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Measuring the Complexity of Information Systems and Organizations - Insights from an Action Case

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MEASURING THE COMPLEXITY OF INFORMATION SYSTEMS AND ORGANIZATIONS – INSIGHTS FROM AN ACTION CASE

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Abstract

As organizations increasingly depend on information technology for their operation, complexity of information systems becomes an important issue for management in the context of organizational engineering. This paper shows how the combination of cybernetics with conceptual modelling contributes to the measurement of complexity for the analysis and design of information systems and organizations. Based on the discussion of a language-based approach, we show how conceptual modelling as an instrument for organizational analysis can significantly contribute to organizational engineering if used in combination with an established theory for control and communication. Within an action case study in an information technology controlling setting, we apply the concept of variety as a measure for complexity in combination with conceptual modelling and explore its usefulness for the diagnosis and redesign of a controlling and reporting system.

Keywords: Organizational Engineering, Complexity, Variety, Conceptual Modelling.

1 INTRODUCTION

As of today, organizations invest greatly in information technology (IT) in order to improve their operational and strategic position (Laudon & Laudon 2005, p. 7). Therefore the extent to which information systems (IS) play a part in organizations is increasing rapidly. The interaction between IT and organization is very complex and influenced by a great many mediating factors, including the organization's structure, standard operating procedures, politics, culture, environment and management decisions (Laudon & Laudon 2005, p. 77). Consequently, the main problem for an organization in achieving viability is the complexity and uncertainty exhibited by itself and its environment (Jackson 1989, p. 413). Organizational engineering (OE) aggregates multi-disciplinary concepts, methods and technologies to model, develop and analyze various aspects of changing organizations in order to create and keep the alignment between business strategy, business processes and business support systems (Tribolet & Sousa 2004). As a consequence, complexity of IS and organizations becomes a subject for OE research.

Banks are especially affected by these changes due the nature of their products. For example, their marketable products are mainly immaterial. Consequently, the production process of a bank mainly consists of information processing, thus creating new products which likewise can be seen as largely existing of information. Therefore, IT has become one of the main factors of production in banking. Historically, banks have always been sensitive to the value proposition that IT offered for acquiring, processing, and delivering information. Banks belonged to the first users of mainframes. and up until today usually are pioneers concerning the use of new IT. After the success of automated teller machines during the 1980s, the internet and IT now offer new possibilities to approach customers (Tan & Teo 2000).

The FSB[1] banking group is among the leading asset managers and financial service providers throughout Europe (as measured by managed capital). FSB runs subsidiaries in over 20 countries, engaging approximately 20,000 employees in over 600 branches. In the field of internet banking FSB is among the market leaders in Europe as measured by number of customers. Throughout Europe FSB serves more than five million customers, one million of these in Germany. In 2000, FSB acquired a German bank which became known as FSB AG. In Germany, FSB AG operates within the business areas retail banking, merchant banking, commercial real estate and asset management.

In October 2004, managers of FSB AG approached our research group, voicing difficulties in their IT controlling processes. Especially the reporting was mentioned as an area of concern, creating frustration amongst the business units. They concluded that the current IT controlling and reporting system was too complex. After a joined workshop where we discussed the relevant practical questions for FSB AG and the appropriate research methodologies, we agreed to analyze the IT controlling and reporting system and the accompanying information flows and processes at FSB AG. Addressing both relevance and rigor, the following research questions were of special interest to us:

- What are the causes for the (perceived) complexity of the IT controlling and reporting system?
- How can the IT controlling and reporting system be redesigned with respect to theses causes?
- Can we categorize the mediating factors for complexity in IS and organizations?
- Are we able to measure the complexity of an IS or organization?

In this paper, we propose to combine concepts and theories from cybernetics with a language-based approach for conceptual modelling in order to measure the complexity of IS and organizations. In the remainder of the paper we proceed as follows. First, in section 2, we introduce the concept of variety as a measure for complexity. We present our understanding of conceptual models based on language

[1] Real name withheld for reasons of anonymity.

critique and argue that conceptual models are a means to make variety visible. Afterwards, in section 3, we apply and test our approach in an action case study. Based on our analysis of the IT controlling and reporting system of FSB AG, we formulate and test hypotheses regarding the variety of this system, and make recommendations for its redesign which address relevant practical problems. Finally, in section 4, we summarize our findings and discuss implications for further research.

2 THE IDEA – VARIETY AS A MEASURE FOR COMPLEXITY

Despite extensive use of the word, there is no generally accepted definition of complexity. Complexity is a multi-facetted term which has many possible meanings (Klir 1985, Flood & Carson 1993). Since complexity is something perceived by an observer, the complexity of the system being observed can be described as a measure of the perceived effort that is required to understand and cope with the system (Backlund 2002, p. 31). Consequently, as complexity is a subjective property (Ashby 1973, p. 1), this makes the analysis and design of complexity in IS more difficult. Moreover, the Principle of Incompatibility states that as the complexity of a system increases, the ability to make precise yet significant statement about the system's behaviour diminishes (Zadeh 1973). Since unnecessarily complex IS seem undesirable, we should find methods to reduce such complexity. However, we cannot adequately address this problem unless we have a shared meaning of what comprises the complexity of an IS. Furthermore, it would be desirable to compare several organizations or IS regarding their complexity (Backlund 2002, p. 40). Then, how can we measure the complexity of an IS? Can we categorize the mediating factors for complexity in IS and organizations if complexity depends on the subjective understanding of an observer? Or are we even able to deduct a more general and intersubjective measurement for complexity?

