# Design methodology of collaborative systems based on a social approach

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## Abstract

*The aim of this research is to construct a design methodology for collaborative systems (artifacts for collaboration), which utilizes one of social analyses called Ethnomethodology.*

*So far, the author proposed guidelines, principles and a model as components of the design methodology based on examples of collaborative assembly of an everyday product and remote instruction which uses a movable laser pointer.*

*After the introduction of the proposed methodology components, this paper describes how they are organized as a design methodology, followed by discussions of future issues.*

*Although design methodologies have been established in designing interactive systems for a single user, no such a methodology has been proposed for collaborative systems. This paper is the first try.*

## 1. Introduction

There have been many researches and developments on Computer-Supported Cooperative Work (CSCW) reflecting the Social Analysis after the year of 90's. These were for instance Media Space technology such as TV conference [1] or Control centre technology for underground railway or airport [2].

Social Analysis contributed and clarified the methodology of actual context in such technology development. More over it also clarified how to organize Cooperative Work applying to artifacts*. Through this, it revealed the points and methods how the technologies would support and then contributed to advance the technology of "To be used by human".

However it was too profound for those people of scientific engineering field since the nature of the social analysis (Ethnomethodology [3]) was highly specialized. The focus of the analysis was to explain the process organized by society through the way of bottom up approach. It used highly specialized terminologies and discussed and tried to analyze quite narrow examples and neglected its evaluation. It mainly discussed the detailed piled up improvisational behavior chains. Hence the scientific engineers were required to modify its result to apply to the design by translating the terminologies and abstracting the narrow examples and adding the technological evaluation. Therefore a collaboration with such social researchers and scientific engineers was necessary.

Recently many researchers have been involved and discussed the usage of social analysis. For instance, Martin D. reported his research to categorize the results from current social analysis and proposed a guideline with design notice points composed of the categorized cooperative work system [4]. It is usable at the initial design process without participation of social researchers since it is more or less written abstractly. Hutchins E. recognized heavy load portions or patterns in the information process by observing of the information flow. He then proposed "Distributed Cognition" that intermingles between the social analysis and the actual design through technical approach [5]. However their efforts are not enough structured comparing with the interaction design for personal devices [6], particularly display design, which is quite well structured and clarified on design method, guideline, evaluation/ analysis method and design process.

This paper discusses about the design methodology of collaborative systems based on an explanatory model, design principles and guidelines which the author proposed from ehnomethodological CSCW researches.

## 2. Social issues

We first explain what social analysis is and why it is important in the design of CSCW technologies.

* Artifacts: A product that is made by human being. The artifact has two phases: hardware such as computer system, manual, parts and tools, and mental thing such as expression or memory.

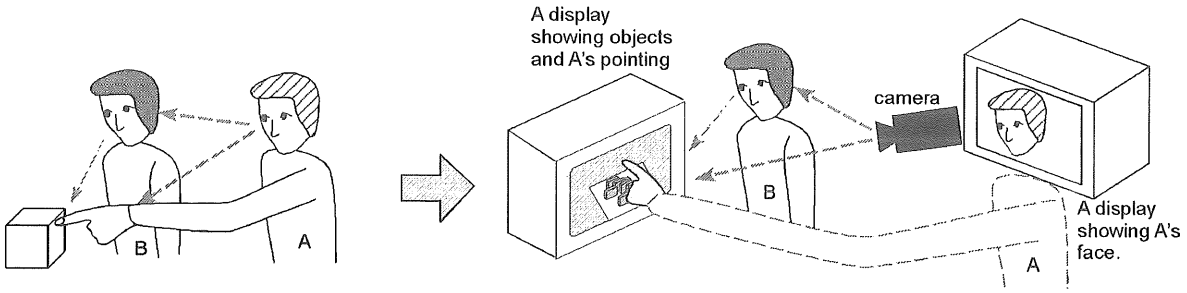


**Figure 1. Pointing in case of co-existing situation (left) and pointing using a system based on body metaphor (right).**

Society emerges in interactions among people who are surrounded by various technologies and social institutions.

