at hand provide the basis for identifying relevant parts of the reference model. Significant divergences could indicate the need for modifying the model content. In order to avoid violating constraints of the model design the user of the reference model should analyze the documented model justification and assess the validity of the underlying assumptions and objectives. The justification for the design of the individual information model could be adapted and the model user becomes aware of crucial modeling issues.

The derived individual information model in turn is used to support task fulfillment in a real information system. The model user gains experiences regarding both the model operability and its value. Changes of individual information model could indicate a changed environment and its respective requirements, wrong assumptions and predictions during the model construction phase or an underperformance of the provided solution. Changes of the model content (△ModCnt) could comprise innovative solutions for the originating problem by supporting a better performance. But a co-occurring change of the model context description (△ModCtxt) could indicate that the situation at hand is out of the scope of the reference model. Figure 4 depicts the adaption and change of

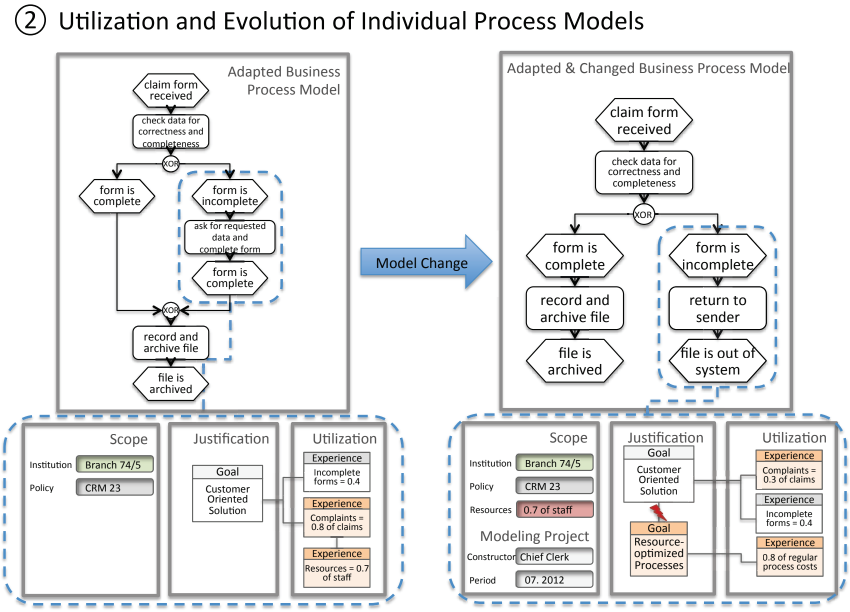


Fig. 4. Example for Changed Process Model and Partial Context Description

an individual information model caused by changed contextual parameters. The model content of the reference model was initially be adopted without modifications. The monitoring of the sensor concepts revealed a sharp rise of customer complaints. An analysis of causes detected staff shortage and a concomitant productivity loss. The responsible chief clerk replaced the customer oriented process design by a resourced optimized design. The originating and novel sensor concepts are still monitored. To support a systematic evolution of the originating reference model by mining the derived individual information models, an analyzable change log and captured performance indicators should be provided. These information are an important source for detecting required, optional or avoidable changes of the reference model.

5 Maintaining and Evolving Valid Reference Models

An information system is affected by its ever-changing environment and is therefore in continuous development. Thus, the conceptual information model has to be changed along with the changes of the respective information system in order to represent its current structures. A systematic analysis of performance indicators supports a successful and continuous improvement of the conceptual information model. A performance analysis for reference models could base on hard factors and soft factors, respectively. Hard factors could be captured and analyzed objectively, like the frequency of application and the frequency of change. This kind of decision support could be executed automated by adequate algorithms. Case based reasoning approaches mostly draw on these approaches (e.g. [24]). Soft factors represent the perceived usefulness of the respective conceptual information model by its user. These factors depend on the subjective interpretation by the affected model stakeholders and could not be automated captured and analyzed. The maintainer of the reference model has to analyze the repository of individual information models to detect relevant content and context deviations. Dependent on their importance for potential reuse the analysis results could cause the evolution and the retention of the reference model, respectively. Figure 2 depicts essential maintenance tasks and their potential impact on the considered reference model. We deduced diverse impacts from the combination of detected model changes regarding the content and the context.

Comparing the context of the originating reference model and the used individual information model should reveal changed environmental influencing factors. The results of the deviation analysis could confirm or object to assumptions and predictions underlying the reference model design. The distinction between generalities and situation specific influencing factors is the challenging part of this task.

$$sim^{ModCtxt}(m_1, m_2) = \begin{cases} 1 & \text{if context of } m_1, m_2 \text{ are equal} \\ (0;1) & \text{if context of } m_1, m_2 \text{ bear analogy} \\ 0 & \text{if } m_1, m_2 \text{ have no similar context} \end{cases} \tag{1}$$

Comparing the model contents should detect innovative solutions for the discussed issues. Within an atmosphere of continuous improvement novel solutions for managing the information system will be created and documented within changed content of the respective information model. The analysis of alternative solutions along with its captured performance indicators enables a weighting and ranking of alternatives for reference model design. Beyond that, misconceptions of the originating reference model could be detected.

$$sim^{ModCnt}(m_1, m_2) = \begin{cases} 1 & \text{if statements of } m_1, m_2 \text{ are equal} \\ (0;1) & \text{if statements of } m_1, m_2 \text{ bear analogy} \\ 0 & \text{if } m_1, m_2 \text{ have no similar statements} \end{cases} \quad (2)$$

Adequate analysis algorithms should provide decision support for deciding which individual solutions are relevant for *design for reuse*. In this regard information regarding the detection of feasible solutions, most frequent used solutions, best solutions or issues without general reusable solutions are useful.

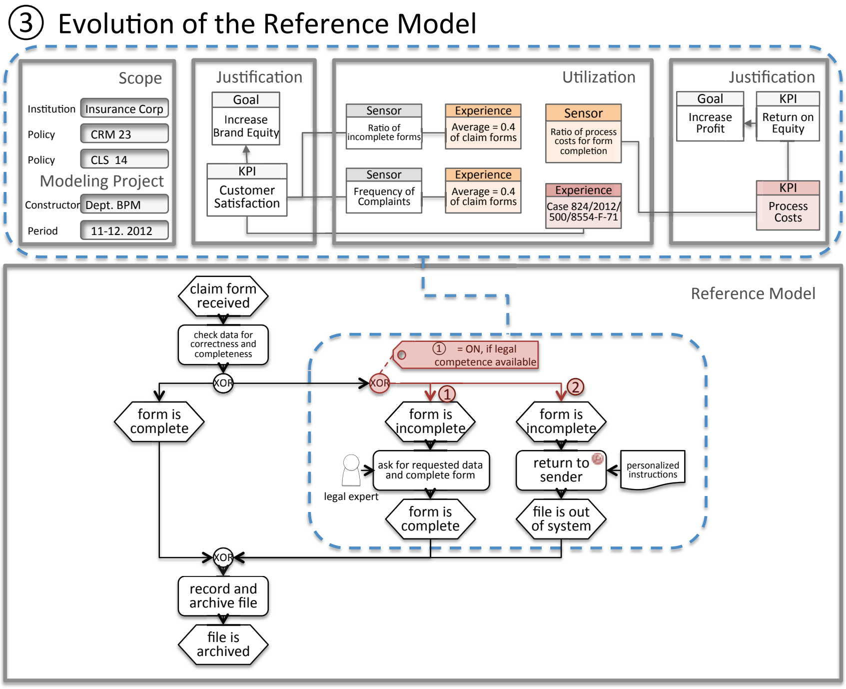


Fig. 5. Example for Evolved Reference Model and Partial Context Description

5.1 Maintaining the Reference Model

The most unspectacular analysis result is the compliance of the individual model content with the reference model content (see figure **??**).

$$sim^{ModCnt}(m_{reference}, m_{individual}){=}1 \wedge$$

$$sim^{ModCtxt}(m_{reference}, m_{individual}) = 1$$

But to calculate the frequency of usage could confirm the design of the originating reference model. The unmodified individual solutions could be cited as evidence for the proposed reference solution. In this way the recommendation of the reference model will be strengthened. Beyond that an unchanged model content along with a changed context description could indicate an extended scope of the reference model.

$$sim^{ModCnt}(m_{reference}, m_{individual}){=}1 \wedge$$

$$sim^{ModCtxt}(m_{reference}, m_{individual}) = (0; 1)$$

5.2 Improving Proposed Solution

The evaluation of competing problem solutions for the same context description raises the issue of best goal attainment and the detection of best solutions.

$$sim^{ModCnt}(m_{reference}, m_{individual}){=}(0;1) \wedge$$

$$sim^{ModCtxt}(m_{reference}, m_{individual}) = 1$$

An adequate decision support has to consider the justification for the reference model design ($ModJstf_{reference}$) along with the justification for the individual information model modification ($ModJstf_{individual}$) as well as captured performance indicators ($ModAppl_{individual}$). A changed model content could indicate a innovative solution, if the alternative problem solution has a better goal attainment than the originating solution proposed by the reference model. The maintainer of the reference model has to assess whether the novel solution is generalizable. This depends on the impact and the scope of the innovative solution. As a consequence the content and the justification of the reference model could evolve.

5.3 Elaborating the Reference Model

The analysis of deviating model contents and co-existing deviations of model contexts is most unbiased as to the result.

$$sim^{ModCnt}(m_{reference}, m_{individual}){=}(0;1) \wedge$$

$$sim^{ModCtxt}(m_{reference}, m_{individual}) = (0; 1)$$

Basically the modifications have to be evaluated regarding their relevance for potential reuse and the method of knowledge transfer (*design for reuse*).

Reasons for a changed or new context description of the individual information model could be changed or disregarded environmental influencing factors or misinterpretations of the reference model. If the analysis of context comparison reveals that the context of the individual information model is outside the scope of the reference model, the construction of a new reference model could be advisable.

Model changes affecting the scope of the reference model have to be assessed regarding their relevance for reuse. Often a refinement of context description concludes in a refinement of problem solution. If this refinement is significant to a critical mass of potential reference model users, a permanent alternative design could be included within the reference model. Specific reference modeling languages could label alternative model solutions to corresponding context factors.

Referring to our example, figure 5 depicts the subsequent *design for reuse* process. The change of model content in figure 4 was appraised as irrelevant for reference modeling due to insufficient generalizability. But the awareness of process costs are added to the sensor concepts in order to enable a systematic analysis of the conflicting goals within the following evolution cycle. Beyond the enhancement of the reference model context, its content is significantly modified due to one single experience. The adverse legal effects are appraised as significant relevant for the whole company, so that an evolution of the reference model has been entailed.

