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# Towards Managing IT Complexity: An IT Governance Framework to Measure Business-IT Responsibility Sharing and Structural IT Organization

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## ABSTRACT

For large enterprises, IT governance is a major lever to influence the way how IT enables business. The authors hypothesize that a part of IT governance, namely business-IT responsibility sharing and structural IT organization, has a strong influence on IT architecture complexity of large enterprises. IT complexity is challenging CIOs of large enterprises all over the world day-by-day. Yet, IT complexity so far has been analyzed by scientific research only to a small degree. To prove or falsify the hypothesis that IT governance influences IT architecture complexity, the authors developed concepts to measure both aspects with a framework. In this research, the concept for business-IT responsibility sharing and its scientific background are presented. The IT complexity measurement concept is shown, focusing on IT architecture complexity. An outlook for this research, an empirical study that is currently in progress is given.

### Keywords

IT governance, IT complexity, IT architecture complexity, business-IT responsibility sharing, IT organization, IT structure, responsibility assignment matrix, RACI.

## INTRODUCTION

IT complexity and its management become more important to managers of large enterprises (Beetz and Kolbe, 2010; Mocker, 2009). Since IT governance, especially IT Organization & Business-IT Responsibility Sharing (**IT O&R**), has big impact on the ability to manage IT, the purpose of this research is to develop a concept to "measure" IT O&R and IT architecture complexity. Therefore, research questions are:

1) How can IT organizational structure and business-IT responsibility sharing be measured for large corporations?

2) How can IT architecture complexity be measured for large corporations?

Objective of this paper is to describe the main concepts for IT O&R as well as IT architecture complexity. As an upcoming step, interrelations and dependencies between 1) and 2) will be analyzed based on data from an empirical study that is currently being initiated.

This paper describes scope and theoretical background of IT governance and IT complexity. Main concepts for IT O&R and IT architecture complexity are described, introducing a framework and its reasoning. Finally, an outlook on next steps and a conclusion is given.

## SCOPE AND THEORETICAL BACKGROUND

This section defines the research field and highlights an extract on state-of-the-art literature used for the IT governance and IT complexity research. The comprehensive literature analysis is documented by Beetz and Kolbe, 2010.

### Theoretical Background of IT Governance

There are several scope sets for the term "IT governance". Exemplary, two scope sets are shown to frame this research. IT-Governance-Institute, 2003 focuses on leadership, organizational structures and on process execution. Weill and Ross, 2004 have a different scope set for IT governance, since they understand it as: "*Specifying the decision rights and accountability framework to encourage desirable behavior in the use of IT*". This definition focuses on responsibility sharing to manage IT

and structural organization. This research will follow the second scope set. Nonetheless, literature with a different scope is analyzed as well on aspects relevant for IT O&R.

As the term "IT governance" is used with different scope sets in literature, various papers analyze the different streams of IT governance literature. This "meta" literature is represented e.g. by Brown and Grant, 2005 (analyzing 60 articles on IT governance) and Johannsen and Goeken, 2006 (categorizing 15 IT frameworks that support IT governance).

IT governance literature examples of high importance for this research were selected in addition to Weill and Ross, 2004: Gammelgard, Lindström and Simonsson, 2006 developed a framework for IT management responsibilities. Luftmann, 2000 describes business-IT-alignment maturity. Ross and Weill, 2002 give advice on Business-IT Power sharing, explaining which decisions on IT should be made by business units, not IT departments. De Haes and Van Grembergen, 2009 analyze IT governance methods and define a minimum baseline that each organization should implement. Furthermore, they establish a correlation between IT governance practices and business-IT alignment. Tiwana and Konsynski, 2010 measure the effect of IT modularity and IT governance on IT agility and IT alignment. Yayla and Hu, 2008 as well as Ranganathan and Jha, 2008 analyze the role of CIOs and different compensation schemes to discover their interrelation with business success.

### Theoretical Background of IT Complexity

One of the fundamental milestones for complexity research is Ashby's law of requisite variety (Ashby, 1956), stating that only a sufficient internal variety can manage the variety of an external system. Simon, 1962 analyzes aspects of general system complexity. Hasenpusch, Moos and Schwellbach, 2003 define concrete drivers for enterprise complexity.

Literature in IT complexity still is sparse but research effort increases. Brocke and Klein, 2008 introduce a simplicity approach to develop an evaluation framework for SOA-based organizational changes in investment controlling. They introduce an approach to reduce IT Complexity, but also refer to pitfalls of unilateral simplicity and underline the law of requisite variety. Enterprise architecture is analyzed as well, as IT architecture is highly dependent on it (e.g. Zachmann, 1997; Wilkinson, 2006).

Mocker, 2009 focuses on application architecture complexity and tests propositions from literature. He analyses the effect of different types of IT complexity (interdependency, diversity of technologies, deviation from technology standards, overlap/ redundancy) onto operations and maintenance costs.

Dern, 2009 describes IT-architecture complexity, including application architecture and technological architecture. Dern and Jung, 2009 develop a measurement instrument to quantify IT-Architecture complexity. Kirilyuk and Ulieru, 2009 mathematically prove the inevitability of ICT complexity based on an unreduced problem formulation for possible system realisations.

