

MANAGING CHANGE – DETERMINING THE ADAPTABILITY OF INFORMATION SYSTEMS

Katja Andresen, Chair of Business Information Systems, University of Potsdam, Germany,
kandresen@wi.uni-potsdam.de

Norbert Gronau, Chair of Business Information Systems, University of Potsdam, Germany,
ngronau@wi.uni-potsdam.de

Abstract

The ability to adapt to frequent changes has emerged as a new paradigm for successful business operations. Hereby common information systems are mostly not able to fulfil the requirement of adaptability for business or organisational changes. However, the ability to adapt to changes is crucial for business organisations and the support of business processes by information systems plays a crucial part.

In this paper a requirement model is presented that allows the identification of building blocks and proceeding models for adaptive information system architectures. By using the example of enterprise systems it is emphasised how the pattern approach enables the assessment of the adaptability for information systems, and how adaptability of information systems can be linked with the current external environmental requirements. Initially, adaptability is a fundamental concept widely known in natural systems. The link between adaptability and information systems is outlined within this paper. Patterns about the behaviour of natural systems are taken as a model for the design and organisation of information systems.

Keywords: adaptability, enterprise systems, pattern-based approach

1 INTRODUCTION

Business change is one of the most outstanding and most pervasive qualities of organisational life. There has been some consideration of business change itself, but less emphasis has been on studying the outcomes of this change with regard to information technology (IT) and its interrelation. However, many problems occurring in daily business are of organisational character (Aier and Schoenherr, 2004). Organisational change requires the information systems architecture of an organisation to adjust too (Gronau, 2003). Process examples are for instance increased growth of an organisation, the introduction of a decentralised sales and marketing division instead of a central approach or the continuous process improvement of a manufacturing schedule.

In this contribution the necessity of adjustment for business information systems according to organisational environment conditions will be outlined. Based on the central thesis that adaptability in information systems is measurable, this paper sets the main focus on the determination of the information systems ability to adapt to organisational changes. In the next step it is shown how the degree of IT adaptability supports IT strategic decisions.

In the following section the term adaptability is defined. Adaptability is presented in the context of different application domains. Its main qualities are conveyed to information system. For that, the pattern based approach is chosen. Patterns can be understood as a principle to express intrinsic characteristics of a bounded problem space (Alexander, 1977; Hohpe and Woolf, 2004).

Afterwards, in the 3rd section, the pattern-based approach on the measurement of adaptability is presented. On this account some of the most popular open-source enterprise systems have been installed and tested to demonstrate the feasibility of the research approach. Why have the enterprise systems been chosen? Enterprise systems are usually the backbone of an organisation hence organisational changes do affect the process model of the enterprise systems when modifications have to be made. Applications change over time. An integration solution, such as Enterprise Resource Planning (ERP or enterprise) systems, has to keep pace with the changes in the applications it connects. Integration solutions can easily get caught in an avalanche effect of change – if one system changes, all other systems may be affected. Integration solutions need to transmit information between systems that use different programming languages, operating platforms and data formats. An integration solution has to be able to interface with all these different solutions. Therefore it is necessary to design for change. Business needs an infrastructure that supports change. Adaptive systems enable the core business to cope with unforeseen circumstances.

We also believe that the pattern-based approach can be applied to any other information system therefore enterprise systems are seen as a model for the measurement of adaptability of other information systems.

2 ADAPTABILITY IN INFORMATION SYSTEMS

For a company being adaptable is to be capable of operating productivity in a competitive environment of continually and unpredictable changes (Balve et. al., 2001). *For an individual* being adaptable is to be capable of contributing to the bottom line of a company that is constantly reorganising its human and technological resources in response to unpredictable market changes.

For the domain of information systems adaptability is defined as a concept which applies biologically-inspired methods to enhance the capabilities of computer systems (Hernandez, 2002). Adaptability enables information systems to follow changes which occur along the lifetime of a software system. In this spirit, adaptability is a visionary concept. A vision which assumes that business support is given almost autonomously during build and runtime of the software system.

The structure of an organisation, its management strategies and interrelations affect how information technology helps an enterprise to sustain a competitive edge, increase its business and compete in an internet-enabled economy (Malhorta, 96). Because the management of technology is seen as a key to competitiveness and wealth creation, a technology perspective is an important criterion for evaluating flexibility and competitiveness of an organisation (Khalil, 2001).