The cybernetic concept of *variety* proposes a solution for this problem. Variety is a measure for complexity, and defines the number of manifestations or patterns of behaviour, the possible states of a system (Ashby 1964, p. 126). Variety, in relation to a set of distinguishable elements of a system, means either 1) the number of distinct elements, or 2) the logarithm to the base 2 of this number. Measured in logarithmic form, the unit of variety is the bit. For example, the variety of 32 playing cards (Ashby 1964, p. 126) is

$$\log_2 32 = 3{,}322 \times \log_{10} 32 = 3{,}322 \times 1{,}505 = 5 \text{ bits}.$$

If a situation has a variety of 32, or 5 bits, it will take five "yes/no" decisions to eliminate the uncertainty implicit in that variety – because $32 = 2^5$ (Beer 1981, p. 45). In theory, it is possible to count all possible states. If this is not directly possible, we can make comparisons ("something has more or less variety than another thing") or apply ordinal scaling ("This product is the fifth most profitable"). Consequently, by using variety as a measure, we are able to compare things that are different in nature.

Ashby's *Law of Requisite Variety* is one important driver for the design of complexity reduction: "Only variety can destroy variety" (Ashby 1964, p. 207), i. e. in order to be effective, a control system must be at least as complex and have as many potential behaviour patterns as the system to be controlled. This forms a problem for management because in order to make a system responsive to change, we need to possess as much variety as the system itself exhibits. With systems that exhibit massive variety, such as organizations and IS, only reducing the environmental variety or increasing the management's own variety enables us to cope with this problem (Jackson 2000, p. 73).

According to Conant and Ashby, model-making is compulsory for the cybernetic control of a system: success in regulation implies that beforehand, a sufficiently similar model must have been built (Conant & Ashby 1970). Thus, every good regulator of a system must be a model of that system. From this arises the concept of management as a kind of mathematical regulator, or controller, that is responsible for *homeostasis*, i. e the property of a system to regulate its internal variety to maintain a stable, constant state (Beer 1981, pp. 25-72, Ashby 1964, pp. 195-272). This assertion rests on the premise that individuals' ability to make effective decisions for the organization is limited primarily by the quality and variety of information available to them. Indeed, organizations may react ineffectively to changes in their environment if they do not possess sufficient information about those changes (Gray 2000).

It appears to be reasonable to test the use variety as our measure for the complexity of IS. But several charges have been put forward against the use of variety as a measure (cf. (Flood & Carson 1993, pp. 87-90, Jackson 2000, pp. 172-177, 207). Most severe seems to be Ulrich's attack on variety as existing on a pure syntactic level (Ulrich 1981). Ulrich argues that variety as the number of distinguishable states of a system operates only at the syntactic level, which is solely concerned with whether a message is well formed or not, in the sense of readability. Consequently, variety ignores the meaning and significance of messages for the receiver. This argument falls short considering our approach based on language critique. In this, we follow Backlund's call to explore the usefulness of variety as a measure when applied to organizations and IS (Backlund 2002, p. 40).

The work on language critique, a branch of constructive philosophy known as the "Erlangen School" of Kamlah and Lorenzen (Kamlah & Lorenzen 1984, Lorenzen 1987), provides useful insights and backup for our understanding. The question of how the conventions that align syntax, semantics, and pragmatics of symbols are formed can be answered using the construct of a *language community*. Kamlah and Lorenzen argue that language as a system of signs promotes mutual understanding as "a 'know-how' held in common, the possession of a 'language community'." (Kamlah & Lorenzen 1984, p. 47). A new term is introduced by explicit agreement between language users with respect to its usage and meaning (Kamlah & Lorenzen 1984, p. 57). This agreement leads to a relation of concept and term, and is shared by a language community as the knowledge of using this term. Accordingly, if members of a group of people communicate, and each has an aligned semantic and pragmatic dimension of a symbol in mind, then this group of people forms a language community.

Usually, conceptual models are understood as part of a method, a planned and systematic (engineering) approach (Braun et al. 2005) which deals with the process of building or interpreting a conceptual model whereby the stakeholders reason and communicate about a domain in order to improve their common understanding of it (Gemino & Wand 2004, p. 80). Conceptual modelling and reference modelling are considered to be important instruments for analyzing and solving several technical and organizational design issues on an application level, enterprise level or industry level (Moody 2005, p. 244). According to our understanding, conceptual models play a significant role in making language communities explicit: conceptual models are designed through linguistic actions of a language community, and therefore are a (written) expression of a shared language understanding, so-called *marks* (Kamlah & Lorenzen 1984, p. 46, Holten 2003a, p. 91). Marks are written-down or printed writing-signs (Kamlah & Lorenzen 1984, p. 51). They are actualized as activities by the one who produces the marks in *writing* them, and again actualized by the one who *reads* them (Kamlah & Lorenzen 1984, p. 46, Gemino & Wand 2004). Models as marks create persistent things. Like road signs, they are solidified activities which stay put, are produced and can be read. Accordingly, conceptual models as marks have persistence just as words do (Kamlah & Lorenzen 1984, p. 46, Holten 2003a, p. 91).