Ethnomethodology is a social analysis method that explicates such interactions. It is most frequently used in the CSCW area among social analysis methods. Its main interest is to explain how people organize human actions interactively and sequentially. In his paper, Heath wrote "The emergent and sequential organization of interaction is also relevant to how we might consider the contextual or in situ significance of visual conduct and the physical properties of human environment" [7].

For example, let's think of a case that A asks B to take an object (Figure 1 left). At first, A says to B "take this" and at the same time points to an object (such a book on the table). A's pointing connects with A's utterance "take this". When B sees A's pointing to the book, B turns his body to the book and will say "ok". B's body movement and utterance display his understanding of A's utterance and gesture. After A draws away A's hand which pointed to the book. By withdrawing the hand, A displays A's understanding of B's understanding to all participants, including B [8]. As shown in this example, participants maintain and reorganize arrangements of bodies and tools interactively to monitor their pointing and other work [9]. According to Goodwin [8], body arrangement of participants is important. For example, when instruction is given, operators move their bodies into appropriate positions to see the shared artifacts. Instructor likewise moves his/her body in such a way that his view of shared artifacts is not obstructed by operators and makes sure that the operators are watching his/her gestures while they are given instructions.

This kind of analysis is useful at the time of the design by CSCW technology. The reason is that humans tend to depend only on the words or giving up to use such technologies at the time with interaction trouble.

This technology will be then frequently used if such an environment is prepared to do the interactions fluently [10].

## 3. Design methodology

Now that design based on the social analysis is explained to some extent, we start talking about how to organize such design methods.

Shneiderman once described a system with a design method and process by Human Computer Interaction (HCI) in his orthodox book [11] (Fig,2). He proposes three levels; the highest level of model can sort out the design process consistently, the middle level of principles can compare with alterative design approaches, the lowest level of guidelines can specify detailed designs. On the other hand, talking about design process he indicates the necessity of iterative prototype evaluation at the beginning of the design stage and its evaluation and test method.

Such a concept of Shneiderman became to be International Standard (IS). The design methods became to be a product standard as ISO 9241 series [6] whereas the design process became to be a process standard as ISO 13407 in detail respectively. Consequently through such total efforts, current interaction design for personal devices, particularly display designs, is promoted much more systematically.

However such system, particularly design method is discriminated to cooperative devices and brings

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| Design methods: | |
| High level: | Model |
| Intermediate level: | Principles |
| Detailed level: | Guidelines |
| Design process: | |
| Process: | Repetitive design |
| Evaluation & test: | Evaluation & test methods |

**Figure 2. Elements of design methodology.**

only limited effect since a lack in the fluent function of communications among multiple people. This is discussed in the section two. The research of social analysis with such background is still in status of collection of fragmented and separated guidelines and it has not reached to the systemized level. Hence it can be said that there is not existed such an effort as to intermingle different two approaches of systemized engineering and social analysis.

## 4. Design methodology of collaborative systems based on a social approach

The author has been proposing components of the design methodology in bottom up manner from practical design guidelines to principles and a model with the scope of social standpoint. In this paper, design guideline is proposed in section 4.1, design principles and a model based on the principles are in section 4.2. The integrated total design method is proposed in section 4.3 where the guidelines, the principles, and the model are discussed.

### 4.1 Guidelines: on collaboration use of artifacts in remote instruction

In virtually remote control environment, the instructor and operator do not exist in the same place such as video chat system which can transmit video and audio interactively. There are still many issues such as the instructor can not well communicate with operator or grasp the status of the operator and the instructor must order repeatedly. Such issue "communicative asymmetry" has been discussed repeatedly by many researchers in this field [1].

However there has been few design guidelines to solve the issue. If there, it will be discussed only fragmented portions and not integrated well [1]. Based on the above mentioned ethnomethodological studies and our studies on video mediated communication, the author tried to solve the issue by describing a design guideline regarding the interaction [12], [13].

The guideline is based on the layout which is drawn in right part of Figure 1 as follows;

1) ***Arrangement of bodies and tools requirement***: The arrangement of bodies and tools should be appropriate for monitoring other participants' behavior for both instructors and operators.
2) ***Orientation of bodies requirement***: Each participant should be able to turn his/her body to other participants and shared artifacts.
3) ***Gestural expression requirement***: The instructor must be able to use freely not only verbal expressions, but also body movements and bodily expressions (gestures).