Terminology on adaptability is not consistent. The most essential terms comprise for instance flexibility, adaptation and agility.

Historically, the study of *adaptation* in natural systems provides a starting point for a theory and methodology of adaptability. The comprehension of adaptation has been heavily influenced by Holland and is linked with artificial intelligence. Holland defines adaptive processes as optimisation processes whereby the system typically has many alternatives to act on which where programmed (provided from the outside) in advance (Holland, 1992).

Flexibility, agility and adaptability are often used interchangeably. The dictionary definition reveals a broad variety of interpretations on flexibility, e.g. pliability, manipulability, but also adaptability. Within flexibility most authors compare the range of possible states as being anticipated and pre-installed at the point of initial investment (Upton 1994; Slack 1983; Zaeh and Mueller, 2005)

In consequence, the flexibility range (of alternatives) is fixed. Within this range the system (IT, production and organisation) can easily adapt, whereas leaving the corridor is not within the scope. In

contrast adaptable systems are not limited to a fixed problem space. These systems are highly self-organised so that a solution can be created from within the system to adapt properly.

Agility is considered dynamic context-specific, aggressively change—embracing and growth-oriented. Most authors agree that ‘agility’ is the ability to rapidly respond to an external and unexpected event. The argument promoting agility is that it enables better survival in turbulent market conditions (Sun and Zhang 2005; Kidd 1996, Nelson and Harvey 1995). Agility is mainly seen in a business or process context emphasising fast and efficient behaviour.

From a research viewpoint adaptable systems represent the ideal final condition reflecting unlimited problem space. Therefore it is necessary to extract the qualities which are responsible for adaptable behaviour and to transfer these qualities on information systems.

To measure the relation of IT adaptability and its impact on the organisation, research suggests considering two important aspects: First, the organisational dimensions (e.g. customer, partnering and operational agility) and second, the technical system (e.g. the IT infrastructure) that supports or hinders adaptability in these areas (Ngo-Ye and; Ahsan, 2005; Henderson and Venkatraman 1993). Ngo-Ye and Ahsan propose a strategic alignment model of “fit” between information technology and organisational requirements. They argue that both dimensions should be outbalanced to ensure an “agile” overall organisation’s performance.

2.1 The Concept of Patterns

Patterns provide a way to capture and document expert knowledge to be used by non-experts. The pattern approach provides the foundation for various pattern styles such as design and analysis pattern for instance. The pattern itself describes a problem which occurs in similar variations within a defined problem domain (Fowler, 2003). The description focuses on similarities within the problem space and provides a high-level solution. Hohpe and Woolf (Hohpe and Woolf, 2004) take a different perspective by describing a pattern as a decision which has to be made and the considerations that go into that decision.

Patterns are often and partially unconsciously used by humans as a problem-solution scheme. Examples for the deliberate deployment comprise architecture (Alexander et. al. 1977), strategy and warfare (Tzu and Pin, 1996), jazz music (Coker et. al. 1970), the management of organisations (Hinton 2002), the analysis of cognitive processes (Gardener et. al. 1998), and the development of reusable software (Coplien et. al. 1995).

Given the assumptions of organisational change presented in *chapter 2* this research suggests that it is possible to observe a number of patterns that exist specific to adaptability requirements in enterprise systems. The detected patterns are based on iterative analyses of business process requirements and technical features with regard to adaptability and its attributes such as efficiency and flexibility for instance.

2.2 Patterns of Adaptability

Identified patterns for enterprise systems fall into two main categories. The first of these identifies technological artefacts. This category is termed system-based patterns of adaptability. System-based patterns relate to the enterprise system and its given architecture elements. Patterns of this dimension enable the system to adapt.

The second dimension recognises patterns in the process of applying enterprise systems in real world scenarios. Business patterns outline the business need for adaptability and permit to change scenarios.

While the first of these dimensions identifies the structures that exist in the information systems themselves the second recognises patterns in the process of intervention which bring about changes in the enterprise system (as a consequence of business process changes). The classification is presented in the next figure.