Therefore, conceptual models can be used as a formalized way of stating the intersubjective consensus of a language community. As a result, Ulrich's argument falls short considering language critique. Although variety – like complexity – is an inherently subjective concept, variety becomes intersubjective for the members of a language community as soon as the language community is created. Each member has an aligned semantic and pragmatic dimension of a syntactic symbol in mind. Variety as a measure of complexity for the language terms used by a language community indeed considers pragmatics and semantics respectively. Language restricts the possibilities to communicate the possible states of a system (Daft & Wiginton 1979, p. 181). Variety is a measure of the number of possible states of a system which can be expressed with the terms of a language community. Conceptual models enable us to determine the variety of the organization or IS under consideration. Based on the conceptual models, we are able to count and calculate this variety. In the next section, we show within an action case how the variety of an IS can be made visible by conceptual models, and how Ashby's Law can be used to form and test hypotheses about organizational problems.

3 THE IMPLICATIONS – AN ACTION CASE

3.1 Research Methodology

We must start then by establishing the consequences of our suggestions for our research. Every research approach is based on fundamental philosophical assumptions (Holten et al. 2005, Myers 1997, Lee 2004). Due to our understanding of language, we believe that a constructive philosophy (Lorenzen 1987) which integrates interpretive and positivist approaches is required for this purpose. Consequently, we assume that an objective world exists (*ontological realism*), but that our cognition of this world is subjective or private (*epistemological subjectivism*) (Holten et al. 2005, p. 177). We argue that due to this subjectivity, cognition relies upon the (re)construction of reality through (linguistic) action. In order to acquire an understanding of how complexity of IS can be measured, we must play a part in the development and decision processes belonging to IS development and management. We have to make recommendations and develop strategies, IS and processes, and make use of them. To do all these things without being involved would be impossible. Following this, our research approach is characterized by three roles that the researcher adopts during her or his investigation: *construction of data*, *interpretation of data* and *matching to theory* (Rosenkranz & Holten 2007).

In this paper, the three roles are applied and embodied during an action case study (Hughes & Wood-Harper 1999). After having created a subjective understanding of everyday meanings and common sense within the observed organization (FSB AG), which provides the basis for the interpretive understanding, we create a positivist understanding in order to explain the empirical reality – the explanation being a scientific theory which can be tested against the subjective meaning as recorded in the interpretive understanding (Lee 1991, pp. 351-354). Consequently, we generalize from the interpreted observations to a theory (Type ET generalizability) (Lee & Baskerville 2003, pp. 235-238).

3.2 Case Description

Our project was conducted between November 2004 and March 2006. The action case domain concerns IT controlling at FSB AG. Within the FSB Group all operative tasks concerning IT are delegated to FSB IT, a wholly owned subsidiary of FSB Group. For example, this includes the development and maintenance of networks, mainframes, host systems, databases, servers and user support (e. g. helpdesk). In Germany, these functions are operated by the German branch of FSB IT. Additionally, the Chief Information Officer of FSB AG manages all central tasks concerning IS and IT with respect to the business areas, roles and responsibilities of the German business units. From the business perspective, the specification and design of IS, and the corresponding technical sub-systems or application systems respectively, are the responsibility of the so-called system owner. The business unit that owns a system is responsible for it budget-wise, concerning requirements, change requests et cetera during the whole system life cycle.

FSB IT Development (FSB ITD) is a staff department that conducts planning, development, control, and support of IS for the German business units. On the one hand, FSB ITD develops and supports IS (*development functions*). On the other hand, FSB ITD plans and controls both self-developed IS as well as IS developed by FSB IT in order to make the use of IT services transparent to the German business units and divisional management (*controlling functions*). The so-called *structure of rationality* (Schäffer et al. 2001, Schultz 2005, pp. 80-85) includes all tools and information which directly or indirectly ensure rational action and behaviour of management (or with regard to critical stances on the concept of rationality, e. g. (Hatch 1997, Alvesson & Deetz 2000), *justified* action and behaviour). Consequently, controlling aims at ensuring management's rationality by designing and using the structure of rationality. Structure design in the context of IT controlling includes the creation of controlling tools, standards, and procedures as well as the development and implementation of a controlling infrastructure, e. g. a management IS (MIS) for the needed information supply of the business units concerning their IT usage. Structure utilization includes the use of this infrastructure in order to actually execute planning and controlling. This is done by raising, preparing and supplying relevant information for divisional management through this infrastructure. FSB ITD carries out both structure design and structure utilization for IT controlling at FSB AG. A MIS (based on a data warehouse solution using an Oracle database) is used for IT controlling and reporting in general. Data for individual reports is directly extracted from the MIS, e. g. for use with Microsoft Excel.

3.3 Data Collection & Interpretation

We conducted a series of interpretive, open interviews in workshops with different stakeholders from the domain of IT controlling (see Table 1). The workshops focused on the IT controlling process and on the roles of different people within FSB AG. They were of variable length, ranging from 30 minutes to 120 minutes. Additionally, we had full access to the MIS and to the created IT controlling reports. The transcripts and notes from the interviews, administrative documents of FSB AG, and printouts of the generated IT controlling reports were collected in a project diary. The diary served as the main source of data for the following interpretation.