## METHODOLOGY

The methodology for this research and the conceptual framework was:

1) Researching literature on IT governance and IT complexity and surrounding research fields
2) Analyzing the best fitting and most relevant frameworks in detail
3) Drafting frameworks for IT O&R and IT (architecture) complexity that fit the research requirements
4) Interviewing 9 experts with IT management, research, and/or IT management consulting expertise in large corporations
5) Finalizing the conceptual frameworks, integrating insights from expert interviews

A broad literature research 1) took place including major keywords, e.g. (IT) governance, (IT) complexity, (IT) organization, but also covering side topics, e.g. (IT) simplicity, enterprise architecture, etc. It was condensed towards the 165 most relevant literature sources and used for 2) and 3). Table 3 in the appendix shows the mapping for IT governance frameworks. The interviews of 4) were conducted in parallel until January 2011, each with a length of approximately 30-120 minutes, partly split in several sessions. The 9 interviewees were:

- 4 IT managers ("Group CIO", "CIO", "Senior IT manager"/ IT department head, "Central IT Manager") in large corporations (automotive, utilities, telecommunications)
- 4 IT strategy & IT management consultants (5-20 years of experience in above-named industries plus the travel & transportation and financial services industries) having worked on several projects with IT governance and IT complexity challenges

- 1 researcher with scientific and practical experience in IT governance and IT complexity management

The experts covered the Central European area with exposure to Middle East, North America and Asia. The result of 5) that integrates expert feedback is shown in the following section.

## CONCEPTUAL FRAMEWORK

In this section, requirements for the conceptual framework are set up and the two aspects of the framework IT O&R as well as IT complexity architecture are introduced.

### Requirements

Goal of the conceptual framework is to "measure" IT governance components (IT O&R) as well as IT complexity components (IT architecture complexity) and to analyze the interrelations for research and practice, see Figure 1.

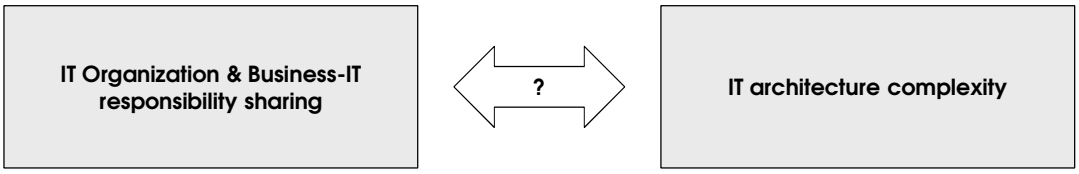


**Figure 1: Framework of this research**

To find interrelations/ implications via correlation analysis, framework variables should at least have an ordinal scale (Raithel, 2006). Furthermore, the framework needs to be applicable specifically for large enterprises, including complex structural organizations, e.g. with holding structures and decentral IT applications. This was a special demand from IT management experts as current frameworks do not explicitly address this ("*The organization of big companies is more complex, this needs to be addressed in an IT governance framework*"). Finally, it should be applicable to specific companies in less than approximately 20-30 minutes to allow using a survey.

### Structural IT Organization & Business-IT Responsibility Sharing (IT O&R)

Several IT governance frameworks exist, each valuable for its specific purpose. Weill and Ross, 2004 have developed an IT governance survey allowing a quick glance on IT governance on one page. On the other hand an in-depth audit is described by Clementi and Carvalho, 2009. Popular IT process frameworks like CobiT and ITIL were analyzed to expand the basis for a framework. For this research, focus is on structural IT organization and business-IT responsibility sharing (IT O&R).

The conceptual framework of IT O&R therefore is mainly influenced by the "Governance Arrangement Matrix" (Weill and Ross, 2004), the analysis of decisions that should be made by business rather than IT (Ross and Weill, 2002), IT management and IT governance process frameworks (IT-Governance-Institute CobiT, 2005; ITIL, 2007; ISO 20000, 2005) that were categorized by Johannsen and Goeken, 2006, as well as insights from expert interviews. First ideas on the IT O&R framework were used as part of a report (Dömer and Schmitz, 2010).

Two aspects are in scope of this framework: Firstly, "business-IT responsibility sharing" defines the general scope of IT (see subsection "Scope of IT"). In line with that, responsibility sharing of IT management tasks and IT value chain components is established via a RACI matrix (Gilmore and Kazanjian, 1989; see subsection "Matrix for Business-IT Responsibility and Structural IT Organization"). Secondly, "structural IT organization" defines the IT organization for the IT value chain components (see same subsection as the matrix covers both aspects).

#### *Scope of IT*

"Scope of IT" means the basic role of IT within a company. It defines how IT is perceived within a company and to which degree IT is responsible and competent for decision making.

| | | | |
|---|---|---|---|
| **CIO Positioning** | Not reporting to a member of the board | Reporting to a member of the board | Member of the board |
| **Role of IT** | IT as support function and to automatize processes | IT as business enabler and consultant | IT as strategic business driver and equal partner |
| **Financial model** | Cost center | Internal profit center at market pricing | External profit center with service offerings for 3rd parties |

**Table 1: Dimensions and values for scope of IT**

*CIO positioning:* As analyzed in recent studies, the positioning of the CIO within a company's management is a major lever for both, business-IT alignment and business success (Ranganathan and Jha, 2008; Yayla and Hu, 2008). Therefore, to understand one major building block for the basic scope of IT, one indicator is the CIO positioning, see Table 1.

