On the Emergence of Common Design Metaphors in Collaborative Design

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Abstract

This paper reports an observation of how designers work together to achieve integrated building design on the basis of individual contributions. A case study shows that the keystone of fruitful collaboration lies in the projection of *common images*; and *common design metaphors* emerging from group interpretation of the common images can function as a communicative device, allowing for participants to collaborate effectively. A set of *constraints on collaboration* is identified via a situation-theoretical analysis of a scenario of collaborative design. As shown, the constraints derived have some implications for building collaboration-supporting tools.

1 An Architecture Dreaming about Fish?

In my earlier case studies of teamwork in architectural design, reported in [6, 7], one of the distinct approaches to teamwork in building design was characterised as 'metaphorist.' And one of the historical cases observed shows the following facts (See Figure 1):

> The Domo Serakaito, built in 1974, is a house christened "coelacanth" because of its (planar) shape. created within a long, heterogeneous group process: five members of the design team designed individual sections, which was allowed to show in the clear joint within the complete building. They gain unity from the image of fish.[1]

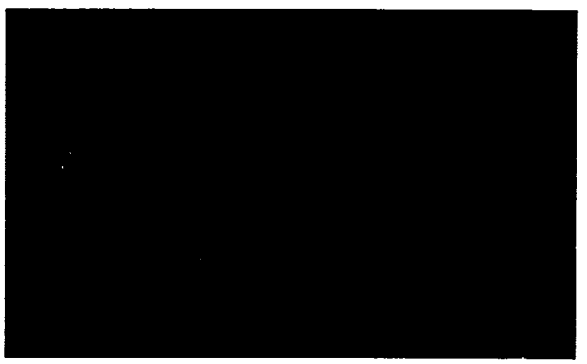

Figure 1: The plan of the Domo Serakanto Kamakura, designed by Team Zoo, Kanagawa Prefecture, Japan, 1974.

The above and other design literature suggests the existence of a distinct teamwork pattern for which we name it *metaphorist*. It involves collective projection and interpretation of 'common images' on the basis of individual parts contributed by different designers. Collaborative design of this pattern presents some interesting features that demand a systematic explanation which, in turn, may serve as references for future system design.

Consider the statement below, given by Spiedel in the same book [8, p.15], as a 'puzzle' to be solved:

> "Team Zoo has discovered that teamwork, even when markedly individual, can still produce a coherent whole, if a common image exists that each individual can interpret differently, and that allows a great deal of scope."

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[1] For this design project, Team Zoo's original statement read as "··· What came out from almost three years of struggle was a coelacanth that crawled out from the sea. Domo Serakanto, with its gill, spine, horn, cilium, teeth, antennae and scales, it appeared in the wind and sank in the light. Domo Serakanto is a fish dreaming about architecture, an architecture dreaming about fish." [8, p.32].

This paper attempts to propose a descriptive theory of collaborative design with the metaphorist features briefly introduced above. The theory aims to explain what constitutes collaboration, and its implications for tool building will follow.

2 The Metaphorist Scenario: An Abstract

An overview of the metaphorist approach to collaborative design in the following simple (somehow abstract) scenario. The scenario also highlights some of the teamwork features to be focused upon. A more elaborate account of these features is given in the next section.

> At the inception of a design project, designers of different expertise and perspectives firstly set up individual workspaces for generating and modifying design expressions targeted at particular design aspects (domains). Participants' setting up individual workspaces may be distributed over several remote working sites without communication in the first instance.
>
> At some (later) design stage, participants take part in meetings to jointly present their local design decisions in a common workspace. On viewing the gathered design expressions, potential connections among individual works may be perceived and discussed among group members. Motivated by the joint conception of putting things together, participants proceed to carry out integration tasks collectively in the common workspace.
>
> By inspecting the resultant integration, participants are, individually, motivated to carry out further design developments in their own working domains. They may decide to modify or refine the design expressions previously made.
>
> As local design solutions are explored or elaborated to a certain extent, participants meet again. Regarding the individual design works newly arrived at, designers carry out, again, integration tasks to reach new states of integrated design.

