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Morelli, Nicola; Tollestrup, Christian

Published in:
Design Inquiries, Nordes 07 Conference

Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

NEW REPRESENTATION TECHNIQUES FOR DESIGNING IN A SYSTEMIC PERSPECTIVE.

BY NICOLA MORELLI AND CHRISTIAN TOLLESTRUP
AALBORG UNIVERSITY, DEPARTMENT OF ARCHITECTURE AND DESIGN
AALBORG, DENMARK
TEL: +45 96359928
NMOR@AOD.AAU.DK
CHT@AOD.AAU.DK

Global production is challenging industrial production to generate solutions that adequate global production to a local systemic conditions. In some case the challenge consists in producing highly individualised and localised solutions, which require new forms of cooperation with local actors, including local service providers and final users. In some case the level of involvement requested to the new actors is high, they can therefore be considered as co-workers in the production of the final solution and the overall view of the production system should be extended to include them as co-producers.

This represents a paradigm shift both for industrial organization and for designers, who will need new tools to analyse and design the system, but find adequate forms of representation to codify knowledge within the new production system.

This paper will emphasise the relevance of those issues in the design activity and outline the main methodological problems to be addressed. The authors will then offer a contribution in this area by providing an overview of different methods and tools used in previous research projects and teaching activities.

BACKGROUND

Industrial production is required to respond to a more and more complex demand, especially in western countries, where markets are saturated, but social patterns and lifestyles are still changing rapidly, mainly due to population ageing and immigration. Companies are addressing this change with a progressive segmentation of their offering: the early models of consumer segmentation are less and less efficient in those markets; indeed such a social context would require very fine market segmentation, up to the level of individual segments, which capture individual values and needs in local contexts.

This represents a paradigm shift in industrial production, which will deeply affect the designers' activity, knowledge and methodology. In the new paradigm, the production of material products will become less and less relevant in business strategies, whereas the design of solutions including both material (products) and immaterial elements (services) will be the main task for industrial companies and for designers (this paper will refer to those solutions as Product Service Systems or PSS). In the new paradigm, solutions are being proposed, which aggregate different actors, institutions, suppliers, service providers and final users, to cooperate in a co-production process (Normann and Ramirez 1994; Ramirez 1999).

The production of such solutions should be planned according to formalised procedures that identify the various system components and show how to aggregate them in a meaningful systemic way. The new paradigm shift suggests that designers redefine their methodological approach and find an adequate *operative paradigm* for the new context.

A NEW OPERATIVE PARADIGM

According to Arbnor and Bjerke (Arbnor and Bjerke 1997) an operative paradigm includes techniques that, given general paradigmatic conditions, translate a methodological approach into defined solutions for a specific problem area.

In other words an operative paradigm is a methodological toolbox that supports the generation of solutions to a concrete problem, on the basis of a certain methodological approach. Such techniques can be borrowed from different disciplines and adapted, through a *methodical procedure* in order to generate specific solutions. Only when a methodical procedure is applied, an existing technique borrowed from another discipline can be seen as a method, in relation to a specific methodological approach. The application of such a techniques-made-into-methods into a concrete problem has been defined as *methodics.*

Morelli (Morelli 2006b) proposes that an operative paradigm to generate new PSS include three main categories of tools and methods:

1) The analysis and interpretation of the context;

2) The development of the system; and

3) The representation and communication of the solution

A wide range of studies have been exploring the first two categories of methodics either making explicit reference to such operative paradigm (Morelli 2005; Morelli 2006a) or with the aim or defining of a new approach to systemic solutions (Manzini and Jegou 2000; Manzini, Collina et al. 2004) and new ways to generate new analytical tools to understand users' individual needs, preferences and lifestyles (Gaver 1999; Buur and Soendergaard 2000; Kumar 2004). The third category of methodics, instead, has often been overlooked, in the assumption that existing representation techniques are already able to communicate all the aspects of a new PSS.

The common assumption that designers could adapt their existing graphic and communication skills to the new solutions may prove to be wrong, in consideration of the nature of the solution, the wide range of actors and the cultural and communicative frames involved in the solution.

COMMUNICATION AND REPRESENTATION TECHNIQUES – WHY THEY ARE CRITICAL

Within the existing paradigm, based on product design, the designer has a well established knowledge on *what* to communicate to *whom*, and *when* in the design process is appropriate. Designers are very acquainted with the set of communication techniques used in the typical product design context. Such techniques are used in the different phases, from analysis to development and synthesis. Such tools have been further developed in more recent user-centred-design studies (Buur and Soendergaard 2000; Brandt 2004), in order to involve users in the product development process. Depending on the subject under development, the final-user could be observed and video-documented for analytical purposes, or the user and designer communicate and test aspects of use and understanding of the product through mock-up models.

