

# DESIGN SPACE STRUCTURE

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## ABSTRACT

The paper outlines the coarse structure, called CO-SITUE, of the design space in which reasoning about information systems design takes place. A frame notation has been developed for representing the constraints and criteria which incrementally constrain the artifact during development and capturing their justification from the point of view of usability engineering. The final paper will describe a case study in which CO-SITUE was applied in analysing and recording the initial specification phase during the design of a spoken language dialogue system prototype.

## KEYWORDS

Design space, usability, designer reasoning, design rationale.

## 1. INTRODUCTION

In order to investigate novel means of providing principled support for usable artifact design, many HCI scientists are turning towards deeper analysis of full-scale design processes [6]. The results are intended to be fed back into requirements for new developments of the science base, new ways of representing the knowledge in the science base in order to support design processes and, ultimately, operational support tools [1]. This is the context of Esprit Basic Research project AMODEUS II [2]. HCI is no longer viewed as a matter of directly importing the science base into design, partly because the science base is not in place with respect to most usability engineering problems, partly because the building of a formal cognitive model in order to address some usability issue is often equivalent in complexity to programming the proposed application [8]. Predictive support for usability engineering in early design may be a matter of combining designer craftsmanship with (a) advanced rapid prototyping methods involving empirical user testing; (b) focused application of science-based methods where available, be it through consultancy, checklists, computer-based tools or in other ways; (c) use of relatively low-level and robust conceptual frameworks which may be turned into computer-based tools; and (d) communication with designers through design case studies in which usability issues are analysed in depth on the assumption that "intuitive generalisation" will do some of the work that theory is currently unable to do.

The paper addresses points (c) and (d) above in outlining a robust, top-down framework for characterising the design space within which information systems designers work. This framework, called CO-SITUE, is presented as a coarse-grained analysis of the problem space within which artifact design takes place (Sections 2 and 3). Sections 4 and 5 will present a case study of the use of CO-SITUE in analysing the initial specification phase of the design of a spoken language dialogue system prototype. Section 6 summarises preliminary experience with CO-SITUE and describes ongoing work.

## 2. WHAT IS BEING DESIGNED?

Let us call what is being designed an artifact. It turns out that artifacts are unexpectedly complex entities. This fact has implications for the understanding of design practice and the nature of the design support which is feasible in HCI. In addressing the question of what is an artifact, let us look at CO-SITUE first. CO-SITUE stands for the following aspects of the artifact which is being designed:

C = Collaborative aspects.

O = Organisational aspects.

S = System aspects.

I = Interface (or more generally: system Image) aspects.

T = Task aspects including task domain aspects.

U = User aspects.

E = User experience aspects.

User performance on the resulting artifact will be the function:  $UPERF = f(C,O,S,I,T,U,E)$

Put an artifact designed for one organisational setting into a different organisation and the artifact may not be used any more; or change the user population from occasional users into full-time professionals and they may become frustrated when using the artifact. The claim behind CO-SITUE, therefore, is that in designing a "system" what is actually being designed is something much more complex. What is being designed is an artifact and artifacts are CO-SITUE complexes.

## 3. CO-SITUE AND THE DESIGN SPACE

During design, designers have to consider and actually do consider to some extent and at various levels of detail the types of aspect included in CO-SITUE. The artifact is designed the way it is in order to satisfy multiple criteria and constraints derived from a consideration of its CO-SITUE aspects. The claim here is not that designers do consider all possible CO-SITUE aspects of the artifact, or all relevant aspects, at appropriate levels of detail, or that they consider the aspects which they do consider in any systematic fashion to make sure that nothing relevant has been left unanalysed. Designers today have no way of making sure that this happens. They work instead with personalised stopping rules and evaluation functions [7]. The point is rather that designers actually work within the conception of an artifact designated by CO-SITUE: *CO-SITUE describes the overall shape of the design space around an artifact during design.*

The claim that what is being designed is a (CO-SITUE) *complex* involves two main points. Firstly, during design the aspects of CO-SITUE constantly interact. Neither normatively nor in actual design practice is there such a thing as first specifying a system and then looking at user requirements, or user tasks, or interface specification (or vice versa). In design reasoning, multiple constraints derived from very different aspects of the evolving artifact are continuously brought to bear within the design space. The resulting physical artifact is an embodiment of a specific CO-SITUE complex. Secondly, there is an important sense in which designers design, not only systems and their interfaces but also collaborative and organisational schemes, tasks, users and their degree of experience. Usable artifact design is not a one-way traffic of optimising the way constraints from those domains influence the usability of the resulting artifact.

Computer artifacts change users' tasks (e.g. [10]). However, this point about change is more general. As viewed from within the dynamical and creative design process, all or most aspects of CO-SITUE are potentially subject to change as a result of design decisions. The reasons are that (1) computer artifacts often change work conditions, i.e. collaborative and organisational schemes of work; (2) artifacts "change" users in the sense that the types of target users and the requirements on their knowledge and experience for operating the artifact are themselves to some extent variable design options; and (3) the system to be designed and its interface are themselves variable design options.