*Role of IT:* For the past decades, the role of IT constantly changed (Chun and Mooney, 2006). Starting with business automatization tasks and user-IT support, it has developed as business enabler and consultant. In some cases, IT even becomes strategic driver and equal partner for business. Therefore, one indicator is the role of IT, see Table 1.

*Financial model:* One statement of the expert interviews was "One basic characteristic of IT is its financial model". Cost centers based on as-is IT costs were common for a long period of time. An internal profit center that is based on market pricing and needs to be self-sustaining becomes more common as it ensures competitiveness with external alternatives. Even external profit centers that serve third parties are an option, see Table 1.

#### *Matrix for Business-IT Responsibility and Structural IT Organization*

In this subsection all parts of the matrix for Business-IT Responsibility and Structural IT Organization are described as shown in Figure 2:

**1.** Management tasks/processes

**2.** IT value chain tasks/processes

Afterwards the two dimensions that are to be measured are described:

**A.** Business-IT task responsibility ("RACI") concept

**B.** IT organizational structure

The IT governance framework has been mapped with well-established IT process and management frameworks: ITIL V3 (IT Infrastructure Library, ITIL, 2007), the standard ISO/IEC 20000 (ISO 20000, 2005) and CobiT 4 (Control Objectives for Information and related Technology, IT-Governance-Institute, 2005) were analyzed. A detailed mapping is shown in the appendix in Table 3.

To decide whether to integrate a task/process into the management tasks dimension, the IT O&R "fit" was analyzed: Tasks/ processes should either be suited to be executed by business or decentral IT or central IT. Or they should be able to be integrated in a structural IT organization. For instance, the overall IT security strategy of a company can be approved either by business or by IT itself, but the technical IT security processes can only be defined by IT. This is why IT security strategy was integrated in this framework, whereas the technical IT security processes were not. "Candidates" for the integration in the structural IT organization were the core tasks/ processes of an IT value chain to change and run the IT of a company.

| | | A. Business-IT Task Responsibilities | | | | | | | | | | | | | | | B. IT Organizational Structure | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Business | | | | | Decentral IT | | | | | Central IT | | | | | Place | | | | | Task | | | | |
| 1. Management tasks | | AR | A | R | C | I | AR | A | R | C | I | AR | A | R | C | I | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| IT strategy management | IT visioning & strategic planning | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Business-IT strategy linking | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT process & organization strategy | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT security strategy | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT service strategy & portfolio | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT budgeting | IT innovation budgeting | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT continuity budgeting | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT architecture management | IT architecture standards & compliance setting | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Global IT architecture roadmapping | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT innovation management | IT process innovation management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT product innovation management | | | | | | | | | | | | | | | | | | | | | | | | | |
| Business process mgmt. | Business process ownership | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Business process design | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT projects & change management | IT project portfolio management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT change management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT project management | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT resource management | IT sourcing & shoring strategy | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT procurement | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT staffing & resource allocation | | | | | | | | | | | | | | | | | | | | | | | | | |
| IT performance management | IT monitoring | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT controlling & evaluation | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. IT Value Chain tasks | | AR | A | R | C | I | AR | A | R | C | I | AR | A | R | C | I | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Demand management | Requirements engineering & consulting | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Prioritization | | | | | | | | | | | | | | | | | | | | | | | | | |
| Development | Functional specification | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Technical specification, implementation, integration & technical testing | | | | | | | | | | | | | | | | | | | | | | | | | |
| | User acceptance testing | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Deployment | | | | | | | | | | | | | | | | | | | | | | | | | |
| Operations | Application operations & configuration management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Platform operations, hosting & housing | | | | | | | | | | | | | | | | | | | | | | | | | |
| End-to-end service mgmt. | Service desk & incident management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Service level management | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IT Organizational Structure overall: | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 2: A Matrix for Business-IT Responsibility and Structural IT Organization**

### *1. Management tasks*

Based on the sources mentioned above, the main IT management tasks can be defined as depicted in Figure 3 (1.).

*IT strategy management:* Strategy development sets overall goals for IT (see "*IT principles*" domain of Weill and Ross, 2004). "IT visioning" defines the IT ambition and vision. "Business-IT strategy linking" is the process of deriving the IT strategy from the business strategy and integrating IT input into business strategy. The "IT process & organization strategy" defines how the IT organizational and IT operational structures are set up and which IT process models are used.

*IT budgeting:* The "*IT investment*" decision domain of Weill and Ross, 2004 is covered by the budgeting management task. It is split up into "IT innovation" and "IT continuity". "IT innovation" covers all change budgets, e.g. development. "IT continuity" covers budgets for operations as well as defects fixing.