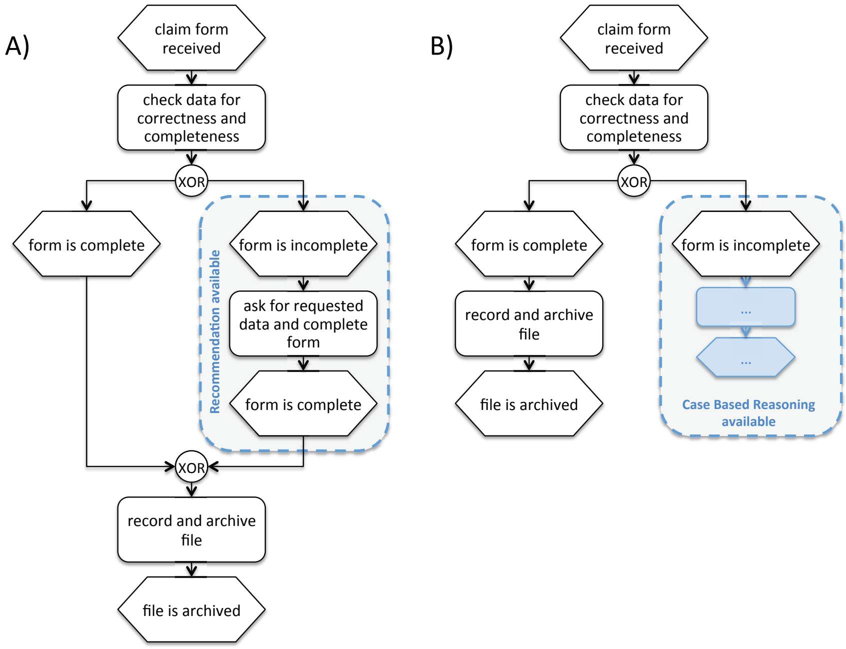


Fig. 6. Alternative Reference Model Designs Depending on Analysis Results

If the analyzed model changes affect the scope of the reference model but do not reach a critical mass of potential reuse situations, their integration as fix reference model structures is not indicated. There are two options for handling relevant model changes. First, the originating or most frequent used option is incorporated within the reference model. But the reference model user will be informed about the existence of alternative solutions (see figure 6 A). They could be provided on request. Second, the deviation of model contents and corresponding contexts are too complex for generalizing a feasible or best solution. In this case the reference model should propose the creation of individual solutions such as by case based reasoning approaches (see figure 6 B).

6 Conclusion

Reference models are accepted means for various modeling tasks within information system management in various industries. Their specific characteristic to abstract from individual problem situations and to generalize reusable design solutions requires specific approaches for construction and maintenance. In this paper we have presented a general framework for comparing the content and the corresponding context of individual information models to initially construct and to evolve reference models systematically. We emphasized the importance of monitoring the utilization of the reference model and the related individual information model for detecting potential for improvement.

Further research will investigate typical use cases for evolutionary reference modeling related to specific tasks within information system management or specific industries. For the defined use cases general requirements on modeling techniques and analysis algorithms will be derived. Our work provides a theoretical cornerstone upon which different scenarios for the confirmation and/or objection of proposed reference model statements could be derived for the targeted use case descriptions. The primary target would be the development of workable modeling techniques and operations to support partial aspects of the presented framework.

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11 Klassifikation von Referenzmodellen: [EL12]

Tabelle 10: Beitrag der Koautoren zum Artikel [EL12]

Titel	Maturity Model for Reference Modeling		
Autor(en)	Werner Esswein, Sina Lehrmann		
Publikation in	Proceedings of the IADIS Multi Conference on Computer Science and Information Systems, 2012.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	20%
		Sina Lehrmann	80%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	80%
	Argumentative Analyse	Werner Esswein	10%
		Sina Lehrmann	90%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	90%
	Kritische Prüfung des Manuskripts	Werner Esswein	40%
		Sina Lehrmann	60%

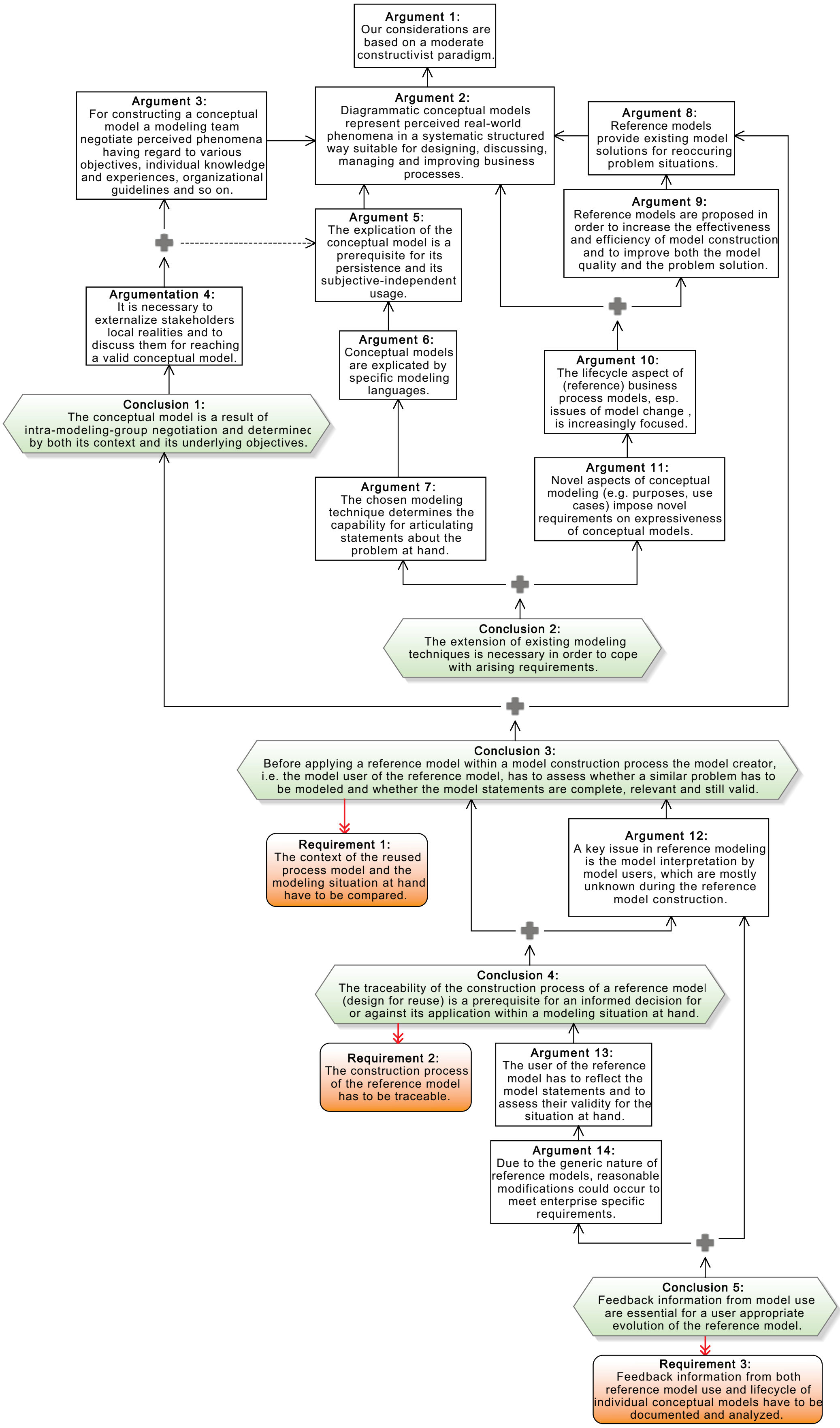
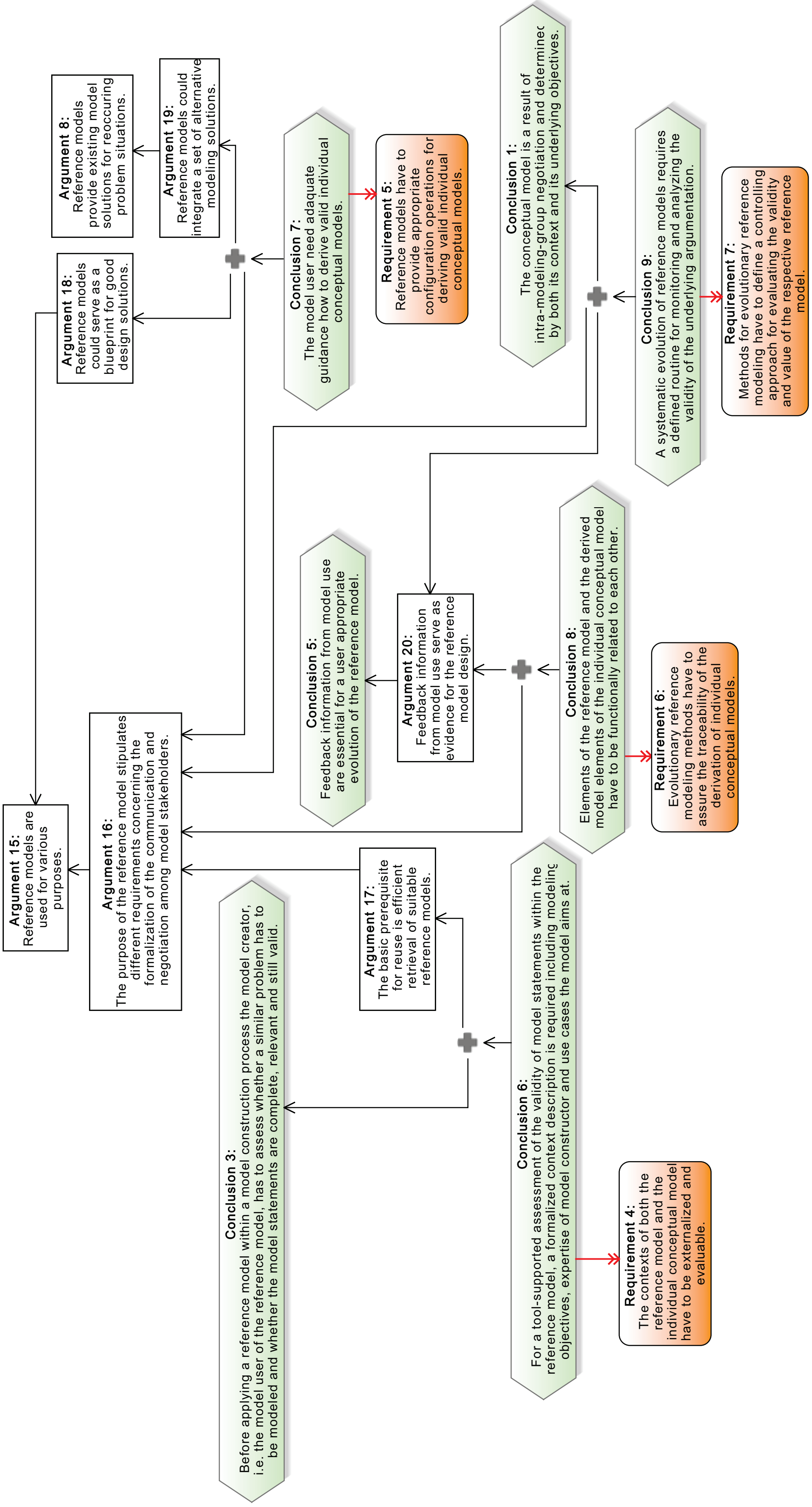


Abbildung 20: Argumentationsmodell 1 für Publikation [EL12]



Argument 8:
Reference models provide existing model solutions for reoccuring problem situations.