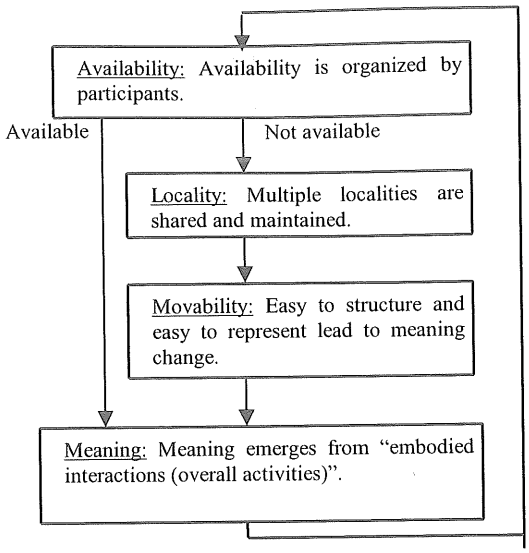


**Figure 3. Four steps explanatory model of collaborative use of artifacts based on four principles.**

4) ***Mutual monitoring requirement***: Participants should be able to monitor each other's body arrangements, orientations, and gestures mutually.
5) ***Sequential organization requirement***: Sequential and interactive organization of the arrangement of bodies, tools and gestural expression must be possible.

When participants are co-existing (Figure 1 left), these requirements, especially mutual monitoring, are naturally realized because an object, A's finger, and B's face are in front of A's face and they are within A's field of view. Thus A can naturally monitor B's gaze direction and B's actions to an object. In order to satisfy these requirements in remote setting, we attempted to use the ordinary body arrangement as a metaphor for the placement of cameras, the face view, and hand-gesture monitors (Figure 1 right). We named the metaphor as 'body metaphor'.

### 4.2 Principles and a model: on collaborative use of artifacts

It turned out that the proposed design guideline in section 4.1 is effective to improve the design with communication technology in remote collaborate situation [12], [13], [14]. However there still exists an issue of its limited scope of which Hutchins E. [5] pointed out the comprehension covering cognitive issues since it is mainly focused on instruction under the collaborated works. Considering generality, there is necessary the consistency between their comprehensions, because collaborated works are series of the making sense efforts [3], [8].

What is more, it is not enough to be a method to simulate the total activities of collaborated works since there is no time domain factor. It is necessary to add the factor such as seven steps model proposed by Norman D.A. [15]. The author organized principles and a model on collaborative use of artifacts [14] referring to the theory of information explicitness proposed by Kirsh D. [16] with considering such background. The author tried to expand the Kirsh D. theory into principles and a model covering collaborated works (Fig.3). Figure 3 shows a model organizing with the four principles.

A) ***Availability***: Required resource such as an artifact is instantly and easily referred and accessed. For instance in an assembling task by two people, when a person categorizes and places screws between them and the other person staying close monitors the action, the screws are "Available" to them.

B) ***Locality***: System organization and locality is necessary in order to establish "Availability". "Locality" must cover parallel actions since almost of all the actions are ordinary in parallel motion. There consequently exist multiple localities.

C) ***Movability***: Normally communications will not be efficient with artifacts for those complicated functions and architectures. In order to improve the communication, it is necessary to make motion physically (structured), to explain with more words, to point with a finger and gestures (expression) [9], [13]. If it is easy to explain with such motions then it enables to modify the meanings easily and there are possibilities to come out well communication environment.

D) ***Meaning***: "Locality" is about the relations between multiple actions and multiple localities. "Movability" is modification of meaning. Therefore artifacts have several meanings in collaborative works.

The principle of "Meaning" is to integrate other principles. The simplest way to make integration is to select just one meaning. In case there founds no other candidates of "Meanings" at "Meaning step", then it is necessary to iterate the loop once again. Even though after several loops, there is no improvement of the situation, there is no possibility to clarify the "Meaning". When several operators are required to recognize unique "Meaning" from the several "Meanings", it is necessary to reflect the context of use. More over it may be possible to expect their collaboration with higher "Meaning" if the unique "Meaning" is definite one.