The scenario given above is short indeed but sufficient to raise some questions:

- How can common design images be aggregated or projected collectively by participants if they know little about each other's design domain?
- It seems to be the case that aggregated design parts or projected overall design consequences may give rise to new developments in individual design works, and vice versa; how can we give an account of the apparently dual communication between what is integrated in a common workspace and what is currently developed in distributed individual workspaces?
- Given the sharing of common design images among participants, how do design changes made in one individual workspace affect those in others?

My current explanation toward the above questions comes from an analysis based on the situation-theoretical framework originally introduced by Barwise and Perry [3, 1]. In particular, by examining the constraints on the *flow of information* among different *situation types*, the current study produces a situation-theoretical account of the metaphorist approach to collaborative design.

3 A Situation-Theoretical Exposition

Given the scenario of teamwork in design abstracted above, it seems natural to stipulate that design is basically a *modelling* activity. By 'modelling', we refer to the performing of *modelling acts* (mental or otherwise) in *modelling spaces* (physical or abstract) by some individuals. Collaborative design, therefore, involves multiple threads of modelling activities that give rise to complex interactions. As will be shown in what follows, one of the benefits of seeing design as modelling is that we can thus arrive at a descriptive theory that unifies the representation and communication aspects of collaborative design.

Our presentation of the descriptive theory consists of four parts. We firstly outline the basic kinds of modelling acts and modelling spaces observed in the metaphorist scenario. By putting the action and the space aspects together, an *action-space* matrix can then be constructed, which specifies eight different *situation types* in collaborative design. Thirdly, we spell out the possible connections among the situation types identified, resulting in a map (or, a pattern) of the *flow of information* in the metaphorist approach. Finally, *constraints on collaboration* are searched out by examining the conditions for information to flow from one situation type to another.

3.1 Modelling Spaces

In seeing design as modelling, we shall introduce the term *modelling spaces* to denote, more formally, the kinds of workspaces set up by designers to carry out design tasks. Two kinds of modelling spaces can be identified from the scenario:

(I) Individual Modelling Spaces (IMSs) — the kind of workspaces where participants create and evolve to model design expressions targeted at a particular design aspect or domain of a design project. An individual's IMS may be physically

and/or logically separate from other individuals'.

(II) Group Modelling Space (GMS) — the kind of workspaces where members of a design team create and evolve to model the integration of design parts, as contributed by the individuals, into larger design wholes. A GMS is initially a public visual space for displaying individually made design expressions; a GMS may be developed to accommodate new elements and functionality emerging from direct or indirect communication among participants. The emerging elements and functions are essential to the realisation of design integration as intended by the group members

3.2 Modelling Acts

As shown in the scenario above, it can be said that designers perform actions of various kinds to produce, change, or evaluate states of design works. We now look into these actions of designing more closely in the following terms:

(a) *Abstraction*—the acts of forming a design representation scheme with which a designer establishes correspondences between his or her modelling space and the aspects of the artefact yet to be constructed in the real world.

(b) *Generation*—the acts of producing specific (concrete) design expressions (i.e., drawings, design specifications, etc.). In short, generation is about the use of a representation scheme by an individual's *design intents*.[2]

(c) *Interpretation*—the acts of assigning, associating, or calibrating the values (or certain meanings) of design expressions generated. The act of interpretation often involves a designer's referring to design knowledge developed and accumulated in certain design domains (e.g., building standards, ergonomics, material strengths, etc.).

(d) *Modification*—the acts of making changes in (parts of) the representation schemes abstracted or the design expressions generated. The acts of modification normally have the objectives of extending the scope of a representation scheme by introducing new elements or operations, and of changing the properties and relations of design instances constructed.

To add another dimension into our view of design as modelling, we may term the above design actions as 'modelling acts'. The entries of modelling acts listed above are four among others; and there are no obvious causal relations assumed between the acts. For our purpose of developing a descriptive theory, the four modelling acts included here are considered sufficient for the time being.