Argument 19:
Reference models could integrate a set of alternative modeling solutions.

Argument 18:
Reference models could serve as a blueprint for good design solutions.

Conclusion 7:
The model user need adaquate guidance how to derive valid individual conceptual models.

Requirement 5:
Reference models have to provide appropriate configuration operations for deriving valid individual conceptual models.

Conclusion 1:
The conceptual model is a result of intra-modeling-group negotiation and determine by both its context and its underlying objectives.

Conclusion 9:
A systematic evolution of reference models requires a defined routine for monitoring and analyzing the validity of the underlying argumentation.

Requirement 7:
Methods for evolutionary reference modeling have to define a controlling approach for evaluating the validity and value of the respective reference model.

Argument 15:
Reference models are used for various purposes.

Argument 16:
The purpose of the reference model stipulates different requirements concerning the formalization of the communication and negotiation among model stakeholders.

Conclusion 5:
Feedback information from model use are essential for a user appropriate evolution of the reference model.

Argument 20:
Feedback information from model use serve as evidence for the reference model design.

Conclusion 8:
Elements of the reference model and the derived model elements of the individual conceptual model have to be functionally related to each other.

Requirement 6:
Evolutionary reference modeling methods have to assure the traceability of the derivation of individual conceptual models.

Argument 17:
The basic prerequisite for reuse is efficient retrieval of suitable reference models.

Conclusion 3:
Before applying a reference model within a model construction process the model creator, i.e. the model user of the reference model, has to assess whether a similar problem has to be modeled and whether the model statements are complete, relevant and still valid.

Conclusion 6:
For a tool-supported assessment of the validity of model statements within the reference model, a formalized context description is required including modelin objectives, expertise of model constructor and use cases the model aims at.

Requirement 4:
The contexts of both the reference model and the individual conceptual model have to be externalized and evaluable.

Abbildung 21: Argumentationsmodell 2 für Publikation [EL12]

12 Erfahrungsbasierte Evolution von Referenzmodellen: [ELS10b]

Tabelle 11: Beitrag der Koautoren zum Artikel [ELS10b]

Titel	Kontinuierliche Referenzmodellverwaltung für die Maschinensimulation		
Autor(en)	Werner Esswein, Sina Lehrmann, Jeannette Stark		
Publikation in	THOMAS,O; NÜTTGENS, M. (Hrsg.): DLM-2010: Diskussionsbeiträge des 2. Workshops Dienstleistungsmodellierung, CEUR Workshop Proceedings, S. 44–64, 2010.		
Beitrag der Autoren	Forschungskonzeption	Werner Esswein	20%
		Sina Lehrmann	70%
		Jeannette Stark	10%
	Identifikation der Theorien	Werner Esswein	20%
		Sina Lehrmann	70%
		Jeannette Stark	10%
	Argumentative Analyse	Werner Esswein	10%
		Sina Lehrmann	80%
		Jeannette Stark	10%
	Formulierung des Manuskripts	Werner Esswein	10%
		Sina Lehrmann	80%
		Jeannette Stark	10%
	Kritische Prüfung des Manuskripts	Werner Esswein	40%
		Sina Lehrmann	40%
		Jeannette Stark	20%

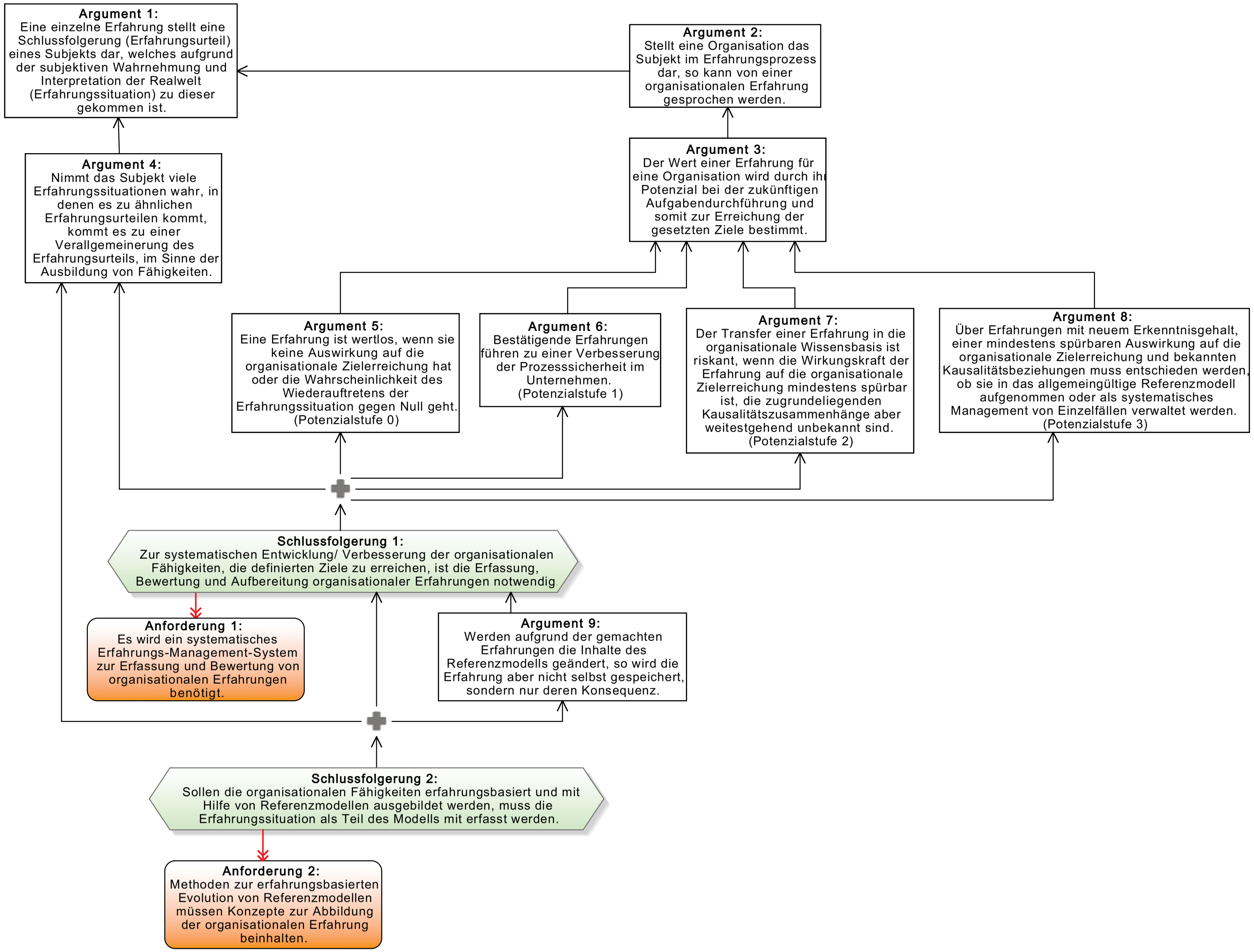


Abbildung 22: Argumentationsmodell 1 für Publikation [ELS10b]

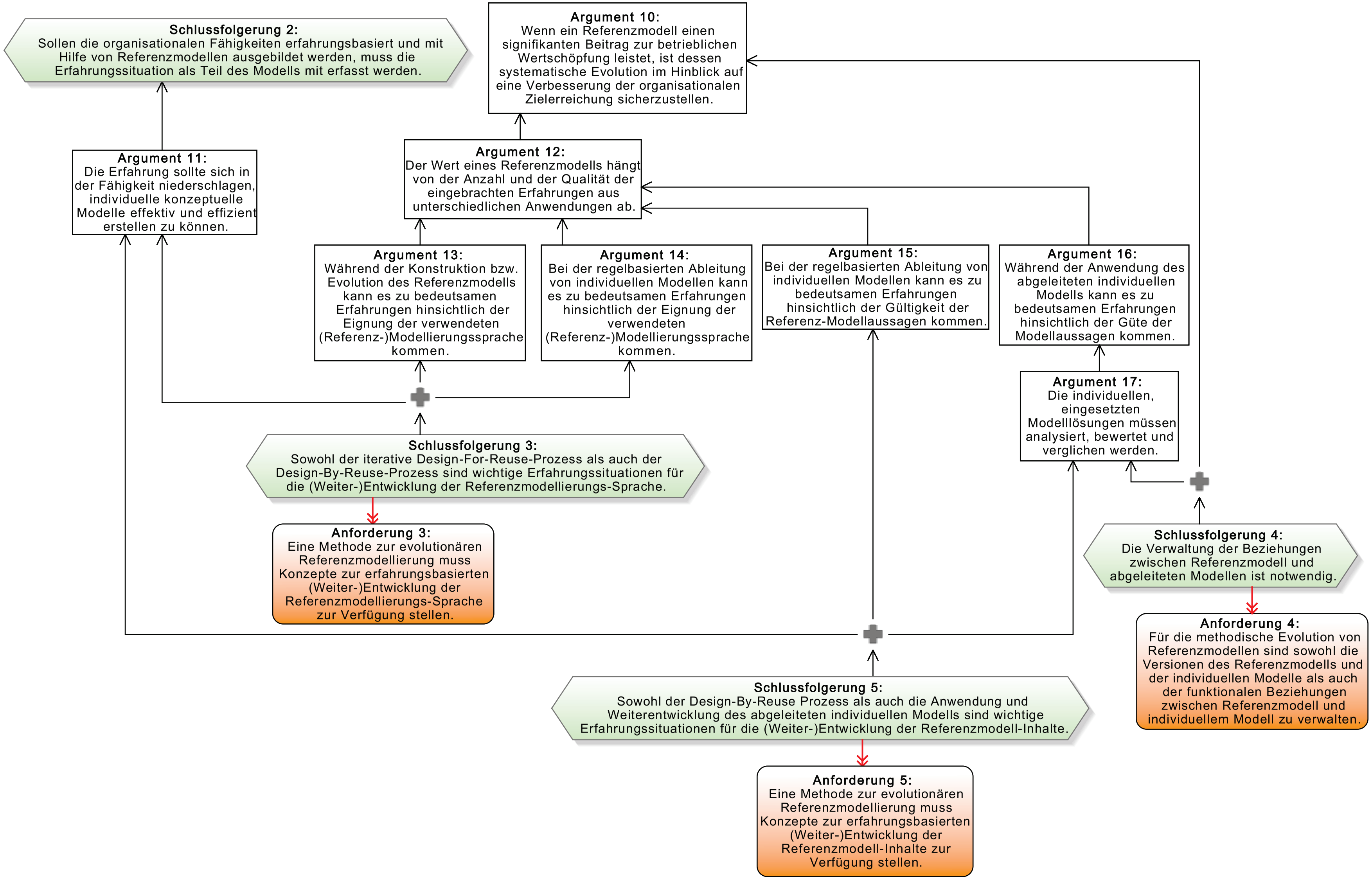


Abbildung 23: Argumentationsmodell 2 für Publikation [ELS10b]