*IT architecture management:* "IT architecture standards and compliance setting" integrates the activities to define IT platforms, programming languages and other architectural paradigms. It includes the degree of actual compliance, e.g. whether exceptions to realize business requirements on an obsolete IT platform may be accepted or not. "Global IT

architecture roadmapping" shows for the whole company/ group which applications and technologies are to be changed/ replaced within the next years.

*IT innovation management:* In addition to IT demand management that covers demands in a business "pull" mode (focus in the IT value chain section), IT innovation management describes the technology "push" of ideas and IT innovations. "IT process innovation management" focuses on management and assessment of ideas and technologies to support business processes with IT. "IT product innovation management" concerns IT as a business product or part of the business product.

*Business process management:* As stated in 3 expert interviews, some IT departments are made responsible for business process management ("*The Chief Information Officer is becoming 'Chief Process Officer'*"). Whether responsible or not, IT is highly affected by business process management. "Business process ownership" defines the accountability for the business process landscape. "Business process design" is the task of defining and detailing the business processes as part of an enterprise architecture management.

*IT project & portfolio management:* "IT project portfolio management" is the task of steering the overall portfolio of IT projects. There, "go" or "no-go" decisions, prioritization between projects and ad-hoc budget constraints are decided upon. "IT change management" defines who is in charge of enabling the organization with the continuous change of the IT architecture landscape. "IT project management" is the operational steering and management of (single) IT projects.

*IT resource management:* How to manage people in an IT organization is decided in the IT resource management process. "IT sourcing & shoring strategy" decides upon make-or-buy, IT competencies management and roadmapping as well as the decision where to hold internal competencies. "IT procurement" is the task to deal with external partners/ suppliers, including supplier selection and supplier management. "IT staffing & resource allocation" is about deciding which resources - internal or external - are allocated on which topic with what amount of time.

*IT performance management:* After having set up key performance indicators in the IT process and organization strategy, these indicators need to be tracked and actions need to be taken. "IT monitoring" is the operational task of tracking the IT performance status and handing over information to the responsible IT and business units. "IT controlling and evaluation" is the process of analyzing tracked information and deducing concrete actions from the given information.

***2. IT value chain***

The IT value chain is the core of IT change and IT run related tasks in a company. It covers demand management, development, operations and the end-to-end service management. For the IT value chain, responsibilities have to be defined as discussed in subsection A.: "Business-IT task responsibilities". Furthermore, the organizational structure needs to be defined, which is described in subsection B.: "IT structure". If using agile methods, the tasks themselves remain stable, but their sequence and frequency will be different.

*Demand management:* IT demand management is the main "bridge" between business and IT for change activities. With "requirements engineering & consulting" high-level demands are discussed to sharpen the needs business units have and to specify the business demand and requirements. These requirements can be analyzed in a technical view and given a rough price tag. With these information packages for each demand, a "prioritization" for the different demands from different or the same business units can be carried out. In the end, a balanced set of demands is specified and detailed technically.

*Development:* In the phase of "technical specification, implementation, integration & technical testing" prioritized demands receive a technical specification and the actual implementation takes place. Furthermore, software needs to be integrated in the existing IT landscape and technically tested as a whole. When the basic technical part of the testing is done, the functional "user acceptance testing" needs to be performed where lead users of the software provide feedback. When the software is fully tested and accepted by test users, the "deployment" or rollout, user trainings, a replacement of a predecessor software, etc. are performed. With these tasks the IT change process ends and IT continuity starts.

*Operations:* One part of IT continuity is operations of IT systems. Internal responsibility is independent from outsourcing decisions (e.g. external hosting, housing, cloud services, etc.). "Application operations & configuration management" covers all activities to ensure agreed service levels as well as day-to-day changing of software configurations. "Platform operations, hosting & housing" provides the necessary software basis for the applications to run on, e.g. database services, web servers, operating systems. Furthermore, it covers the physical and virtual set-up and running of the necessary hardware and IT networks.

*End-to-end service management:* The second big part of IT continuity is an end-to-end service management, including the end-user services and day-to-day management of service levels. "Service desk & incident management" is the point of contact for users concerning end-user applications. Usually on two to three levels, support requests are answered, tickets for

defects or unknown behavior are gathered, administered and forwarded to the relevant experts. “Service level management” focuses on keeping the agreed service levels as well as on defining new service levels when necessary.

### *A. Business-IT task responsibilities*

For all tasks of the previous two subsections, a responsibility charting as defined by Gilmore and Kazanjian, 1989 is used. It defines the responsibility sharing between business, decentral IT and central IT. This often called “RACI” matrix (e.g. ITIL, 2007) allows matching roles and responsibilities. RACI is an acronym for Responsible, Approve (also called “accountable”), Consulting and Informed, see Table 2, following Gilmore and Kazanjian, 1989.

| | |
|---|---|
| **Responsible** | Operatively responsible – the "doers" of the actual work. It may be that several people are responsible at the same time. |
| **Approve/ Accountable** | Overall responsible – the "owners" of the work. They have to sign off the work and are accountable for its success. Only exactly one role may approve one task/ process. |
| **Consulted** | Have to be involved to give relevant input. Help delivering the task. |
| **Informed** | Do not give input nor are they operatively involved and they do not have a veto right either, but are informed, e.g. because the output is relevant for their tasks. |

**Table 2: Description of RACI roles**

The basic roles to apply the responsibility charting are business and IT. For large enterprises, as mentioned in the expert interviews, IT may have decentral and central departments (“*Big enterprises usually are organized in a structure with a group IT and local IT departments*”). Central IT departments supply certain processes for the entire company, whereas decentral IT departments supply single subsidiaries or business departments as defined in “B. IT structure.” Therefore, these roles are treated separately. Roles can be split further for specific companies, e.g. as described by Gottschalk, 2003.