Workshop	Participants	Content and actions
Initial workshop (November 2004)	head of IT controlling, three IT controllers, two researchers	Introduction to IT controlling process in general at FSB AG (~1.5 hours)
IT controlling staff (December 2004)	head of IT controlling, three IT controllers, one researcher	Discussion of IT controlling and reporting system (~2 hours)
IT controlling staff (January 2005)	three IT controllers, one researcher	Discussion and design of conceptual models (~2 hours)
IT controlling staff (March 2005)	two IT controllers, one researcher	Discussion and design of conceptual models (~2 hours)
IT development staff (October 2005)	two system developers, two IT controllers, one researcher	Discussion on IT controlling process for a specific IS (~1 hour)
IT development staff (October 2005)	one system developer, one IT controller, one researcher	Discussion on IT controlling process for a specific IS (~30 minutes)
Business unit staff (November 2005)	head of one business unit, one service staff (from business unit), one IT controller, one researcher	Discussion on IT controlling from business unit perspective (~1.5 hour)
Business unit staff (December 2005)	Two service staff (from business units), one IT controller, one researcher	Discussion on IT controlling from business unit perspective (~45 minutes)

Table 1. Overview about interviews and workshops

For the investigation of the IT controlling reports, we used conceptual models as an instrument for analysis, choosing MetaMIS as a modelling language tailored to the domain of reporting and management views. The MetaMIS approach has been originally developed for the specification of management views on business processes (Holten 2003b, Holten et al. 2005). By using a semantic model based on Riebel's enterprise theory (Riebel 1979), the MetaMIS approach is an ontology-driven method which aims at bridging the communication gap between IT departments and business units. Initially, we constructed the conceptual models based on our understanding of the reports and the MIS, which was refined by insights gained from the workshops and observation of actual controller activities. Afterwards, all project participants at FSB AG were made familiar with the MetaMIS approach, which resulted in a common language in order to discuss the conceptual models during workshops. We did not force the language on the subjects. Instead, all project participants jointly agreed that MetaMIS is especially suitable to the phenomenon under examination and meets the requirements of both researchers (clarification, formalization and interpretation of the subjective understanding of the problem domain) and practitioners (specification, documentation and analysis of the existing IT controlling and reporting system). Consecutively, the models were refined together with all project participants. This resulted in a presentation of facts about the IT controlling and reporting system in such way that all project participants could understand it and relate it to their objectives.

The conceptual models also ensured that we as researchers became part of FSB AG's language community and actually understood what is really happening in IT controlling at FSB AG, since these descriptions were created and discussed by the language community consisting of all project participants. Consequently, the conceptual models allowed us to generate an interpretive understanding of the situation (Lee 1991, p. 351). We asked direct questions in order to analyze the IT controlling and reporting system, and the participants made direct statements. Additionally, we applied the Viable System Model (for a full description see (Beer 1979, Beer 1981, Beer 1985)) for matching our interpreted data and reflecting on the obtained information.

3.4 IT controlling at FSB AG

FSB ITD in its controlling function creates very detailed reports of IT usage for the IT services provided by both FSB ITD and FSB IT (see Figure 1 as an excerpt of the conceptual models jointly created based on the workshops). An in-depth analysis of the constructed models revealed that the reporting is purely cost-based. The costs for the IT services supplied by FSB IT are based on internal transfer prices for IT items which generally are used for the chargeback of IT costs. These prices are negotiated between the divisional management of the German business units and FSB IT's management. The chargeback structure is initially applied for the resource bargaining during periodical budgeting negotiations between FSB IT and the business units. As a result, the charged items are extremely technical (e. g. measured as "costs per CPU second"). The created models are extremely large and intricate, mirroring this phenomenon.