13 Statische und Dynamische Aspekte der Referenzmodellevolution: [Leh13b]

Tabelle 12: Beitrag der Koautoren zum Artikel [Leh13b]

Titel	Evolutionary Reference Models		
Autor(en)	Sina Lehrmann		
Publikation in	Unveröffentlicht, 2013.		
Beitrag der Autoren	Forschungskonzeption	Sina Lehrmann	100%
	Identifikation der Theorien	Sina Lehrmann	100%
	Argumentative Analyse	Sina Lehrmann	100%
	Formulierung des Manuskripts	Sina Lehrmann	100%
	Kritische Prüfung des Manuskripts	Sina Lehrmann	100%

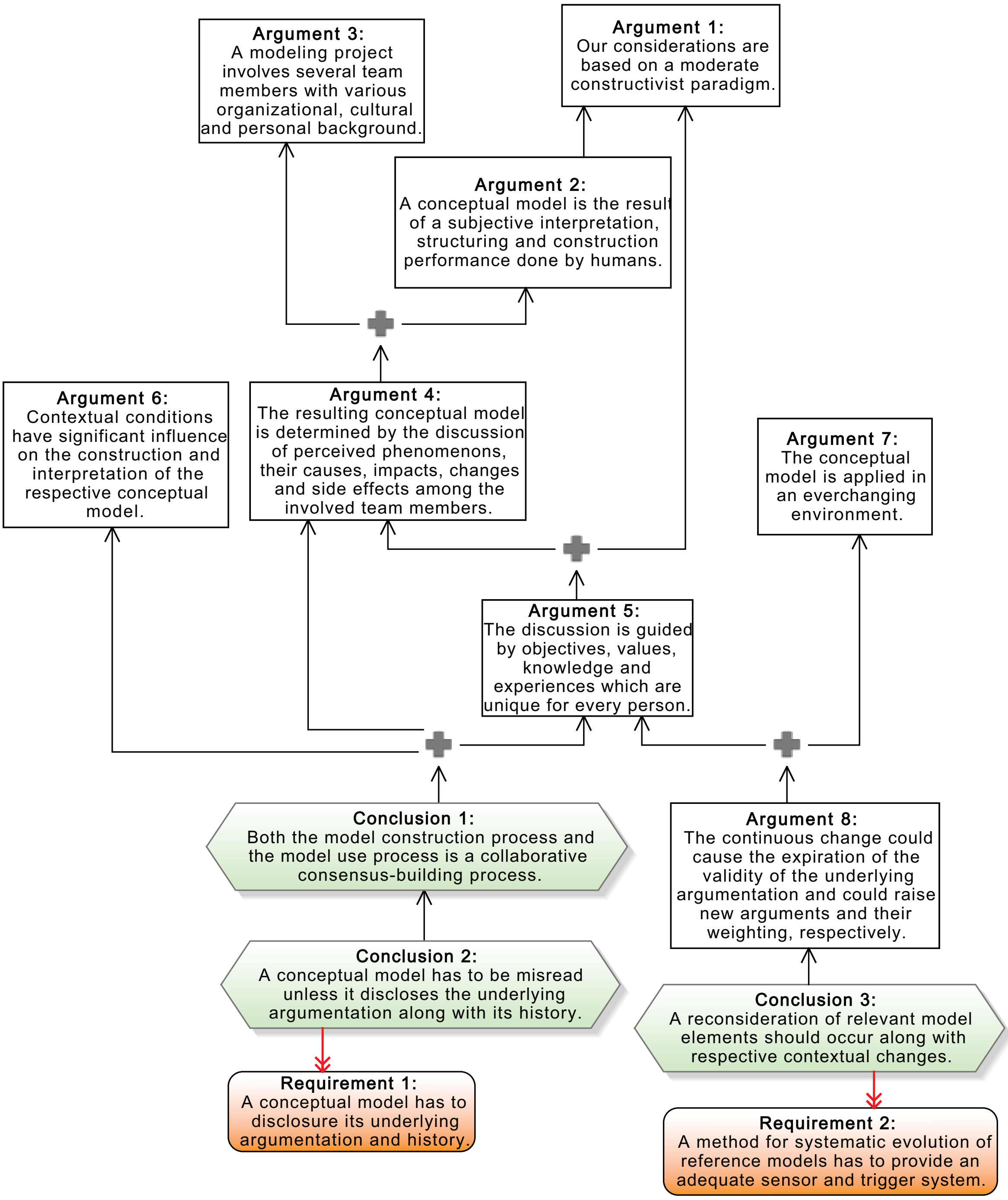


Abbildung 24: Argumentationsmodell 1 für Publikation [Leh13b]

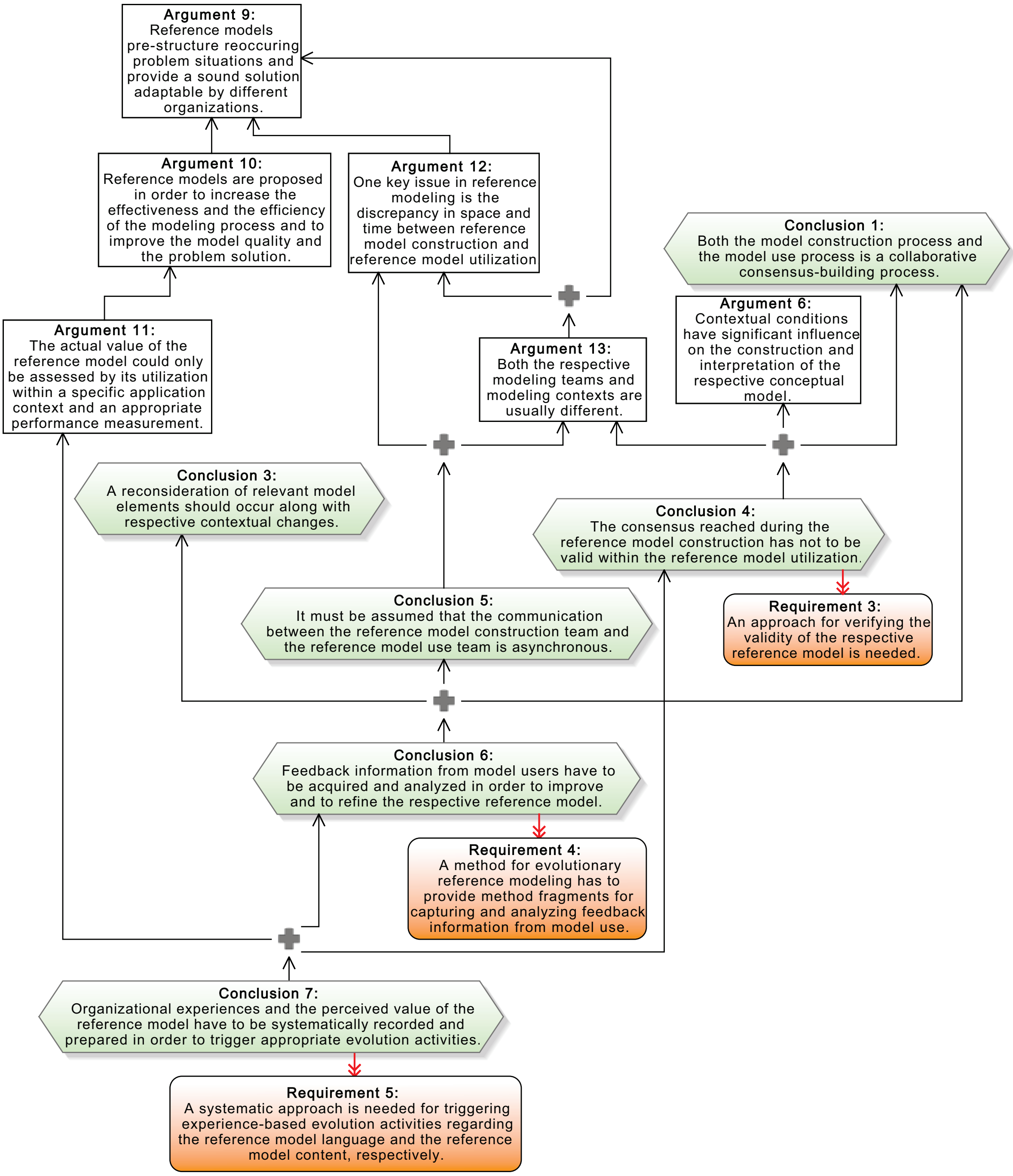


Abbildung 25: Argumentationsmodell 2 für Publikation [Leh13b]

Evolutionary Reference Models

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1 Introduction

Conceptual information models have been always powerful means for the development of information systems. Beside their dominant role within software engineering, they are increasingly used for designing and improving organizational structures (c.f. [DGR$^+$06]; [Fet09]). Especially business process management and improvement are key use cases for the application of the various modeling methods like the Unified Modeling Language (UML) or the Event-driven Process Chains (EPC). But the potential of reference modeling (c.f. [vBT06]) is almost neglected so far. Although a collaborative modeling process and an exchange of existing conceptual models are sought by cooperative partners within a network, like different branches of a company or partners within a supply chain, these endeavors are almost executed on a bottom-up way (for an example within German statutory health insurance see [San11]). The participating partners exchange and adapt their individual conceptual models regardless whether the model design results from specific local conditions or from strategic decisions relevant for the success of the network. In most of the cases a strategic evaluation of these models or a centrally designed solution does not occur. We argue that evolutionary reference modeling could support the strategic alignment of different partners within a network while considering specific local conditions and profiting from collaborative improvement activities.