### *B. IT structure*

IT departments of large enterprises have a defined organizational structure with reporting lines. Reporting lines can be classically hierarchical (shaped like a tree) or - for large companies most likely - be matrix-oriented (Kieser and Walgenbach, 2010). In any case IT departments are structured in a centralized or decentralized way, or in a mixture of both, often called federal (Weill and Ross, 2004). Deduced from Kieser and Walgenbach, 2010 and expert interviews, two dimensions define the top level IT structure and “task” and “place”. In both dimensions IT departments can have a centralized or a decentralized or a federal/ mixed approach.

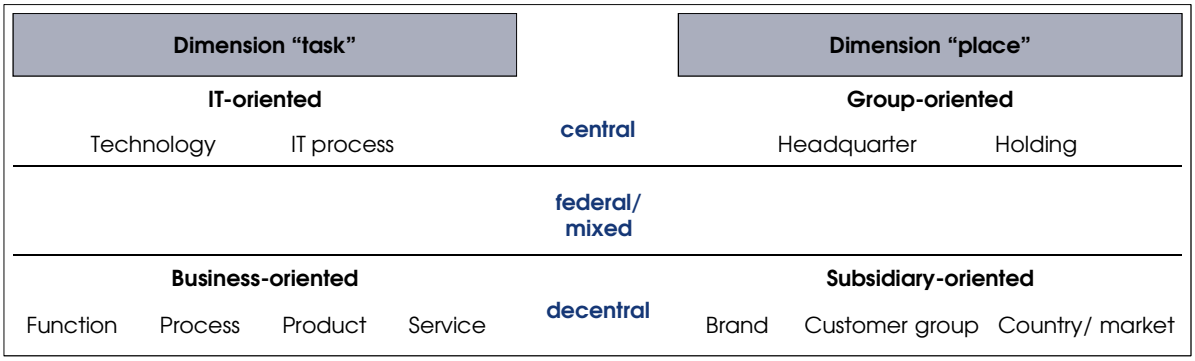


**Figure 3: IT structure dimensions and parameters**

*Task:* Dimension “task” is applicable for any company size and often used for “central” and “decentral” IT classification in IT governance literature (e.g. Brown and Grant, 2005; De Haes and Van Grembergen, 2009). It describes whether the IT organization of a firm is business-oriented in terms of (business) functions, processes, products or services of a company (e.g. logistics, customer service). Alternatively, the IT organization can be IT-oriented in terms of technologies used or IT processes (e.g. J2EE, development, service management). Federal/ mixed IT organizations are possible as well (e.g. production and sales plus IT operations).

*Place:* Dimension "place" is particularly important for large enterprises operating in a holding or group structure, e.g. an automotive manufacturer that sells cars, trucks and buses at the same time. In some cases the same type of business exists for different countries and brands. For these enterprises different options of sharing IT infrastructure and services are available. A company with a subsidiary oriented IT has an IT department for each brand/ region/ customer group. A group oriented IT structure means that only one IT department for all divisions or regions exists.

Both dimensions combined show how centralized or decentralized the organizational IT structure of a company is.

### IT Complexity and IT Architecture Complexity

In this section, a brief overview on the IT complexity framework will be given as it is planned to find correlations and dependencies between IT O&R and IT architecture complexity.

#### *IT complexity and its surroundings*

IT complexity must be set in the overall complexity context a company faces. Relevant are enterprise architecture complexity, enterprise strategy & organizational complexity, legal complexity and IT complexity.