[2]The notion of design intents in the acts of generating design expressions should be emphasized, because a representation scheme on its own cannot explain why different (specific) expressions result even if the individuals employ the same representation scheme.

Modelling Acts / Modelling Spaces	*Abstraction*	*Generation*	*Interpretation*	*Modification*
IMSs	*Individual Object Worlds (IOW)*	*Local Design Decisions (LDD)*	*Domain Design Agendas (DDA)*	*Changes in LDD or in IOW*
GMS	*Shared Integration Schemas (SIS)*	*Common Images (CI)*	*Common Design Metaphors (CMD)*	*Changes in CI or in SIS*

Figure 2: An action-space matrix generating eight generic states of individual and group design work.

3.3 An Action-Space Matrix

In formulating the notions of modelling spaces and modelling acts, for the reason of convenience, we have separated them into two camps. As read in the scenario, modelling acts always take place in group or individual modelling spaces. We now put the two formulations together with the aim of constructing an *action-space matrix* (Figure 2). The matrix is presented to generate and classify eight generic states of individual and group design work.

3.4 The Flow of Information

For every single situation type generated in the action-space matrix, we have given explanations accordingly. The explanation thus carried out seems to suggest some constituents of a structural view of the metaphorist approach. As has been shown in our sequence of explanation, we have tacitly implied a kind of dependence relation among the situation types classified; i.e., some situations may follow if and only if others occur in the first instance. To see the kind of dependency more clearly, we need to put all the situation types presently classified back into the metaphorist scenario given earlier. In so doing, a schematic map of the *flow of information* in the metaphorist approach to collaborative design is constructed in Figure 3.

3.5 Constraints on Collaboration

According to situation theory, when once we have some idea about the flow of information among abstract or concrete situations classified for an activity, we are in a better position to systematically spell out the *constraints* (or logic) which governs that activity. In the final part of our exposition,

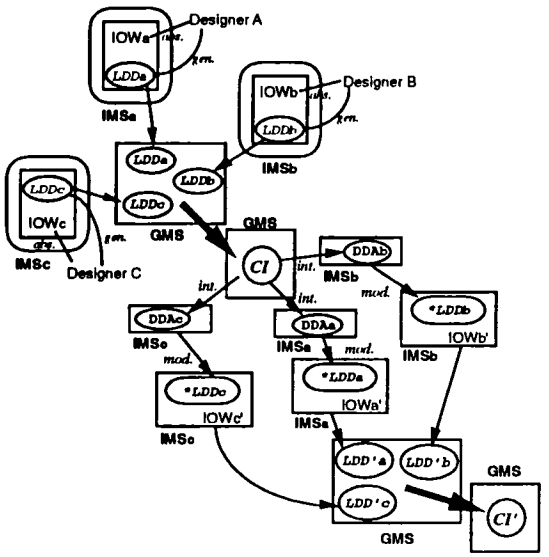

Figure 3: The flow of information among the situation types classified in the metaphorist approach to teamwork in building design.

a logic of the metaphorist approach to collaborative design is sought for. Firstly, in a slightly arbitrary way, the overall picture of the information flow gained above is individuated into four smaller sections. Upon each section, in the format of 'from to', an intermediate goal (task) of teamwork is focused; we then look into the general conditions for these tasks to be fulfilled by members of a design team.

(a) from *distributed local design decisions* ($\mathcal{LDD}_i$) to *a collective presentation of* $\mathcal{LDD}$ ($\Sigma\, \mathcal{LDD}_i$)—What is involved when members of a design team decide to jointly present their local design decisions to one another?

- A *call for participation* is sent out by a member (or members) to other members of a design team, which specifies when and where a design meeting will be held;
- In response to the call, team members do turn up for the meeting and bring along their latest design developments in various design domains;
- A *common visual space* is set up for displaying all participants' $\mathcal{LDD}$s such that potential relations or connections among parts of the $\mathcal{LDD}$s can be perceived and discussed among the participants.