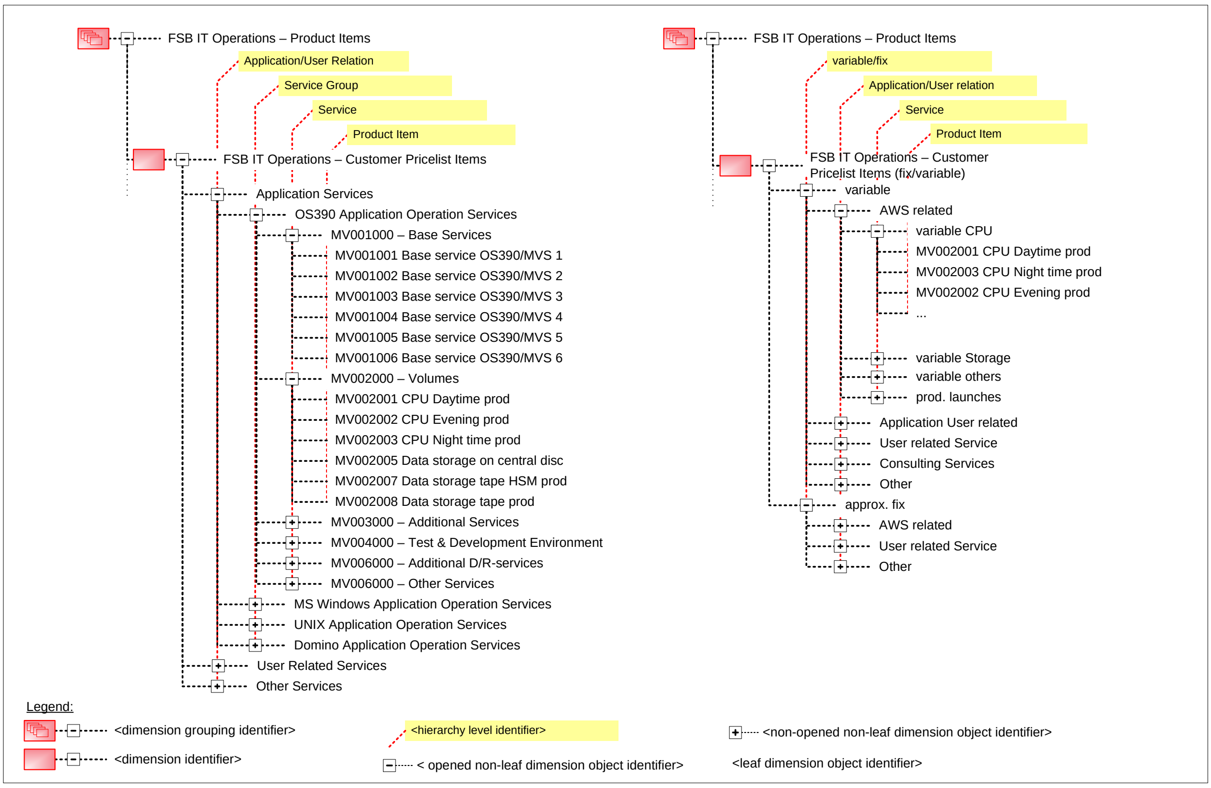


Figure 1. MetaMIS model of item catalogue (excerpt)

The models show that all in all the variety of this item catalogue is very high: it lists over 1,000 single items, grouped according to around 85 services. Each of these items is used in several IS, for which both price negotiation and controlling are undertaken. Usually, a management decision is the selection of one possible state from all the others. Additional complexity arises because even these items are not constant over time, but change between and during budget periods. In the example of a document management system, the MetaMIS models revealed that nearly two-thirds of the charged items for this system changed between two exemplary budgeting periods. There are approximately 550 items *per period* in total – each with a price accuracy down to Euro and cent. The average IS at FSB AG includes about 150 single items per period. FSB has approximately 150 IS in total for which IT charge-back and reporting are conducted.

The *potential* variety of the IT controlling and reporting system, as revealed by the conceptual models and reflected in the item catalogue, appears as approximately

$$V \approx \text{number of IS} \times \text{set of possible combinations using 150 items} = 150 \times 2^{150} \approx 157 \text{ bits}.$$

Note that we did not consider the additional variety which is a result of the changing item structure. In order to identify a particular item – an item for an IS – we need to select one out of that total variety. Of course, constraints (Ashby 1964, p. 127) do apply here, e. g. a Unix system usually will not have any Microsoft Windows items. The reduction to the most encountered items is another type of constraint. But even with grouping and categorization of items, which leads to a further reduction of numbers (and which is a rather fruitless task since the item structure is constantly changing), a decision for a single IS is a matter of selecting "yes/no" answers for more than 150 items on an average. Even though this measure is not numerically accurate, the magnitude of the problem is quite clear and unambiguous. These numbers are large, and usually there are many more dimensions entailed. Consequently, the numbers involved in calculating variety for IT controlling are indeed enormous, and hence for decisions based on this information, too. The models point to a high variety within the coordinatory function of FSB ITD: the item structure used for IT controlling and reporting 1) has many detailed items, and 2) is changing often. Speaking with Beer, "a measure of this kind is irrelevant to any conceivable response" (Beer 1979, p. 35). It is impossible to imagine a system in which the addition of one cent to the price of one single item, or the removal of one cent, could possibly have an operational significance on an IS other than nit-picking. The change of the item structure during and between budgeting periods even makes things more complex.

3.5 Matching with Theory – Hypothesizing on the Establishment of Requisite Variety

To summarize, the IT controlling and reporting system exhibits a proliferating variety. The conceptual models enabled us to make the magnitude of that variety visible. According to Ashby's Law, varieties tend to equate naturally (only variety absorbs variety). Consequently, the proliferating variety will be compensated by other means. The *actual* variety must be less enormous than the potential variety. As a result, we hypothesized that in order to establish requisite variety, either 1) *attenuation* on the side of the business units reduces the variety generated by the IT controlling and reporting system, or 2) *amplification* on the side of the business units increases the variety of divisional management (Beer 1979, pp. 89-93). Both types of adjustment establish requisite variety for the IT controlling and reporting system and should be detectable accordingly. As a consequence, we were seeking an understanding of the variety amplifiers and attenuators whereby FSB AG met the requirements of Ashby's Law. In order to corroborate or falsify this hypothesis about the establishment of requisite variety, we subsequently conducted a second set of unstructured interviews in the workshops between October 2005 and December 2005. The questions for these informal interviews were derived from our application of Ashby's Law. In addition, we used the conceptual models as a starting point for discussions. This is in line with hypothetic-deductive logic (Lee 1989, p. 129) and following the modus operandi of the effective dialogue rule in constructive logic (Lorenzen 1987, p. 90 et seq., Lorenzen 2000, pp. 64, 75). First, we prove the precondition that the variety of the IT controlling and reporting system is very high. Then, we provide evidence for the existence of attenuators and amplifiers for balancing this misdesigned variety, which are a consequence of Ashby's Law and violate Beer's *First Principle of Or-*

ganization: managerial, operational and environmental varieties should be designed to equate with minimal damage to people and to cost (Beer 1979, p. 97).