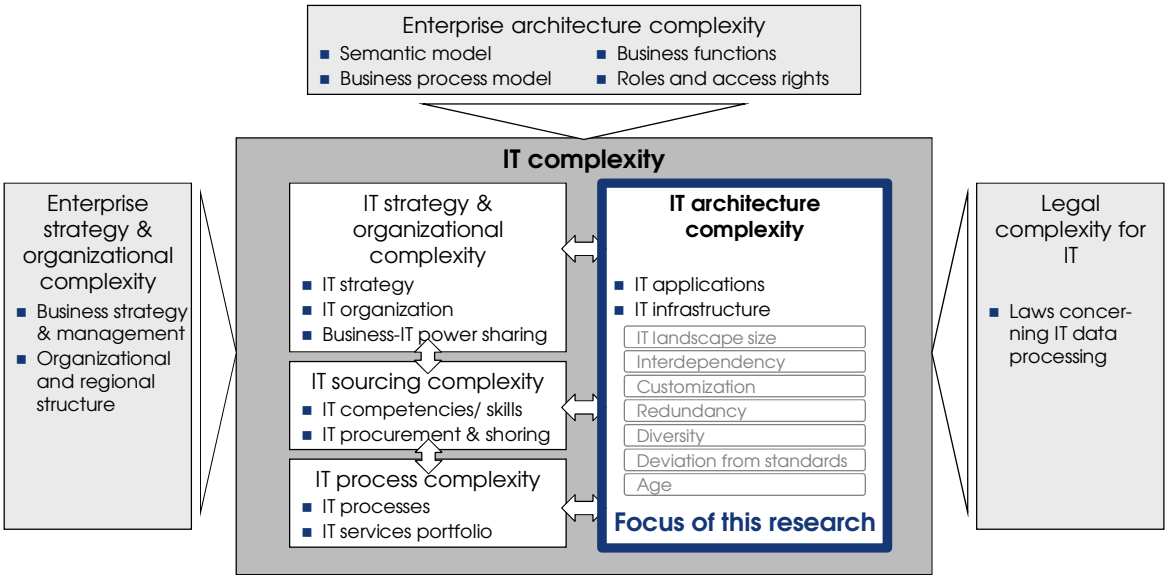


**Figure 4: IT complexity and its surroundings**

As shown in Figure 4, enterprise architecture complexity has a direct impact on IT complexity because the IT system and technology models always are sub layers of enterprise layers (Zachmann, 1997). The second influencing factor is the overall enterprise strategy and organizational complexity in which an IT function is set up. A third influencing factor is legal complexity that IT has to comply with. IT complexity itself means complexity of IT strategy & organization, architecture, sourcing and processes. As IT architecture is main focus of this research, its components are described in the following subsection.

#### *IT architecture complexity*

According to Dern, 2009, IT architecture consists of application, software and infrastructure architecture. In this research, focus lies on the overall IT landscape of an enterprise, expanding the framework of Mocker, 2009. "IT applications" covers the application architecture. "IT infrastructure" covers the basic software and infrastructure components.

IT architecture complexity comprises IT landscape size, interdependency, customization, redundancy, diversity, deviation from standards and age. For each of these complexity dimensions indicators are defined that can be quantitatively measured for any company, see Figure 5.