The above three conditions point to the need of holding *design meetings*, in which design decisions made by different individuals in distributed sites are gathered together in a single workspace. From this, we may formulate our first constraint on collaborative design as follows:

$$Cons't\ 1 : ([\mathcal{LDD}_a, \mathcal{LDD}_b, \cdots] \rightsquigarrow \Sigma\mathcal{LDD}_i) \Longrightarrow Meeting$$

(b) from $\Sigma\mathcal{LDD}_i$ to *the generation of common images* ($\mathcal{CI}$)—Given a common visual space is available, what is involved in participants' arriving at common design images from their joint display of local design decisions?

When participants of a design meeting envisage that parts of their local design decisions can be interrelated in one way or another, common design images can be constructed in a shared workspace on the basis of gathered $\mathcal{LDD}$s. To realise the relations intended, the generation of $\mathcal{CI}$ may necessarily involve sets of *concepts for integration*, for example:

- concepts in terms of *new design elements* that can be deployed by participants when joining their local designs into a larger composition;
- concepts in terms of *spatial operations* that can be applied to geometrically transform parts of local designs prior to the final generation of integrated design images;
- concepts in terms of *projective operations* applicable to project certain kinds of over all design effect on the basis of multiple inputs of local design decisions.

As interpreted in our action-space matrix, *Shared Integration Schemas* may result from group members' joint abstraction of the means for realising the intended interrelations among individual works. Seen in the information flow framework, $\mathcal{SIS}$ has a functional role to play—elements of $\mathcal{SIS}$ constrain the flow of design information from gathered $\mathcal{LDD}$s to $\mathcal{CI}$.[3] For this reason, the second constraint on collaborative design may be expressed as follows:

$$Cons't\ 2 : (\Sigma\mathcal{LDD}_i \rightsquigarrow \mathcal{CI}) \Longrightarrow \mathcal{SIS}$$

(c) from $\mathcal{CI}$ to *distributed domain design agendas* ($\mathcal{DDA}_i$)—How do participants acquire their domain design agendas for further design developments in relation to the common images generated previously?

There are evidences from designers' retrospection showing that a state of $\mathcal{CI}$ can be mapped

[3] A further analysis into what is involved in participants' developing shared integration schemas is reported in [5].

onto (interpreted as) particular *templates* or *patterns* which serve members of a design team to achieve a sense of *wholeness*. The mapping (or interpretation) may be initially proposed by some individual(s), and then get recognised by the rest of the team members.[4] When such an interpretation of $\mathcal{CI}$ is commonly agreed by all participants, we say that a common design metaphor has emerged.

Here is a situation similar to the use of metaphors in ordinary conversations—the creative uses of some rhetorical devices for the purpose of communication. However, as mentioned before, the metaphors created and passed around by designers are more of the nature of imagery or graphics, hence the term 'design metaphors' is introduced.

Given a metaphorical framework emerging from group design processes, participants can always have individual interpretations of $\mathcal{CI}$ with a different purpose from inter-personal design communication.[5] An individual's interpretation of $\mathcal{CI}$ is mainly oriented toward a redefinition of existing relations, or an articulation of new relations, between individual contributions and emerging wholes.

This is like a participant's reflecting on (1) what his or her (new) local role is about, given an emerging design context rendered in $\mathcal{CDM}$; (2) what needs to be done to fulfil the role more exactly. Therefore, interpretation of this mode involves a domain-specific design perspective and knowledge that an individual is working with. A domain design agenda may arise from an individual's design enquiry of this kind. To different participants, the agendas acquired highlight design issues to be handled in refining or changing domain design decisions previously made.

Following the above account, we may point out that without the emergence of $\mathcal{CDM}$, it is less likely that each design party could draw up instant guiding agendas that are pertinent to continual domain design developments:

$$Cons't\ 3: (\mathcal{CI} \rightsquigarrow [\mathcal{DDA}_A, \mathcal{DDA}_B, \cdots]) \Longrightarrow \mathcal{CDM}$$

(d) from *individual or joint design changes in local design decisions* ($\Delta\Sigma\ \mathcal{LDD}_i$) to *design changes in common images* ($\Delta\ \mathcal{CI}$)—Assume that some design changes are made by some individuals (in accordance with their domain design agendas), how are the changes intended by individuals reflected in the changes of common images?