In other words, during design one constantly has to identify and select between options concerning the way the system is to be built, the way the interface is to be built, the possible ways to change the organisational and collaborative work schemes of users, the ways to change their tasks, and the ways to select the types of end-users and the knowledge and experience they will need.

Not every aspect included in CO-SITUE is a legitimate variable during the design process, however. CO-SITUE itself is not, nor are, for instance, general aspects of users' cognitive architecture. These are *constants* or *invariants* rather than variables, which designers can only ignore at their peril. Bad design often results from overlooking such invariants, from users' limited working memory to the fact that doctors decline to transfer responsibility to expert systems. The existence of invariants opens up the possibility of articulating invariant CO-SITUE aspects of the design space.

If CO-SITUE provides an approximate, coarse-grained characterisation of the design space around an artifact, design can be turned into a process of making explicit a number of generic constraints on the artifact to be designed and applying, through a process of interpretation, discovery, justification, trade-off and decision-making, those constraints to all aspects of the evolving artifact. Each general constraint or criterion, and each result of applying these to the artifact adds an additional constraint on subsequent specifications. This process can be incrementally described in a numbered series of CO-SITUE frames which frame the definition of interacting design criteria at increasing levels of detail. Below is shown the frame that was used in analysing and recording the initial specification phase of a spoken language dialogue system prototype [3], [4], [5].

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**CO-SITUE No. (0)**

**A. General constraints and criteria**

Overall design goal:

General feasibility constraints:

Scientific and technological feasibility constraints:

Designer preferences:

Realism criteria:

Usability criteria:

Naturalness criteria:

**B. Application of constraints and criteria to the artifact within the design space**

C =

O =

S =

I =

T(S) =  
T(U) =  
U =  
E =

**C. Hypothetical issues:**

**D. DR/QOC arguments:**

**E. Conventions:**

T(S) = System Task aspects including task domain aspects.

T(U) = User Task aspects including task domain aspects.

CO-SITUE No. ( ) indicates the number of the current CO-SITUE specification.

Further conventions become added as artifact specification proceeds.

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Using this notation, four successive frames allowed a succinct representation of the initial design specification phase from the point of view of usability engineering, capturing all the main design criteria and constraints used, their interpretation with respect to the overall design goal and their justification in terms of user characteristics. This incremental process of representation will be described in Sections 4 and 5 of the paper.

## 6. CONCLUSION

The merits of CO-SITUE in its present form are that:

- CO-SITUE is a framework for making explicit the general aspects of the design space surrounding computer artifacts and hence enforces a consideration, during design, of each aspect from the point of view of usability engineering;
- even in substantial design efforts, the CO-SITUE notation compactly represents the design decisions relevant to usability and the constraints and criteria on which they are based;
- maintaining a numbered series of CO-SITUE frames can be useful in recording designer consensus and the reasoning behind it.

Ongoing work aims at combining CO-SITUE with the DR/Questions, Options and Criteria approach to Design Rationale [9] for more explicit incorporation of designer reasoning; forging links with the user-modelling approaches being developed in AMODEUS II; and further articulating CO-SITUE in terms of design space invariants in the form of (a) a taxonomy of CO-SITUE complexes and (b) identification of general invariant structures of organisations, collaborations, systems, interfaces, interactive tasks and their domains, and users.

## REFERENCES

1. Barnard, P. Bridging between basic theories and the artifacts of human-computer interaction. In Carroll, J.M., Ed. *Designing Interaction. Psychology at the Human-Computer Interface*. Cambridge, Cambridge University Press, 1991.
2. Barnard, P. Technical Annex for Esprit Basic Research Project 7040, AMODEUS II, 1992.
3. Bernsen, N.O.: Design of a Spoken Language Dialogue System. A Study of the Initial Specification Phase. *Working Papers in Cognitive Science* WPCS-92-5. Centre of Cognitive Science, Roskilde University 1992.

4. Bernsen, N.O. The Structure of the Design Space. CO-SITUE Illustrated by a Study in Early Artifact Design. AMODEUS II project deliverable 1993. In press.
5. Bernsen, N.O. Structuring the Design Space. In Byerley, P., Barnard, P. and May, J., Eds. *Usability and Integrated Services: Design Issues and Methods*. Amsterdam, North-Holland, 1993. In press.
6. Carroll, J.M., Ed. *Designing Interaction. Psychology at the Human-Computer Interface*. Cambridge, Cambridge University Press, 1991.
7. Goel, V. and Pirolli, P. The structure of design problem spaces. *Cognitive Science* 16, 1992, 395-429.
8. Lewis, C., Polson, P., Rieman, J. and Wharton, C. Testing a walkthrough methodology for theory-based design of walk-up-and-use interfaces. *Proceedings of the CHI '90 Conference on Human Factors in Computing Systems*, 1990, 235-42. New York, ACM.
9. MacLean, A., Young, R., Bellotti, V. and Moran, T.P. Questions, Options, and Criteria: Elements of Design Space Analysis. *Human-Computer Interaction* 6, 1991, 201-50.
10. Norman, D.A. Cognitive artifacts. In Carroll, J.M., Ed. *Designing Interaction. Psychology at the Human-Computer Interface*. Cambridge, Cambridge University Press, 1991.