Following our analysis, our hypothesis about the establishment of requisite variety was corroborated according to our findings. To summarize our results, people from FSB AG's business units have difficulties to understand the IT controlling reports. They are not "written in business language" and "not related to the daily affairs". In addition, the pure number of the provided information generates a feeling of "information overload". Summarizing this, an IT controller stated (in a workshop conducted in October 2005): "*They [the IT department] talk of transparency concerning the item catalogue: everything and every detail is open to analysis. But providing all the detailed information does not create transparency with regard to daily business. In fact, we are drowning in details.*" In order to cope with this problem, the business units have developed various strategies. We present two examples of amplification and attenuation.

- One business unit appointed two employees with a background in IT that are responsible for the analysis of the IT reports and for the understanding of the item catalogue. Additionally, the same business unit extended the original item catalogue with self-provided descriptions in order to make the items understandable for non-IT personnel. With these two mechanisms, this business unit establishes the missing variety by amplification.
- Other business units, mostly larger ones, ignore the item catalogue and the IT controlling reports completely. They simply wave the IT costs through their internal cost control. This acts like an attenuator that filters out the variety generated by the IT controlling and reporting system.

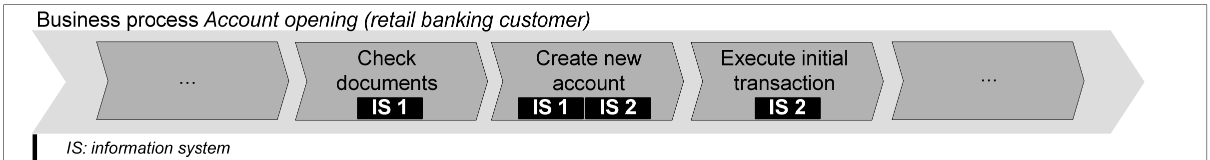
Of course, despite these findings, the as-is item catalogue is far from useless. It provides the structure to gather data for IT chargeback at the most detailed level and is necessary in accounting for a fair allocation according to the input involved. But often data is confused with variety. Data distinguishes possible states of the system, but they are generated by/through classifications, categories and definitions, which determine the variety and are within our power to design (Beer 1985, p. 24). The structure needed for IT chargeback is not instantly usable for IT controlling and reporting because the level of detail does not make the usage of IT transparent to the business units.

3.6 Relevance for Intervention – Practical Consequences

According to our findings, the implemented IT controlling and reporting system at FSB AG is not designed with regard to requisite variety. Therefore, it is quite clear by the different strategies employed by different business units that the existing IT controlling system fails to deliver information that makes the usage of IT transparent to the business units. Consequently, control and regulation cannot be successful, since no sufficient model has been built. This leads for example to the need of experts with good knowledge of IT in order to establish requisite variety for divisional management, and consequently to a misuse of resources (i. e. time, people and/or money). As a practical recommendation, the IT controlling and reporting system should be redesigned in order to fulfil its cybernetic role as a regulator. Therefore, we proposed to FSB ITD that this problem could be solved by a radically reduced item catalogue, made up of terms that are understandable by both business units and IT departments in the sense of a language community (Zarnekow & Brenner 2003, Nolan 1977). The attention must be directed to a classification of items which attenuates the variety of the IS to the nearest matching item of a much smaller list of items, thus reducing the variety and the combinatorial implications.

As a result, FSB ITD decided to design and test a new IT controlling and reporting system in a preliminary study. Building up on the original item catalogue, an activity based costing (ABC) approach (Kaplan 1985) was used to foster communication between the IT departments and the business units (Ross et al. 1999). In order to make the use of IT more transparent to divisional management, the technical items are encapsulated in packages based on business processes and activities (Gerlach et al. 2002). ABC allows a fair allocation of costs according to the input involved in terms related to business processes and daily business affairs. The preliminary study successfully tested the approach for a specific IS in one of the business units. The new reduced item catalogue offers items that are closely related to business processes. *Volume-driven costs* are calculated by spreading the sum of the IT costs according to the activity-specific IT usage indicated by cost drivers. *Volume-neutral costs*, which occur independently of cost drivers, are charged to the activities proportionally to IT usage. The sum of both cost types is used in order to determine the process cost rate which mirrors the IT costs for the handling of one process. One difficulty regarding ABC for IT services is to determine the exact contribution of specific IT resources to volume-driven costs (Gerlach et al. 2002). Since several business processes share one or more IS, sometimes the contribution of each IS to a process or activity can only be estimated, relying on assumptions and judgements jointly made by IT staff and business users.