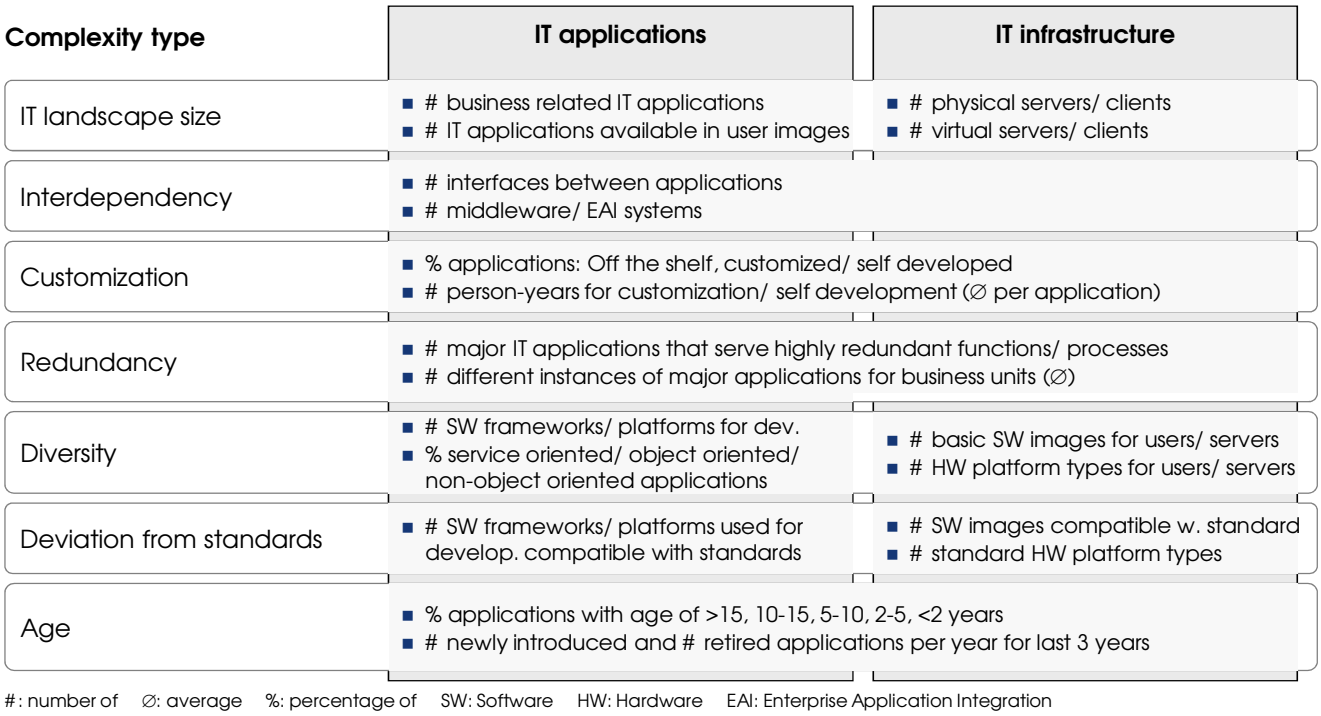


**Figure 5: IT architecture complexity for IT landscapes of large enterprises**

*IT landscape size:* IT landscape size gives information about the overall IT architecture size and describes the number of components of an IT landscape (Dern and Jung, 2009). "Number of business related IT applications" describes business related software. This measure is used to distinguish how 'big' the business related IT architecture complexity of a company is (together with customization). "Number of IT applications available in user images" counts how many different software 'fat clients' or 'rich clients' (Lewandowski, 1998) are maintained in the software portfolio that can be installed on a personal computer for end users. "Number of business related IT applications" and "number of IT applications available in user images" include redundant applications, namely all applications that are business related and at the same time have a user fat client. This redundancy is designated/ favored because it shows additional complexity to maintain the software on the end users PCs compared to a "pure" web-oriented architecture. "Number of physical servers & clients" describes how many physical machines are managed by the IT department. "Number of virtual servers & clients" shows how many virtual machines are maintained.

*Interdependency:* The interdependency complexity dimension of Mocker, 2009 was transformed to an IT landscape focus. "Number of interfaces between applications" counts the total amount of interfaces within the application landscape. The maximum amount of interfaces is n*(n-1)/2 (Dern and Jung, 2009). This is the case when each application has an interface to each other system. "Number of middleware/ EAI systems" shows whether there exists middleware (also called Enterprise Application Integration) to connect applications via a connection framework which can reduce the amount of interfaces.

*Customization:* Many features that had to be self-developed in former times can today be purchased 'off the shelf' as part of a standard software product. Still, to gain market advantages or to fulfill special business needs, customization can be appropriate or necessary. As described by Mocker, 2009 software was formerly measured e.g. with lines of code which is not relevant on a corporate level. As for the experts interviewed, a good indicator is the amount of effort invested by the company – namely customization ("*Customization drives costs and complexity more than the software product it is based upon*"). It is measured as "Percentage of total applications that are 1. completely off the self, 2. customized or 3. self-developed". To indicate the effort for customization per application, "average number of person-years for customization or self-development" is used.

*Redundancy:* "Number of major IT applications that serve highly redundant functions/ processes" measures the degree of redundancies on an IT landscape level (based on Mocker, 2009). "Average number of different instances of central applications for business units" shows whether central applications are used for all business units or customized per business unit. If customized, the same functions exist in one application with different configurations.

*Diversity:* Diversity defines different technologies and frameworks used for an IT landscape. Mocker, 2009 found no significance on single application level but stated that for an application landscape the results could be different. "Number of software frameworks/ platforms used for development" counts the number of programming guidelines and technologies used for software development. The "percentage of service oriented/ object oriented/ non-object oriented applications" shows to which degree different software development approaches are used. "Number of basic software images for users/ servers" shows how many different computer system images exist for users and servers. "Number of hardware platform types for users/ servers" shows how many hardware types are used for user PCs/ laptops and for servers.

*Deviation from standards:* Goal is to analyze whether different technologies and frameworks are compatible with existing company standards. As discussed in the expert interviews, large enterprises tend to have IT architecture departments installed that define IT architecture standards. Therefore three indicators analogous to the indicators used for the "Diversity" dimension are used, answering whether compatible with standards or not (see Figure 5).

*Age:* As discussed by Mocker, 2009 the age of IT applications is often referenced to be one of the causes for IT complexity. "Percentage of applications with age of >15, 10-15, 5-10, 2-5, <2 years" shows how old the application landscape of a company is. "Number of newly introduced and number of retired applications per year for the last three years" shows the trend of a company to reduce or to increase the number of applications over time. If the relation of retired to new applications is greater than 1, the application landscape is growing, if below 1, it is shrinking.

## CONCLUSION & OUTLOOK

This research provides a conceptual framework to measure IT organization and business-IT responsibility sharing (IT O&R) as well as IT architecture complexity for large enterprises. The framework is deduced from current IT governance and IT complexity research and complemented by expert knowledge from research and industry. It is now possible to apply the framework: compare IT O&R of different companies and analyze their IT architecture complexity. This is the basis to find interrelations and perhaps even dependencies between IT O&R and IT architecture complexity.

As a contribution for research, IT O&R can be measured and its interrelations with IT architecture complexity can be described for large enterprises with global governance structures. This may be relevant for other Information Systems aspects. For practice it means that companies can understand which IT governance levers they can pull to influence IT architecture complexity. Furthermore, benchmarks with peer companies can help giving advice on best practices.