The left down arrow in the left part of the Figure 3 describes usable case with availability. The right down arrow does without availability. Detailed comprehensions are generally piled up with improvisational approaches in collaborative works [2],[3],[12],[13]. This model explains it with iterations of the loops. For instance one artifact is observed from several angles to thoroughly recognize and understand the functions.

During the iteration, it allows to comprehend the other artifacts or their relations. It also allows that social analysis clarifies about dexterously organized and applied combinations of the glance, the posture, the hand motion, the position and direction of the artifact in collaborated works.

### 4.3 Use of Model, Principles and Guidelines

This section reviews the guideline in section 4.1 and the principles and the model in section 4.2. The design methodology is described by three design processes (requirement acquisition, design and its evaluation) since the methodology covers total design process. Firstly at the state of requirement acquisition, it is necessary to fully understand the context of use by the users in the development of CSCW technology. It is commonly said that explanatory model is effective to acquire the requirements [11]. For instance, Norman D.A. model is well known as an explanatory model of individual activities. The model consists of seven steps and forecasts the emergence of the errors. The model in Figure 3 is an explanatory model which enables the behavior simulation as well as Norman model. Almost all the behaviors in collaboration are well explained with this. Details will be described in the article of [16] and it can be defined about the fragileness of orderings or localities, important and specialized functions and architecture, and common sense factors of human relations.

The model and principle in Figure 3 are necessary to evolve into design guideline at the stage of design. The reason is that at this stage it is then necessary to indicate more practical measures since the Figure 3 stays still explanatory model and describes up to situations and status. The experts can evolve the principle and model design [17] but the novice may well refer to such guidelines in section 4.1.

However generally there exist various guidelines and the contents of adapted design guideline normally vary by the context of use which is composed by tasks, target users and its environments. Currently there are few guidelines such as proposed in section 4.1. If there, it must be quite specialized application dependant. At present, it will be better to evolve from such a principle and model.

Under these circumstances, sections of 4.1 and 4.2 are good examples. When the task is identified as remote instruction, "Locality" can be evolved arrangement of bodies and tools requirement, orientation of bodies requirement, and mutual

monitoring requirement. "Movability" can be evolved gestural expression requirement and "Availability" can be evolved sequential organization requirement. "Meaning" can be replaced by embodied space.

At the final stage of evaluation, both the guideline in section 4.1 and the principle in section 4.2 can be applied. The details are in references of [6] and [17]. The reference of [16] is described the evaluation by the checklist. The reference of [17] is about heuristic evaluation method. Both can be applied to the evaluation at the detailed level.

## 5. Future issues

The model of Section 4.2 and the design guidelines of Section 4.1 are briefly discussed respectively.

At first on the model, the number of principles, namely four, might be more than four considering the success of Norman's seven steps theory which had some more steps than similar theories in the past. For example, as explained in the end of section four, "Locality" expanded to three guidelines which suggest more principles. Further research is necessary to reconsider overall balance of totality and granularity of the principles for better explanation and effectiveness.

Secondly on the design guidelines, another set of guidelines should be developed because "task" perspective of the guidelines is only one perspective among four which constitute usability of a product. Other three perspectives include "user", "other equipments", and "environment" according to ISO 9241 [6]. Usability differs significantly depending on the four perspectives. If another set of guidelines is developed from the design principles concentrating on one of other perspectives, the principles of section 4.2 will also be more justified their goodness as a set of principles.

## 6. Concluding remarks

This paper discussed about the design methodology of collaborative systems based on an explanatory model, design principles and guidelines which the author proposed from ethnomethodological CSCW researches.

CSCW researches based on the social analysis started as an antithesis of related human research areas such as cognitive science. The related areas put too much emphasis on mental things such as mental models and mental representations without regard to paying attention to details of actual use of technologies. Such social approaches, however, were in trouble. They often used unfamiliar sociological terminologies and tended to refuse abstraction, which brought difficulties for engineers in utilizing their results.

Proposed methodology here provides a solution for this issue. It is a first step toward the organized methodologies like those of the interaction design for personal devices.

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