Figure 2 exemplarily summarizes the construction of a new business-related item for the business process of "Account opening (retail banking customer)". Instead of listing costs for every used IT resource and every IS, the technical complexity of the original item catalogue has been encapsulated in one process-oriented item. The resulting process cost rate determines the costs for this packaged item and determines the internal transfer prices. Business units can influence the cost drivers of the activities, which are related to their daily affairs, and the resulting IT costs respectively. The IT controlling and reporting system based on these items is designed with requisite variety in mind. Shortly after the preliminary study, the new CEO of the FSB Group decided (independently of our suggestion to FSB AG) to drastically reduce the number of items in the item catalogue by using it on an aggregated level only. For us, this indicates that our approach is going in the right direction.



ABC model for item *Account opening (retail banking customer)*

Activity	Cost driver: Type	Cost driver: Quantitiy	IT costs (in EUR): Volume-driven costs	IT costs (in EUR): Volume-neutral costs	Activity based IT costs (in EUR)
Check documents	Number of documents	450,000	356,000	50,000	1.10 per unit
Create new account	Number of account openings	25,000	40,000	10,000	2.00 per unit
Execute initial transaction	Number of transactions	120,000	200,000	5,000	1.71 per unit
...	...		...		...
				Process cost rate / transfer price:	∑ 17.50

Figure 2. ABC model for item / business process "Account opening (retail banking customer)"

4 DISCUSSION & CONCLUSION

In this paper, we showed how conceptual modelling and cybernetics can be combined in order to provide an effective instrument for the measurement of complexity in OE. By applying language critique as a means to understand conceptual models, we were able to justify the use of variety as a measure for the complexity of IS and organizations. We confronted Ashby's Law as a theory with our interpreted observations in order to deduct meaningful insights. Based on Ashby's Law, we generated the hypothesis that facing failed design of the IT controlling and reporting system, requisite variety asserts itself in other ways, i. e. through the business units. Consequently, we generalized from the interpreted observations to a theory. The consequences of the necessity of requisite variety as predicted by Ashby's Law have been corroborated for this single case. Certainly, the practical recommendations could have been obtained without reference to any theory, by just observing and describing the illustrated problems and reactions to them. However, the application of a rigorous theory adds more value than a common sense description; it *explains* the particular behaviour and allows the scientific evaluation of a relevant problem. Our understanding shows how conceptual modelling can be applied as a tool for diagnosis in OE if used in combination with a scientific theory for evaluation. Using the concept of variety and Ashby's Law as a theory in order to test our hypotheses, we make sure that our research approach is both rigorous and relevant. The use of the conceptual models allows us to develop a measure of complexity, building on the concept of variety. Thus, conceptual models as marks of linguistic action serve as a diagnostic instrument for organizational problems and make variety visible. Consequently, we explored and showed the usefulness of variety as a measure for complexity of IS and organizations. Without conceptual models, we would have been unable to conduct our analysis. But from our perspective, the use of conceptual models without a scientific theory for grounding is not very helpful in order to arrive at meaningful conclusions. Next, we will investigate if variety can be combined with other metrics for complexity. We are convinced that variety as measure can also be applied to other organizational domains.

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References

Alvesson, M. and Deetz, S. (2000) *Doing Critical Management Research.* Sage, London, UK et al.

Ashby, W. R. (1964) *An Introduction to Cybernetics.* University Paperbacks, London, UK.

Ashby, W. R. (1973) Some peculiarities of complex systems. *Cybernetic Medicine* 9 (2), 1-7.

Backlund, A. (2002) The concept of complexity in organisations and information systems. *Kybernetes* 31 (1), 30-43.

Beer, S. (1979) *The Heart of Enterprise.* John Wiley & Sons, Chichester, UK et al.

Beer, S. (1981) *Brain of the Firm.* John Wiley & Sons, Chichester, UK et al.

Beer, S. (1985) *Diagnosing the System for Organizations.* John Wiley & Sons, Chichester, UK et al.

Braun, C., Wortmann, F., Hafner, M. and Winter, R. (2005) Method Construction - A Core Approach to Organizational Engineering. In *20th ACM Symposium on Applied Computing (SAC 2005)*, pp 1295-1299, Santa Fe, New Mexico, USA.

Conant, R. C. and Ashby, W. R. (1970) Every good regulator of a system must be a model of that system. *International Journal of Systems Science* 1 (2), 89-97.

Daft, R. L. and Wiginton, J. C. (1979) Language and Organization. *The Academy of Management Review* 4 (2), 179-191.

Flood, R. L. and Carson, E. R. (1993) *Dealing with Complexity. An Introduction to the Theory and Application of Systems Science.* Plenum Press, New York, NY, USA.

Gemino, A. and Wand, Y. (2004) A framework for empirical evaluation of conceptual modeling techniques. *Requirements Engineering* 9 (4), 248-260.

Gerlach, J., Neumann, B., Moldauer, E., Argo, M. and Frisby, D. (2002) Determining the Costs of IT Services. *Communications of the ACM* 45 (9), 61-67.

Gray, P. H. (2000) The effects of knowledge management systems on emergent teams: towards a research model. *The Journal of Strategic Information Systems* 9 (2), 175-191.