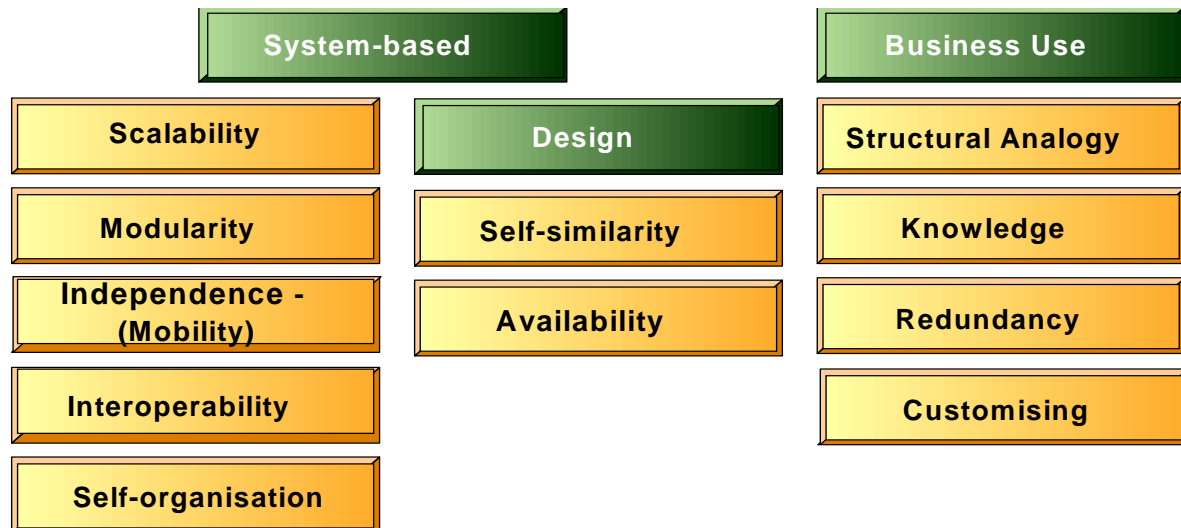


Figure 1. Identified Patterns of Adaptability

System patterns describe the immanent qualities of the information system itself. Independent from surrounding conditions system patterns show the latent ability of the system to support adaptability. The system is considered a closed system to measure its capacities to manage change. System-based patterns comprise design-related patterns. The sub-category design pattern represents high-level abstractions that describe specific design decisions.

The business dimension characterises the circumstances of usage for an information system. It is outlined that the degree of adaptability, which can be reached by a specific information system, is influenced by decisions referring to the deployment of the software within a business organisation. For this reason the patterns presented below are called business use patterns.

The use patterns or the business dimension characterise the circumstances of the usage of an information system. They reflect that adaptability enabling factors are also related to decisions referring to the deployment of the system. In this area patterns are for instance the capabilities of personnel (person-bound) knowledge; existing guidelines to properly deploy a software system.

3 MESURING ADAPTABILITY

To demonstrate the usage of the approach, four popular open-source enterprise systems have been chosen, namely AvERP, Lx-Office and WebERP+.

The system-based dimension is measured by evaluating the technological realisation of the software based on patterns. Behind each pattern a questionnaire is hidden to judge the quality of each pattern.

For instance, a technology as web services is a popular for implementing service-oriented applications. How adaptable is a web service? Generally, web services facilitate the seamless integration of services. Web services do allow organisations to link applications to and across enterprises.

Organisations have the ability to add or drop services of other business partners without worrying about the implementation details. However, the central dictionary that describes the services is a constraint in terms of scalability (Gronau 2003b, Marx- Gómez et. al. 2004). Also, web services are able to adapt to changes in their requirement(s), and they are self-descriptive. Some features have been automated within web services, which make the systems that are based on web services self-organising. The following table shows the general evaluation of web services based on a three point scale (whereby the value “0” representing “hinders adaptability” is not assigned).

Pattern	Web Service	Judgement
Scalability	1	Might support adaptability (depending on realisation)
Modularity	2	Full support
Independence	2	Full support
Interoperability	2	Full support
Self-organisation	2	Full support
Availability	1	Might support adaptability
Self-similarity	2	Full support

Table 1: Example for Judgement of Adaptability

The evaluation of the business process dimension is accomplished by modelling process examples into an enterprise system. The evaluation is based on the patterns knowledge and customising in the first place. For example the assessment of *customising* checks possibilities to adjust a system manually to support a given (pre-defined) process. The scale indicates the effort to adjust the system to support the process. The range starts at zero for no possibility to customise and finishes at the stage of completely automated indicating an implemented self-organisation of the system.