The contribution of the paper consists in a framework for an evolutionary reference modeling approach by revealing crucial dependency relationships between design-for-reuse and design-by-reuse activities. Beyond that, we provide an approach for evaluating organizational experiences and including them into the reference model evolution. Basing on these theoretical reflections existing conceptual modeling methods could be enhanced by specific method fragments for evolutionary reference modeling. Evolutionary reference modeling should become thereby a management instrument for strategic alignment of individual partners within a defined network and collaborative improvement of their organizational structures.

The structure of the paper is as follows. In section 2 we define our research problem by a motivating example within the scope of goal-directed business process design. In section

3 we discuss related work on conceptual (reference) modeling in business engineering and design rationale approaches in other research disciplines. On the basis of this theoretical background we introduce a framework for an evolutionary reference modeling approach in section 4. Subsequently we demonstrate the application of the presented framework by resumption of the introductory example in section 5. Finally, in section 6 we summarize the paper and outline where we see fruitful research directions.

2 A Motivating Example

Headquarters of an insurance company pursue the goal of business process standardization in order to align service provision of the various branches to the overall strategic objectives and planning. The standard practice for describing the prescribed business process is the application of process models like depicted in figure 1 (based on [San11]). Figure 1 represents two alternative procedures to deal with incomplete forms. Alternative A prescribes the rejection of the submitted form whereas alternative B recommends the completion of the form by responsible clerk.

The prescribed standard process mostly has to be adapted to individual conditions caused by local circumstances. This general and adaptable process model valid for all relevant branches acts as a reference model. Regular internal audits should assure the conformance of the individual business processes to the standard process and should reveal best and worst practices.

Conventional modeling methods like the event-driven process chain (EPC) do not provide any further information regarding the argumentation underlying the depicted process design. This lack of information causes several obstacles to both model use and model evolution.

One key issue for user of the reference model is the inability to identify model fragments bearing high reference to the strategic planning of the company and to distinguish them from insignificant, not specific deliberately designed parts. Under these conditions the acceptance of the reference model could suffer due to the flawed and unconvincing reasoning for the validity of model statements. Referring to the example of figure 1, the model reader is unable to decide which process alternative is more valuable for the situation at hand. The decision has to rely on subjective preferences, objectives, experiences and so on. Beyond the issue of acceptance, the lack of rationale for model design could cause the violation of constraints and interdependencies. In this case the identification of causes for undesirable effects during the model application seems to be almost impossible.

The lack of rationale information regarding the model use obstacles the evolution of the reference model in turn. The evaluation of model changes on individual level is not able to identify process changes caused by local circumstances and being irrelevant for strategic goal attainment. Referring to our example, the process alternative A does not reveal that the divergence to process alternative B is accounted for by shortage of qualified staff.

This simple example of reference modeling in business process design demonstrates the importance of context information for a meaningful construction, application and evolu-

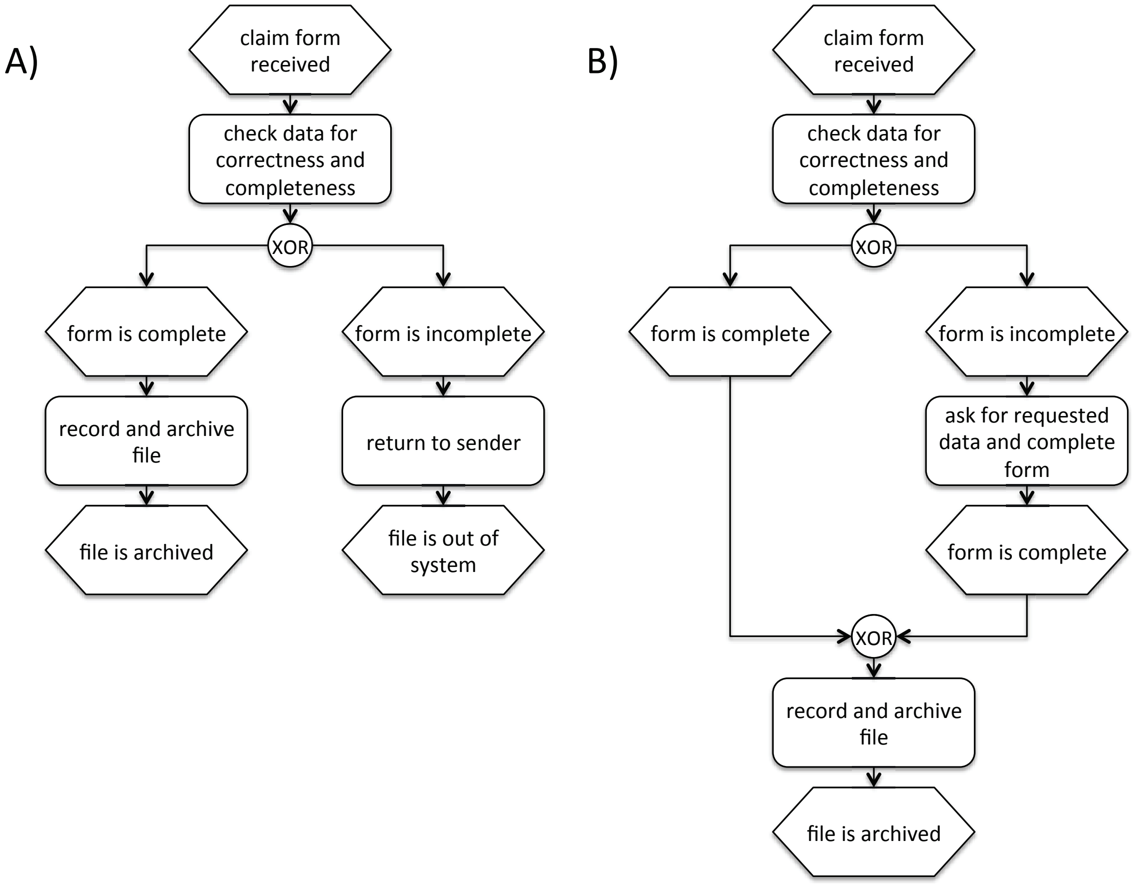

Figure 1: Alternative business process designs for handling incomplete claim forms (based on [San11])

tion of reference models. Our further reflections base on the key assumption that a conceptual model, regardless whether it acts as a reference model or not, has to be misread unless it discloses the underlying argumentation along with its history. Since the reader of the reference model does not have a chance to communicate with the model constructor directly, these information have to be captured and formalized during the reference model construction.

Even if the presented example is fictional, but it bases on common real problem situations. The issue of completing or rejecting incomplete forms is well known in public administration. During our project work we have even observed both solutions within one organization depending on the type of case.

The research goal of our paper is the identification of key concepts of decision processes within the lifecycle of reference models and their interdependencies. The development of a reliable theory integrating existing research regarding the constructivist modeling paradigm and reference modeling facilitates the targeted development of corresponding method fragments. On this account the next section summarizes existing relevant research.

3 Theoretical Background on Reference Modeling

Our research bases on the constructivist understanding of conceptual modeling where conceptual models are considered as the result of a subjective interpretation, structuring and construction performance done by humans (c.f. [SR98]; [Wol01]; [Tho06]; [Ahl09]). A modeling team perceives a problem in a real business situation. The team members discuss its causes, impacts, possible solutions and side effects. This discussion is guided among others by objectives, values, knowledge and experiences of every team-member. Potential alliances between participating parties could give prominence to a certain idea (see [RS05]). The resulting solution is documented by the conceptual model.

Since decades, exponents of the strong constructivism in conceptual modeling object to the understanding of a conceptual model as a single artifact and claim for the integration of information regarding the context, modeling objectives, interpretation rules and so on (c.f. [Wol01]; [Ham99]). Even moderate scientists in conceptual modeling emphasize the important impact of contextual conditions on the application of modeling methods and the resulting conceptual modeling script (c.f. [WW02], [RRF08]). These theoretical reflections are increasingly considered for the development of powerful modeling techniques. For example, the integration of pursued objectives as justification for the choice of model alternatives has already gained attention within academia (c.f.[KK97]; [YM96]; [Yu09]). But no coherent and profound framework exists suited for classifying existing approaches and for revealing need for research.

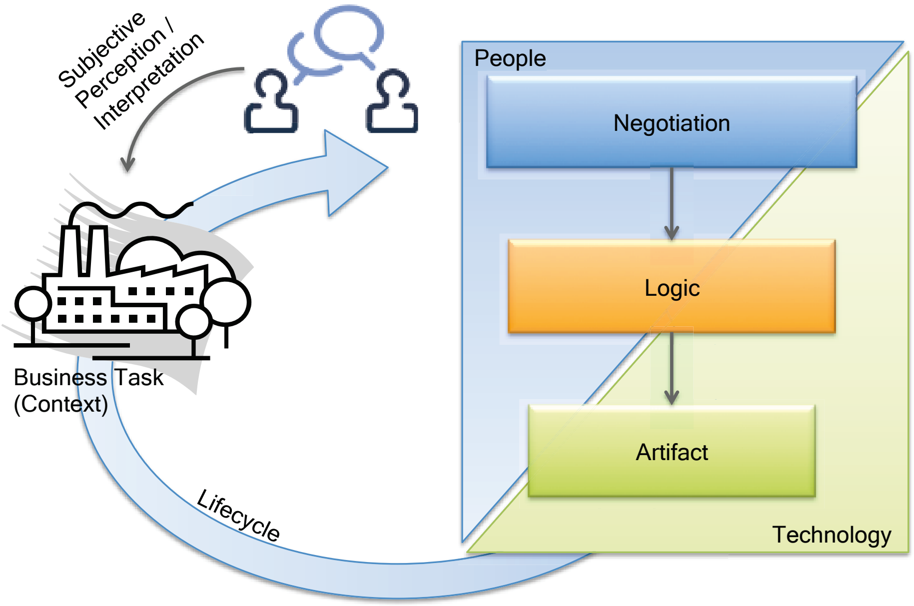

Figure 2: Negotiation aspect of conceptual modeling

In figure 2 we depict consequences for a continuous evolution of conceptual models derived from the constructivist modeling paradigm. Two main aspects have been identified, the *collaborative consensus-building* and the *continuous change of environment*. The aspect of collaborative consensus-building has been structured into three levels characterized among others by the participation of human action. The argumentative negotiation for sound model solutions (*Negotiation*) provides the basis for the logic conclusion of model statements (*Logic*). This model content is explicated by means of specific modeling languages and could be archived as an artifact (*Artifact*). The upper level *negotiation* represents human-related communication issues which are hardly to control or to evaluate by formal approaches. Whereas the lower level *artifact* represents technology-related issues which are assessable and controllable by formal approaches. Regarding conceptual modeling on this level often methods for assuring syntactic and semantic quality are discussed (e.g. [FTH12], [Höf07]). The level midway between negotiation and artifact, the logic-level, is characterized by both individual culture, knowledge, objectives etc. (people-centered issues) and objectively measurable and controllable decisions. Regarding the logic-level often methods for providing visualizations of argumentation and decision support systems are discussed (e.g. [KSC03], [DMMP06]).