Hatch, M. J. (1997) *Organization Theory. Modern, Symbolic and Postmodern Perspectives.* Oxford University Press, Oxford, UK et al.

Holten, R. (2003a) Integration von Informationssystemen. Theorie und Anwendung im Supply Chain Management. Universität Münster, Münster, pp 133-216.

Holten, R. (2003b) Specification of Management Views in Information Warehouse Projects. *Information Systems* 28 (7), 709-751.

Holten, R., Dreiling, A. and Becker, J. (2005) Ontology-Driven Method Engineering for Information Systems Development. In *Business Systems Analysis with Ontologies* (Green, P. and Rosemann, M., Eds), pp 174-215, IDEA Group, Hershey, PA, USA et al.

Hughes, J. and Wood-Harper, A. T. (1999) Systems development as a research act. *Journal of Information Technology* 14 (1), 83-94.

Jackson, M. C. (1989) Evaluationg the managerial significance of the VSM. In *The Viable System Model. Interpretations and Applications of Stafford Beer's VSM* (Espejo, R. and Harnden, R., Eds), pp 407-439, John Wiley & Sons, Chichester, UK et al.
Jackson, M. C. (2000) *Systems Approaches to Management.* Kluwer Academic/Plenum Publishers, New York, NY, USA.
Kamlah, W. and Lorenzen, P. (1984) *Logical Propaedeutic. Pre-School of Reasonable Discourse.* University Press of America, Lanham, MD, USA.
Kaplan, R. S. (1985) Cost Accounting - A Revolution in the Making. *Corporate Accounting* (Spring 1985), 10-16.
Klir, G. (1985) Complexity: some general observations. *Systems Research* 2, 131-140.
Laudon, K. C. and Laudon, J. P. (2005) *Essentials of Management Information Systems. Managing the Digital Firm.* Pearson Prentice Hall, Upper Saddle River, NJ, USA.
Lee, A. S. (1989) Case Studies as Natural Experiments. *Human Relations* 42 (2), 117-137.
Lee, A. S. (1991) Integrating Positivist and Interpretive Approaches to Organizational Research. *Organization Science* 2 (4), 342-365.
Lee, A. S. (2004) Thinking about Social Theory and Philosophy for Information Systems. In *Social Theory and Philosophy for Information Systems* (Willcocks, L. and Mingers, J., Eds), pp 1-26, John Wiley & Sons, Chichester, UK et al.
Lee, A. S. and Baskerville, R. L. (2003) Gerneralizing Generalizability in Information Systems Research. *Information Systems Research* 14 (3), 221-243.
Lorenzen, P. (1987) *Constructive Philosophy.* The University of Massachusetts Press, Amherst, MD, USA.
Lorenzen, P. (2000) *Lehrbuch der konstruktiven Wissenschaftstheorie.* J. B. Metzler, Stuttgart, Weimar, Germany.
Moody, D. L. (2005) Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & Knowledge Engineering* 55, 243-276.
Myers, M. D. (1997) Qualitative Research in Information Systems. *MIS Quarterly* 21 (2), 241-242.
Nolan, R. L. (1977) Effects of Chargeout on User/Manager Attitudes. *Communications of the ACM* 20 (3), 177-185.
Riebel, P. (1979) Gestaltungsprobleme einer zweckneutralen Grundrechnung. *Zeitschrift für betriebswirtschaftliche Forschung* 31, 863-893.
Rosenkranz, C. and Holten, R. (2007) Combining Cybernetics and Conceptual Modeling – The Concept of Variety in Organizational Engineering. In *22nd Annual ACM Symposium on Applied Computing (SAC 2007),* Seoul, Korea.
Ross, J. W., Vitale, M. R. and Beath, C. M. (1999) The Untapped Potential of IT Chargeback. *MIS Quarterly* 23 (2), 215-237.
Schäffer, U., Weber, J. and Prenzler, C. (2001) Characterising and Developing Controller Tasks – A German Perspective. *CCM-Forschungspapiere,* Otto Beisheim School of Management, Koblenz, Germany.
Schultz, M. B. (2005) *Anreizorientiertes Investitionscontrolling mit vollständigen Finanzplänen - Ein Referenzprozessmodell für Investment Center.* Berlin.
Tan, M. and Teo, T. S. H. (2000) Factors Influencing the Adoption of Internet Banking. *Journal of the Association for information Systems* 1, 1-42.
Tribolet, J. and Sousa, P. (2004) Editorial Message: Special Track on Organizational Engineering. In *19th Annual ACM Symposium on Applied Computing (SAC'2004),* pp 1337-1338, Nicosia, Cyprus.
Ulrich, W. (1981) A critique of pure cybernetic reason: the Chilenian experience with cybernetics. *Journal of Applied Systems Analysis* 8, 33-59.
Zadeh, L. A. (1973) Outline of a New Approach to the Analysis of Complex Systems and Decision Processes. *IEEE Transactions on Systems, Man, and Cybernetics* SMC-3, 28-44.
Zarnekow, R. and Brenner, W. (2003) A product-based information management approach. In *11th European Conference on Information Systems (ECIS 2003)* (Ciborra, C. U. and Mercurio, R. and De Marco, M. and Martinez, M. and Carignani, A., Eds), Naples, Italy.