Scale	Customising
0	Customising not possible
1	Possible by re-arranging the source code
2	Supported – functions are available for integration
3	Completely automated

Table 2: Scale for degree of customising

In order to differentiate priorities of patterns, the Analytical Hierarchical Process (AHP) was applied to express that the patterns of a layer are unequally important (Saaty and Vargas 1994). AHP is a multi-attribute evaluation method (Saaty 1980). As a result the patterns are assigned different priorities represented by weights used for evaluating the system-based and the business use dimension.

3.1 Merging Dimensions

The following figure shows the result of the evaluation of the enterprise systems. The business and the system-based dimension are shown on the relevant axis.



Figure2. Merging Dimensions.

The four areas do allow the following interpretation:

1. Area: Average values (low system-based, low in business use):

The system is not adaptable. The system architecture is not able to respond to changes and business processes cannot be converted. As these systems merely support business process changes, they should only be deployed in a stable environment implying stable processes.

2. Technical-advanced area: low system-based, high in business use:

System architecture does not meet the requirements of a turbulent environment. However, it is possible to model the business processes which were chosen individually. This result is typical for simple, standardised processes. This situation reflects a minimal requirement. The system should only be chosen if the environment is predicted to be stable in future too.

3. Process-advanced area: high system-based, low business-based:

The system meets the requirements of adaptable system architecture. On the other hand the system is poorly designed to support business processes. The reasons for it can be various. The extreme perspective would reveal an adaptable system with limited functionalities of an enterprise system. Since the system shows poor support for business process changes, the system's purpose could be different from an enterprise system.

4. Adaptability excellence: high system-based, high business-based:

The system is highly adaptable. The architecture along with business features will cover the needed degree of adaptability if the business processes are well chosen. It is therefore suitable to be deployed in a turbulent environment.

Although there is a difference between the results, all systems fall into the same area named “average”, providing low support for business as well as systems dimension. At the business dimension no major differences are visible. Although the business processes were build on a simple basis to fulfil the most essential for a re-organisational fit, the sub processes are not well supported in any tested system. On a systems level there is much room for improvement with regard to self-organisation. Patterns such as self-documentation and self-diagnosis are hardly realised.

3.2 Better Adaptability in LX-Office extended (LX-Office ext.)

To demonstrate the influence of patterns LX-Office was chosen to become more adaptable by enhancing the system-based architecture. For this reason LX-Office was extended with a diagnostic tool – a component enhancing especially self-organisation. The tool features allow that predefined system parameters can be checked by the system automatically. On this basis an action such as “decentralise now” can be taken automatically or arranged manually. The latter means that each step performed by the system can be approved or neglected.

The extended version of LX-Office now utilises means to import/export data and self-diagnoses. The implemented features help to improve interoperability along with self-organisation. As a result, the technical system-based adaptability is improved. Since the business process (decentralisation) can be fully modelled into the system, now the matrix values reflect a better degree here too. To sum up, LX-Office extended is more adaptable; as a result it is now located in the process-advanced area.

4 SUMMARY

The main line of this paper contributes to the debate on the adaptability of information systems within a changing organisational environment. To overcome the lack of methodical support, patterns embedded in procedure models to assess and evaluate the adaptability of information systems were outlined. To demonstrate feasibility, the focus was narrowed to enterprise systems representing core assets in the information system’s architecture. The study suggested the consideration of two dimensions: the general technical (system-based) and the individual process-related (business use) dimension. The assessment in both cases is criteria-grounded. The criteria were formulated in the form of a pattern language.

To show the feasibility of the pattern approach, open-source systems have been tested on the basis of weighted patterns. The system-based and the business use dimension were analysed separately, showing that both dimensions are minor developed for all analysed systems. Nonetheless, it could be demonstrated that enhanced adaptability potential is a result of an improved pattern performance. The enterprise system LX-office, which was manipulated to support self-diagnosis, provided an example for this.