The continuous change of environment could cause the expiration of the validity of the underlying argumentation and could raise new arguments and their weighting, respectively. Thus, a reconsideration of relevant model elements should occur along with respective contextual changes.

In the last decades reference models as reusable conceptual models got increased attention within academia.[1] They are proposed in order to increase the effectiveness and efficiency of the modeling process and to improve both the model quality and the problem solution by pre-structuring reoccurring problem situations and providing a sound solution adaptable by different organizations (c.f. [vBB06]). Thus, we define the term reference model in the sense of the constructivist understanding of conceptual modeling (c.f. [SR98], [Ham99], [Wol01]). As a specific conceptual model, reference models are deliberately designed for reuse and has been already reused for specific modeling purposes (c.f. [vB03], [Bra07], [Tho06]).

Definition 1. *An reference model is a specific conceptual model deliberately designed for reuse and already reused for a specific modeling purpose.*

One determining factor for the development of reference modeling methods is the specific communication situation which is depicted in figure 3. Seizing the idea of collaborative consensus-building and environmental change, the sender-receiver-model (c.f. [SW98]) has been enhanced by the negotiation aspect (see ②) and the respective context (see ④). One key issue in reference modeling is the discrepancy in space and time between reference model construction and reference model utilization. Thus, the modeling teams and the modeling contexts are usually different. This raises the following issues:

① **Sender-Receiver-Situation:** Due to the asynchronous communication within reference modeling the reference model constructor team and the reference model user

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[1] Within academia the body of literature is constantly growing on adaptation techniques (e.g. [BDK07]; [vB07]), suitable extensions of modeling grammars (e.g. [BDK04]; [RvdA07]) and the necessity for configuration management (e.g. [BEGW07]; [Tho08]).

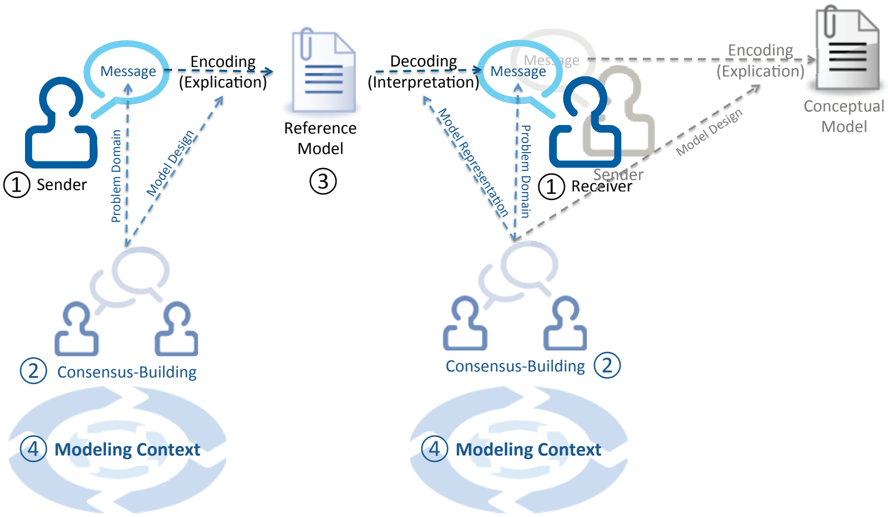

Figure 3: Communication within Reference Modeling

team usually do not know each other. The attitude like the “not invented here - syndrome” could become a critical success factor (c.f. [Fra07]). Thus, reference modeling includes issues of trust.

② **Collaborative Consensus-Building:** Assuming a constructivist paradigm, the reference model results from a consensus among the involved team members. This consensus has been reached by discussing and weighting individual arguments, experiences and objectives. It has to be considered that the authority of the respective person within the modeling team has a significant influence on the weight of his arguments. However, since the modeling team for constructing the reference model and the modeling team for constructing the individual conceptual model are different, the consensus reached during the reference model construction has not to be valid within the reference model utilization.[2] Thus, reference modeling includes issues of consensus-building.

③ **Reference Model:** As the reference model is the used means of communication, it could be regarded as a linguistic artifact. Thus, reference modeling includes issues of establishing a language community.

④ **Modeling Context:** Regarding the modeling context two aspects have to be considered. First, similar to the distinctness of the respective modeling teams, the respective modeling contexts differ. Second, ongoing changes in environmental and organizational conditions could cause the invalidity of the initial argumentation for the reference model.[3] Thus, reference modeling includes issues of validity.

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[2] Since the 1970th the development of methods for supporting and documenting the decision making in information system design are present part of research (e.g. [KR70]; [MYBM96]; [LL00]). Especially the issue of communication between developer and user is addressed by [RRLT04].

[3] The lifecycle aspect of reference models is increasingly focused within academia. Approaches for modifying conceptual information models within construction phase (c.f. [DRvdAS08]), evolving or (re-) designing reference models by analyzing existing conceptual information models (c.f. [LRW11]) or modifying existing

We conclude that a face-to-face communication between model constructor and model user could not be presupposed within reference modeling. Since the involvement of the model user in the model construction is required (c.f. [Sch98]), feedback information from model users have to be acquired in order to improve and to refine the respective reference model. In section 4 we will outline types of feedback information relevant for the systematic evolution of reference models. As a consequence, we define the systematic evolution of reference models as a critical quality criterion.

Definition 2. *An evolutionary reference model is a reference model developed and enhanced in an evolutionary process by analyzing feedback information from model use.*

4 Evidence-Based Evolution of Reference Model

On the theoretical reflections of the previous section several requirements for reference modeling methods could be derived. Due to the ongoing change of environment and the claimed validity of reference models for a fair quantity of cases of application a systematic and methodical supported evolution of the reference model is required. The constructivist understanding of conceptual modeling claims in turn the explication of the construction and use context including the underlying assumptions and objectives of both the reference model constructor and the reference model user. The utilization of the reference model for the construction of conceptual models for a specific situation at hand evaluates its usefulness and the validity of model statements. Due to the character of a reference model a synchronous communication between reference model constructor and reference model user is almost inoperable. Therefore the explication of the negotiation between the involved model constructors and the logical structure underlying the final model design has to be documented by means of customized methods. In addition, the negotiation between the model users and their reasons for modifications have to be captured and traced back to the respective model statements within the origin reference model. Only a well-functioning asynchronous communication between the model stakeholders involved could facilitate an evolutionary development of valid and valuable reference models.

4.1 Determining Factors of Evolutionary Reference Models

Figure 4 depicts the lifecycle phases of a reference model (construction, utilization and evolution) and their relationships with the respective reference model and its modification. We skipped the evaluation phase (as presented by [Bra07]) on the ground that evaluation activities are part of the evolution phase.

Due to the sequence of events the initial construction of a reference model is characterized by decisions under uncertainty. The model constructor predicts future developments and assumes effects caused by activities depicted within the reference model. For assessing the

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conceptual information models due to changes of business objectives (c.f. [NCMR06]) gain increasingly attention.

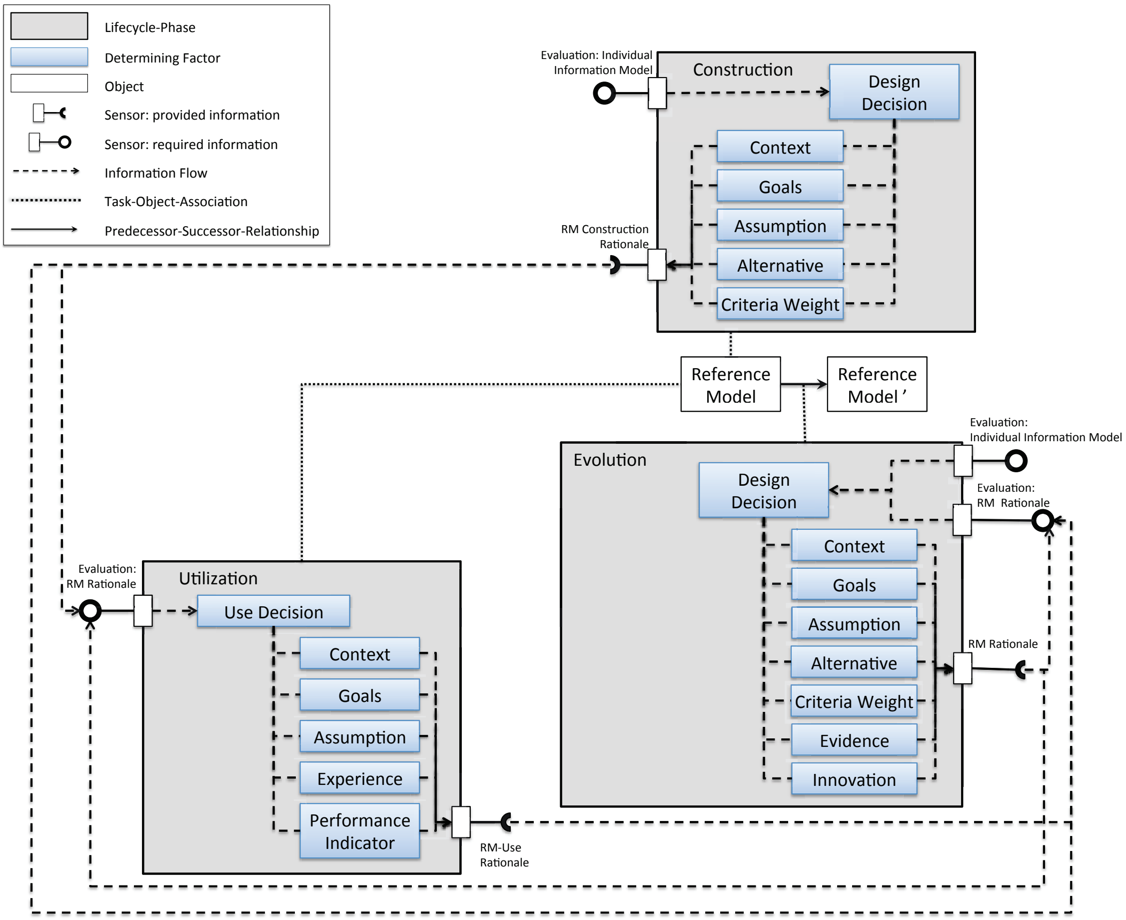

Figure 4: Negotiation-based framework for evolutionary reference modeling

validity and the value of the reference model, the model user has to consider the context of model construction (like responsible institution, legal or corporate liability of depicted solution, etc.), the objectives of reference modeling and diffusion of the depicted solution and the validity of assumptions dominating the underlying consensus-building process (i.e. the negotiation among model stakeholders). This information has to be documented and systematically monitored in order to evaluate the validity and usefulness of the corresponding reference model. These information are provided by the reference model constructor as reference model rationale and are used for evaluation purposes by the reference model user and the reference model maintainer, respectively.