The next steps will be to establish detailed hypotheses about qualitative and quantitative interrelations between IT O&R and IT architecture complexity and to prove or falsify them, e.g. with correlation/ factor analysis. The different factors will be weighted, e.g. a virtual server might add less complexity than a physical one. Furthermore, a survey is in progress to measure IT O&R and IT architecture complexity based on the concepts that were presented here, using methodology e.g. from Tiwana and Konsynski, 2010; Schmidt, 2009. Addressees are 500-1000 CIOs of large and very large enterprises. In addition, case studies will help to analyze some aspects more deeply, e.g. effects over time. Examples for hypotheses are:

- "The higher the degree of IT structure decentralization, the higher the IT landscape size, customization, redundancy"
- "The lower the IT responsibility, the higher the IT landscape size, customization, deviation from standards, redundancy"
- "The lower the role of IT and CIO positioning, the higher the IT application architecture age"

Initial findings suggest that a strong interrelation exists between IT O&R and IT architecture complexity. As these results originate from a small control sample, the hypotheses have to be scientifically substantiated. This will be the main objective and ambition of the survey and the next steps of this research.

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## APPENDIX

| | Own framework | CobiT 4.0 | ITIL V3 | ISO 20000 |
|---|---|---|---|---|
| **IT strategy management** | IT visioning & strategic planning | PO1 Define a Strategic IT Plan and direction; PO6 Communicate Management Aims and Direction | Strategy generation | |
| | Business – IT strategy linking | PO4 Define the IT Processes, Organization and Relationships; PO6 Communicate Management Aims and Direction | | Business relationship mgt |
| | IT process & organization strategy | PO4 Define the IT Processes, Organization and Relationships; ME4 Provide IT Governance | | |
| | IT security strategy | (DS5 Ensure Systems Security) | (Information security mgt ) | (Security mgt) |
| | IT service strategy & portfolio | (DS2 Manage Third-party Services) | Service portfolio mgt; service catalogue mgt; service knowledge mgt; service improvement | |
| **IT budgeting** | IT innovation budgeting | PO5 Manage the IT Investment; (DS6 Identify and Allocate Costs) | IT financial management | |
| | IT continuity budgeting | PO5 Manage the IT Investment | IT financial management | Budgeting & accounting for IT services |
| **IT architecture management** | IT architecture standards & compliance setting | (PO2 Define the Information Architecture) | | |
| | Global IT architecture roadmapping | PO2 Define the Information Architecture; PO3 Determine Technological Direction | | |
| **IT innovation management** | IT process innovation management | (AI1 Identify Automated Solutions); (AI7 Install and Accredit Solutions and Changes) | | |
| | IT product innovation management | (AI1 Identify Automated Solutions) | | |
| **Business process management** | Business process ownership | | | |
| | Business process design | | | |
| **IT projects & change management** | IT project portfolio management | (PO10 Manage Projects) | | |
| | IT change management | AI6 Manage Changes | Transition planning & support; Change mgt | Change mgt |
| | IT project management | PO10 Manage Projects | | |
| **IT resource management** | IT sourcing & shoring strategy | (AI5 Procure IT Resources) | (Supplier mgt) | (Supplier mgt) |
| | IT procurement | AI5 Procure IT Resources | Supplier mgt | Supplier mgt |
| | IT staffing & resource allocation | PO7 Manage IT Human Resources | | |
| **IT performance management** | IT monitoring | ME1 Monitor and Evaluate IT Processes; ME2 Monitor and Evaluate Internal Control; PO9 Assess and Manage IT Risks; DS3 Manage Performance and Capacity | service measurement; service reporting | Service reporting |
| | IT controlling & evaluation | ME1 Monitor and Evaluate IT Processes; ME2 Monitor and Evaluate Internal Control; ME3 Ensure Regulatory Compliance; PO8 Manage Quality; PO9 Assess and Manage IT Risks; DS3 Manage Performance and Capacity | Evaluation mgt; service analysis; service reporting | Service reporting |
| **Demand management** | Requirements engineering & consulting | (AI1 Identify Automated Solutions) | Demand mgt | |
| | Prioritization | (DS6 Identify and Allocate Costs); (AI1 Identify Automated Solutions) | | |
| **Development** | Functional specification | | | |
| | Technical specification, implementation, integration & technical testing | | Validation & testing mgt | |
| | User acceptance testing | | Validation & testing mgt | |
| | Deployment | AI4 Enable Operation and Use | Release & deployment mgt | Release mgt |
| **Operations** | Application operations & configuration management | DS9 Manage the Configuration; (AI2 Acquire and Maintain Application Software); DS4 Ensure Continuous Service; DS13 Manage Operations | Service asset & configuration mgt; availability mgt; capacity mgt; service continuity mgt; operations mgt | Configuration mgt, availability & continuity mgt; capacity mgt |
| | Platform operations, hosting & housing | DS11 Manage Data; DS13 Manage Operations; (AI3 Acquire and Maintain Technology Infrastructure); DS12 Manage the Physical Environment | Availability mgt; capacity mgt; service continuity mgt; operations mgt; technology/ technical mgt | Availability & continuity mgt; capacity mgt |
| **End-to-end service management** | Service desk & incident management | DS8 Manage Service Desk and Incidents; DS10 Manage Problems | Event mgt; request fulfilment; incident mgt; problem mgt; access mgt | Incident mgt; problem mgt |
| | Service level management | DS1 Define and Manage Service Levels | Service level mgt | Service level mgt |

**Table 3: Mapping of IT O&R tasks with IT governance frameworks**