References

- Aier, S and Schoenherr, M.: Enterprise Application Integration - Flexibilisierung komplexer Unternehmensarchitekturen. GITO-Verlag, Berlin, 2004.
- Alexander, C.; Ishikawa, S.; Silverstein, M.: A Pattern Language: Towns, Buildings, Construction. In: Center for Environmental Structure Series, 2. Oxford University Press, New York, NY, 1977.
- Balve, P., Wiendahl, H., Westkämper, E.: Order management in transformable business structures - basics and concepts. In: Robotics and Computer Integrated Manufacturing, Volume 17, Issue 6, 2001; 461-468.
- Coker, J; Casale, J.; Campbell, G.; Greene, J.: Patterns for Jazz: for Bass Clef Instruments. Studio Publications Recordings, Miami, FL, 1970.
- Coplien J., O.; Schmidt, D., C. (ed.): Pattern Languages of Program Design. In: The First Annual Conference of Pattern Languages of Programs (PLoP), Monticello, Ill., 1994. Addison-Wesley, Reading, MA, 1995.
- Fowler, M.: Patterns of Enterprise Application Architecture, Addison-Wesley, 2003.
- Gardner, K., M.; Rush, A., R.; Crist, M., K.; Konitzer, R.; Teegarden, B.: Cognitive Patterns: Problem-Solving Frameworks for Object Technology. In: Managing Object Technology Series, 14. Cambridge University Press, Cambridge, UK, 1998.
- Gronau, N.: Web services as a part of an adaptive information system framework for concurrent engineering. In (Jardim-Goncalves, R.; Cha, J.; Steiger-Garcia, A.): Concurrent Engineering: Enhanced Interoperable Systems, A. A. Balkema (Lisse Abingdon Exton Tokio), 2003.
- Hernandez Morales, R.: Systematik der Wandlungsfähigkeit in der Fabrikplanung. In: Fortschritt-Berichte VDI, 16. Hannover, Univ., Diss., 2002.
- Henderson, J., Venkatraman, N.: Strategic Alignment: Leveraging Information Technology for Transforming Organisations. In: IBM Systems Journal, Volume 32, 1993; 4-16.
- Hinton, C., M.: Towards a pattern language for information-centred business change. In: International Journal of Information Management, Volume 22, Issue 5, 2002; 325 - 341.
- Holland, J., H.: Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence. In: Complex Adaptive Systems. MIT Press, Cambridge, Mass., 1992.
- Khalil, T., M. (ed.): Management of Technology: The Key to Prosperity in the Third Millennium; Selected Papers from the Ninth International Conference on Management of Technology, 9, 2000, Miami, Fla.. Pergamon, Amsterdam, 2001.
- Kidd, P., T.: Agile Manufacturing: A strategy for the 21st Century. In: IEE Colloquium (Digest), 179, 1996.
- Marx-Gómez, J., Krüger, O., Kühne, C., Lübke, D., Rautenstrauch, C.: Developing a Distributed ERP System Based on Peer-to-Peer-Networks and Web Services. In: ICSC Interdisciplinary Research: Engineering of intelligent systems, EIS 2004, 4th international ICSC Symposium University of Madeira Funchal, Portugal, February 29th March 2 2004; CDROM
- Malhorta, Y.: Enterprise Architecture: An Overview, [WWW document], <http://www.kmbook.com/enterarch.htm>, last accessed 2005-11-11
- Nelson, A., Harvey, F., A.: Technologies for Training and Supporting Your Agile Workforce. In: Creating the Agile Organisation: Models, Metrics and Pilots, Proceedings 4th Agility Forum Annual Conference, Agility Forum, Bethlehem, PA, 1995;
- Ngo-Ye, L.; Ahsan, M.: Enterprise IT Application Systems Agility and Organizational Agility. In: Americas Conference on Information Systems (AMCIS), 2005.
- Saaty, T., L.: The Analytic Hierarchy Process. McGraw-Hill, New York, 1980;
- Saaty, T., L., Vargas, L., G.: Decision Making in Economic, Political, Social and Technological Environments With the Analytic Hierarchy Process: 7 (The Analytic Hierarchy Process Series, V.7), Rws Pubns, 1994;

Slack, N.: Flexibility as a Manufacturing Objective. In: International Journal of Operations and Production Management, Volume 3, No. 3, 1983; 4-13.

Tzu, S.; Pin, S.: The Complete Art of War. Westview Press, Boulder, Colo., 1996.

Yi Sun, Z Zhang, X Luan, A. Roberts, Proceedings, CARV Conference 2005.

Upton, D.M.: The Management of Manufacturing Flexibility. In: California Management Review, Volume 36, Issue 2, 1994; 72 - 89.

Zaeh, M., F., Mueller, N., Rimpau, C.: A Holistic Framework for Enhancing the Changeability of Production Systems, In: Proceedings of 1st International Conference in Changeable, Agile, Reconfigurable and Virtual Production (CARV 2005), Garching, 22.-23.09.2005.