The model user in turn applies the reference model for the specific situation at hand. The adaptation of the model content is determined by individual objectives, assumptions and local conditions. The adaptation of the reference model and the utilization of the derived individual conceptual model constitute the experiential context for the reference model evaluation. For a systematic evolution of reference models it is essential to capture experiential counterparts of the assumptions made within the construction process. To meet this essential requirement for a methodical lifecycle support we defined the sensor concepts. A sensor concept has to mark assumptions crucial for the validity of the modeling argumentation and to monitor relevant experiential values.

The transition between a reference model and its successor (Reference Model and Reference Model' in figure 4) is executed by evolutionary activities. The design decisions are supported by analyzed sensor data originating from reference model construction, its utilization or former evolution cycles. These sensor data are provided by the preceding modeling activities and could be compared to actual conditions. The evaluation results and a related relevance appraisal could provide evidence for retained and innovative solutions, respectively. In this context evidences consist of original assumptions and related experiences.

The utilization of experiences and dynamic aspects of the presented framework are described in the following subsections and illustrated by continuing the introductory example in section 5.

4.2 Experience Utilization

We define three experience-related scenarios relevant for the evolution of reference models. First, the construction, the utilization and the evolution of the reference model could reveal defects or shortcomings of the applied modeling language. Second, experiences from the utilization of the reference model within a certain context or from the analysis of changed individual models could indicate the need for an evolution of the reference model content. Thirdly, experiences gained by utilizing the derived individual model could cause the modification of the individual model, e.g. due to a changed environment. Dependent on an in-depth evaluation of the respective experiences a modification of the reference object (individual model, reference model or reference modeling language) could be required.

In order to evaluate the captured experiences we defined a class-divided weighting applicable to any kind of experiences. On the basis of a philosophical discourse on human experience (c.f. [Ham97]) we defined the key criteria *Novelty*, *Impact* and *Probability of Recurrence* graduated by their relevance for maintaining the (reference) model (see figure 5).

According to the underlying constructivist understanding we define a single experience as a conclusion, which is drawn by an individual subject due to its own perceptions and interpretations of the real world (experience situation) (cf. [Ham97]). The experience of similar experience situations leads to a generalization of the experiential judgment (general validity).

Beyond human experiences, organizations also have the capability to gather experiences. The organization represents the subject within the experiential process and the gained experiences are called organizational experiences. In this context an organization is defined as a system with a clear boundary to its environment, a strategic focus and a governed division of business (cf. [Sch08]).

The key issue within experience-based evolution is the appraisal of captured organizational experiences. The value for the respective organization depends on the potential for future

	I	II	III
Novelty	Known	Expected	Contradicts to Expectations
Impact	Negligible	Noticeable	Critical
Probability of Recurrence	Unimaginable	Conceivable	Certainty

■ Potential Level 1

▨ Potential Level 2

□ Potential Level 3

Figure 5: Potential level of experiences

successful task performance. For this purpose we defined three potential levels dependent on the evaluation results in terms of the defined criteria novelty, impact and probability of recurrence (see figure 5).

Potential Level 1 Experiences without any impact on the organizational target achievement or of assumed impossible occurrence should be disregarded. The recording of this kind of experiences would not only involve additional costs but would cause an information overload. This could form an obstacle to evolving the respective reference model in an efficient and effective way.

Potential Level 2 Experiences of level 2 require further investigations regarding the causality and the scope. Dependent on the evaluation results a demand for an evolution cycle could arise.

Records of specific experiences could be used as quality indicators for a reference model if they confirm the assumptions and expectations involved in the reference model utilization. Therefor confirming expectations should be captured carefully and used for weighting alternatives during the construction or evolution of reference models.

Experiences with at least noticeable impact have to be assessed regarding their probability of recurrence. In order to be able to estimate the probability of recurrence, the causality of the experience has to be assured. Otherwise a generalization of the experiential judgment and its transfer into the reference model would be risky.

Potential Level 3 The most valuable experiences for reference model evolution are those who contradict to the underlying assumptions and expectations. They will trigger evolution activities, if they are critical to successful task performance and if their probability of recurrence is certain. Beyond that, the knowledge about the causality of the experience is crucial.

We emphasize the fact that the modification of the reference model, resulted from an analysis of captured experiences, is only the consequence of the respective experiences. Usually the causal experience itself is not documented within the reference model (due to missing modeling concepts defined by the underlying modeling language). But it is crucial for reference model evolution being traceable.

4.3 How to Trigger a Reference Model Evolution?

Figure 6 depicts a statechart diagram of evolutionary reference modeling. The definition of the states and the transitions reflect both the negotiation aspect of conceptual modeling (see figure 2) and the theoretical framework for evolutionary reference model (see figure 4). The first state of evolutionary reference modeling is the initial *construction*. In order to define and to guide the required construction task the starting problem situation, the objectives and the requirements have to be defined. Subsequently the conventional modeling tasks are fulfilled including the discussion of alternative solutions, the design for reuse and the documentation of the underlying argumentation. These tasks are already considered in existing life cycles for reference models (e.g. [Sch98], p. 184ff.; [RS07]). We extend this definition of construction-tasks by activities for supporting a systematic evaluation and evolution of the respective reference model. Capturing the construction context and defining context parameters should support the selection and evaluation of the reference model for a specific problem situation at hand (support for reference model use). The definition of relevant sensor concepts and the implementation of an aligned trigger system should enable both the monitoring of the validity of the respective argumentation for crucial design decisions and the initiation of evolution-tasks.

After the final reference model is published, it is available for use. The *utilization* of the reference model comprises two aspects. First, the utilization of the reference model for constructing an individual conceptual model. Second, the utilization of the derived individual conceptual model within a specific problem situation. The first step in utilizing a reference model is to define the specific problem situation at hand, the objectives and the respective requirements. On this basis the validity of the reference model and the quality of the proposed solution are evaluated (e.g. by criteria as suggested by [Fra07]). If a reference model is selected, the configuration instructions are carried out in order to derive a valid individual conceptual model. As we assume a constructivist understanding of conceptual modeling, a consensus about the modeling options has to be reached among the model stakeholders. In order to support the interpretation of the individual conceptual model, the argumentation for the final model design has to be captured. Beyond the support for future model user, the backward communication with the constructor of the reference model should be supported in order to enable a systematic evolution. Therefor relevant experiences with the handling of the reference model are captured.

If a valid individual conceptual model has been derived, it is used within a specific application context. The experiences gained by the use of the individual conceptual model (esp. performance indicators) represent the actual value of the solutions depicted by the reference model. Therefore the documentation of relevant experiences and the justification for model modifications are of considerable value for the systematic evolution of the

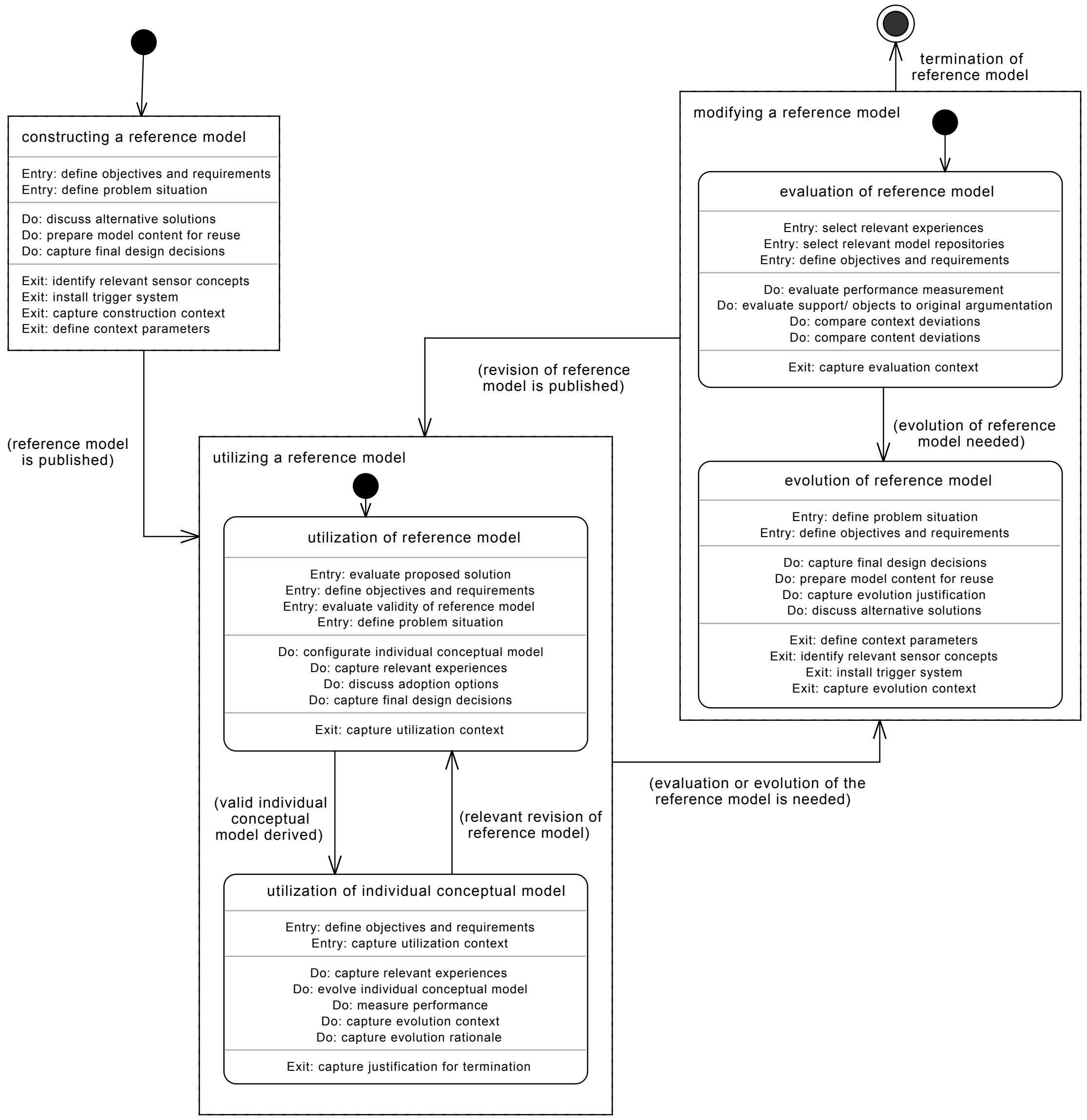

Figure 6: Statechart for Reference Model Evolution

respective reference model. The sensor concepts defined within the construction phase could guide the documentation of required use information.