Given a newly acquired $\mathcal{DDA}$, a participant may proceed to develop his or her domain designs further, resulting in certain (intended) changes, regarding the existing $\mathcal{LDD}$, or more fundamentally, the current status of $\mathcal{IOW}$.

Due to participants' sharing a working protocol for design integration, changes intended in one design domain may have critical implications for the works pursued in other domains; that is, the 'repercussion' effect. Therefore, for an individual to be able to actually realise his or her intended changes, they have to be publicised to other participants for holding an 'exploratory integration'. By examining the consequent changes in the current state of $\mathcal{CI}$, participants can have their own (domain- oriented) judgements for supporting or rejecting the changes proposed. More specifically, we may think of the following examples of group interaction involved in making design changes:

- *backtracking*. The person who proposes has to drop the intended changes because some members cannot accept the outcome or the implications of the proposed changes from their own design perspectives;
- *competing*. The proposed design changes are not agreed by some other members but invite the members' design thinking, and they may subsequently produce alternative design changes that compete with the original ones;
- *coordinating*. Participants accept the result from an explorative integration and respond to the changes projected by making changes in relevant design domains to coordinate the proposed ones;
- *confirming*. The explored integration result judged satisfactory to all participants, and it does not demand further changes to be made in relevant design domains; participants simply send their confirmations to the proposer(s).

Viewed as the above, communications among team members are necessarily involved in the transition from changes in local design decisions to a new state of common images.[6] To better summarise what conditions information flow

[4] A deeper exposition of what constrains a person's ability to suggest such an interpretation and the abilities of others to recognise the proposed interpretation is beyond the scope of this paper.

[5] It is questionable if all participants can always exercise their individual interpretation of a state of $\mathcal{CI}$. This paper suggests that the association of a $\mathcal{CDM}$ with a state of $\mathcal{CI}$ is an essential attribute for allowing multiple interpretations of $\mathcal{CI}$.

[6] There lies a basic difference between the constraint of *Meeting* described earlier and the constraint *Consulting* identified here; the meeting constraint points to the joint abstraction of means for design integration, while the latter one points to the joint judge-

in this section, a *Consulting* constraint is expressed as follows:

$$Cons't\ 4 : (\Sigma\Delta\mathcal{LDD}_i \rightsquigarrow \Delta\mathcal{CI}) \Longrightarrow Consulting$$

4 Pointers to Developing Collaboration Support

Researchers of situation theory have demonstrated that a situation-theoretical modelling of human activities can lay a foundation for designing interactive information systems useful to the activities (see, e.g., [2, 4] among others). As a reserach agenda, the current study of the metaphorist pattern of creative human collaboration also suggests several supporting issues to be further investigated:

(1) *Support for joint presentation of local design decisions.* A *common visual space* is needed in which members of a design team can jointly present their latest domain design developments so that potential connections among locally developed works can be constantly envisaged by whoever participates in the meeting. More specifically, this suggests at least three mechanisms to be provided: the *networking* of remote workspaces, the *scheduling* of meeting, and the *filtering* of surface images from domain design expressions.

(2) *Support for joint abstraction of shared integration schemas.* An important requirement is that the construction of common images are always based on local design decisions as the source expressions. Therefore, a general *spatial* or *functional language* is needed so that participants can define new joint elements or operations by translating and combining domain concepts into shared integration schemas.

(3) *Support for joint interpretation of common images.* Currently, we don't have evidence showing that common design metaphors are represented in any explicit way but seemingly 'floating' among the meeting minds. However, a *distributed database* allowing participants to quickly retrieve *visual references* for current use can certainly enhance group interaction in recognizing the significance of a newly generated common image.

(4) *Support for consultation in making design changes.* Due to the operation of shared integration schemas, one member's design changes may cause further changes in other domains to be followed. A *housekeeping* mechanism can be developed to send alerts to group members when making design changes.

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ments of the results of design integration.