The installed trigger system in turn could cause a state transition from utilizing a reference model to *modifying* a reference model. This state transition could occur because of an audit schedule or relevant experiences have been exceed a stimulus threshold. Regarding the explanations in section 4.2 these experiences could concern either the reference modeling language or the reference model content. Their relevance could be evaluated regarding their potential level. Level 1 is irrelevant for the reference model evolution. Level 2 needs additional evaluation like the frequency of occurrence or a manual weighting. And level 3, however, is relevant in any case and should be considered for reference model evolution.

Starting point for any evolution activities is the evaluation of the respective reference model regarding its validity and its actual value. For this purpose the underlying argumentation, indicator values, model use experiences and related individual information models are indispensable input. In this regard model use experiences comprise all kind of experiences related to the use of the reference model or the use of referenced individual information model. These experiences and the performance indicators serve as empirical evidence within an assessment of reference model value.

The comparison of the construction context and the use contexts, respectively, along with the comparison of the model contents form a strong basis for evaluating the validity and value of the reference model and for revealing needs for improvement. The repository of individual conceptual models and their performance indicators delivers all relevant information needed for a useful analysis for gaining innovative solution alternatives. For this reason it is essential that these individual information models provide the above mentioned rationale information as well.

On the basis of the evaluation results the need for an evolution of the reference model could be defined. These evolution-activities are similar to the construction-activities. But the discussion of alternative solutions and innovations, respectively, could be supported by empirical evidences captured during the utilization state.

5 Closing the Introducing Example

For the application of the developed framework for evolutionary reference modeling we continue the introductory example of standardizing the business process of registration of received claim forms. Figure 7 depicts the logical structure of objectives, assumptions and arguments underlying the construction of the resulting reference model (top right).

On the bottom right of figure 7 both alternatives for process design are depicted. The reference model constructor balances reasons and weighs the proposals. For this purpose he identifies the relevant corporate objectives (process costs, customer complaints), derives individual objectives for an optimized process design and argues for the best solution (customer-focused solution (alternative B)). The argumentation is supported by experiences regarding increased customer complaints correlated with the rejection of incomplete claim forms. On the left side of figure 7 sensor concepts are defined in order to monitor assumptions crucial for the validity of the resulting process design. Due to unverified assumptions regarding process alternative B, users of the reference model should be aware of the costs for complaint handling and costs for completion by clerks. In the case of unexpected experiences evolutionary activities should be triggered. At first instance a model change on individual change would occur, but the evaluation of model use experiences could reveal its relevance for the entire scope of the reference model.

Continuing the example of figure 7 it is conceivable that one of the branches of the insurance company performs a momentous mistake by completing an incomplete claim form. The legal consequences and the damage of corporate reputation are worse than the costs for handling customer complaints resulting from the rejection of the incomplete form. This momentous experience could trigger the evolution of the reference model. For reasons of

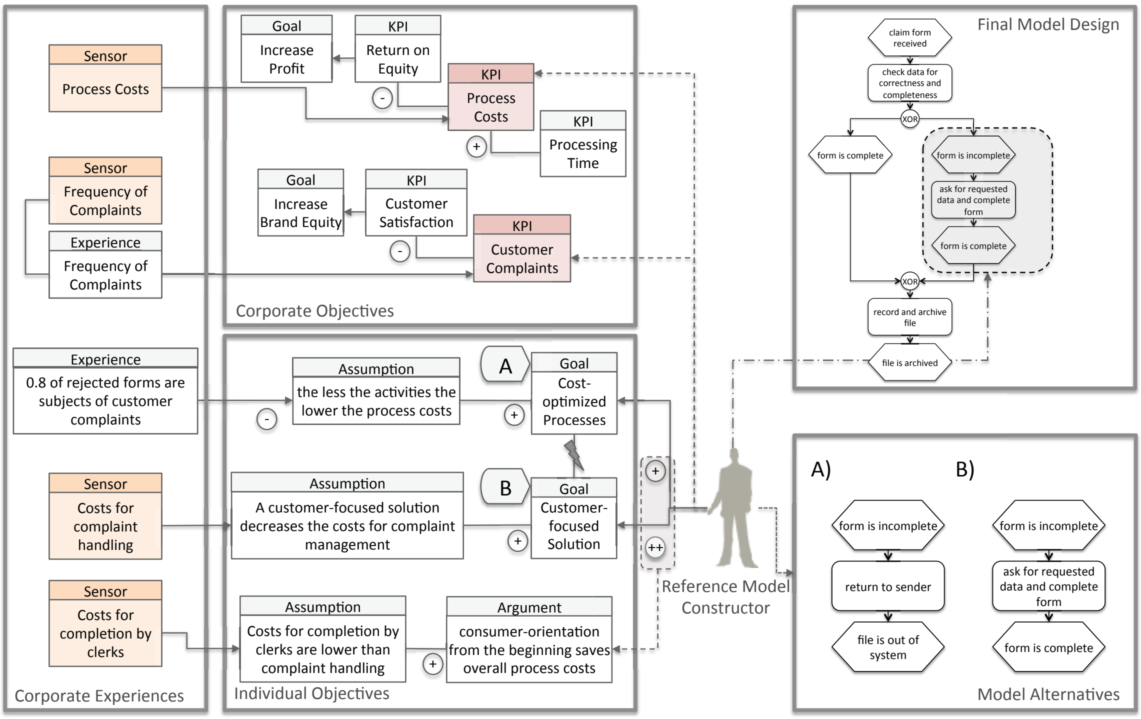

Figure 7: Application of the negotiation-based framework for evolutionary reference modeling

simplification we leave innovative solutions (like the implementation of online systems) out of consideration. The argumentation depicted in figure 7 could be added by the mentioned experience and reconsidered objectives, assumptions and arguments.

One feasible solution is depicted in figure 8. The reference model provides two process alternatives. If the branch is sufficiently staffed with legal competencies, incomplete claim forms should be completed by clerks. Otherwise the incomplete form should be returned along with personalized instructions for way of proceeding. Due to the complex structure of final model design, considered alternatives, argumentation and sensor data, this meta-information should be captured in different views and related to relevant elements of the reference model. For example the process alternative return to sender in figure 6 displays a magnifier symbol. This symbol indicates the availability of rationale information for the design of this part of the reference model. As a consequence the identification of deliberately designed model elements along with the ability of evaluating their validity for the situation at hand could be systematically and methodical supported.

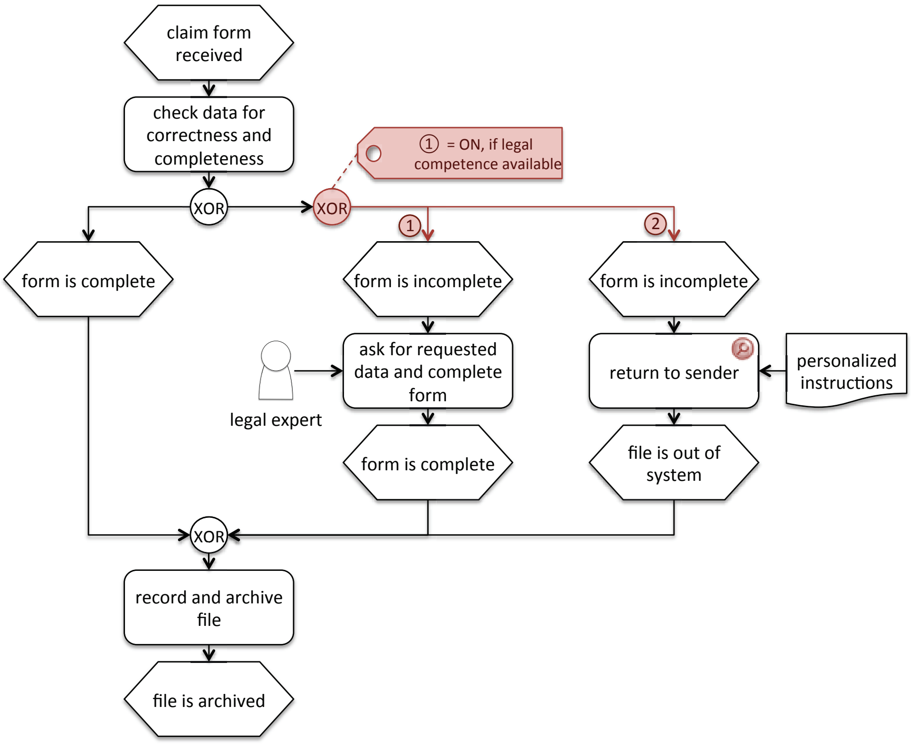

Figure 8: Resulting reference model evolved by deliberately monitored sensors

6 Conclusion

The presented research bases on the recognition that the potential of reference models could not be exploited unless they reveal the underlying rationale. The key assumption contains the demand for documentation of construction and use rationale along with related experience in order to support a systematic evolution of the reference model. Thus, the research goal of our paper was the identification of key concepts of decision processes within the lifecycle of reference models. Basing on an in-depth analysis of the constructivist understanding of conceptual information models, we developed a negotiation-based framework for evolutionary reference modeling. We demonstrate the procedure of reference model evolution by discussing a common problem of handling incomplete forms. Objectives, assumptions, arguments, sensors and experiences have been identified as crucial concepts for a systematic evolution of reference models.

Our future work will be the development of a prototypical implementation of an enhanced information system for reference modeling. We will evaluate promising modeling methods and analysis algorithms as well as crucial influencing factors within a case study. The key focus of our future research will be on the application area of health care and its specific requirements in particular. We will refine our framework on the basis of these empirical results for this specific application context.

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