The designer can communicate to the engineer or workers from the production line using technical representations ranging from principal drawings to blueprints. The designer can communicate to final users using renderings, photo's mock-up models and scenario descriptions and visualisations of the product.

When dealing with PSS instead, new actors are involved besides the traditional technical actors, such as producers, constructers, managers: service providers, organisations and final users, once external to the production system or passive receivers of its outcomes are now involved as active co-producers. In such an *extended production system* their action needs to be appropriately addressed with adequate forms of communication.

Furthermore the nature of the solution is much more complex, as immaterial components, such as uncodified and codified knowledge, cultural values and organisational settings are often more relevant than the material components (products).

Designers have good communication tools to manage the material part of their solution, but they are not necessarily able to represent such immaterial qualities, which must be effectively communicated in various ways, depending on the recipient.

MAPPING NEW REPRESENTATION TECHNIQUES

The new representation and communication techniques should be used to provide several kinds of information to different kinds of people. According to the characteristics and the aim of communication, some tools can be defined, which represent the new territory of communication tools for designers.

The toolbox designers need in order to operate in the new context will include representation techniques for communicating the new solutions:

a) **in all the phases** (the analytical as well as the design phase, the technical phase or the final rendering),

b) **with all the actors** involved (technical people as well as final actors); and

c) **in different scales** (detailed representation as well as overall view).

The following paragraphs and illustrations will provide indications on some of the tools used in the analytical and design/development phases (condition a) in previous research projects and teaching activities[1]. The description will emphasise the relevance of each tool and technique for the conditions b) and c) as well.

[1] The following sections will report methods and tools developed within the teaching activity of the school of Architecture and Design at Aalborg University (Morelli 2004), and other research project including *Telecentra*(Morelli 2003), *HiCS*(Manzini, Collina et al. 2004) and SusHouse. The economy of this paper does not allow for an extensive description of the techniques. The bibliographical references, though, provide more information on each of those tools.

ANALYTICAL PHASE

In the analytical phase designers need to collect as much information as possible about the social and cultural context they are working it. They have to map the actors that are likely to (directly or indirectly) influence the systemic solution, generate profiles of the main actors, understand possible interactions between the actors.

This phase usually aims at *shaping the problem*. It therefore requires that designers acquire a deeper understanding of the context they work on and how they could modify it.

ACTOR NETWORK MAPPING

Actor network mapping gives an overall picture of the network of actors and components in the system. The focus is on roles, grouping and relations. The grouping aspect of the technique is used to organise the actors by their function.

Different points of view can originate different maps. By focusing on a service's users, for instance, an actors map can visualise products, service and nature of the interaction between users and other actors. Although a user-centred map of the system would represent the user perspective, this kind of representation would not necessarily be a user oriented representation, indeed the nature of this representation may not be suitable for communicating with final users. Furthermore the Actor network map can be used as a mean to delegate main functions to actors.

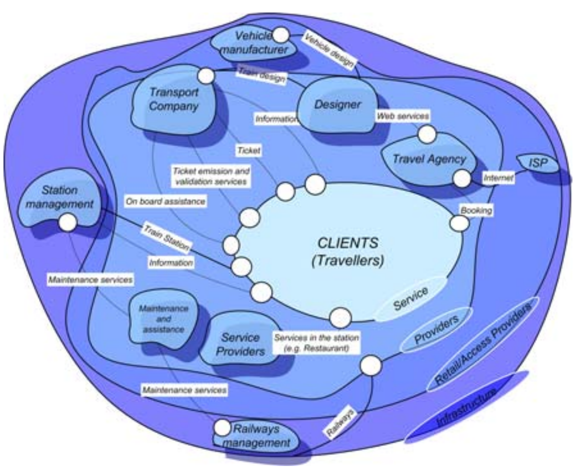


Figure 1 The map of actors involved in a train trip

A network map could be used to represent an existing system or to generate models of a new system. In this case actor interactions could be mapped, in order to represent different possible configurations of the new system and analyse the interaction between the actors in each configuration.

Figure 2 Modelling a system through the analysis of the actors' network: in this project for a shared bike-trailer system different hypotheses were done on who should promote the system and how this would impact on the other actors' involvement.. Source (Jepsen, Max V. Nielsen et al. 2003; Morelli 2004)

MOTIVATION MATRIX

The new production systems will often consist in a network of actors participating on the co-production of a result on the basis of their own specific interests. Organisations, companies suppliers, producers and final users could participate to such a network for different reasons: because it is a good business opportunity, because it offers opportunities to create new knowledge that can become part of the organisations´ future asset, because of the perspective of a future competitive advantage or because it solves a specific problem. The cooperation between those actors is an essential condition for the success of any initiative; it is therefore important that the motivation of each actor to participate and the reciprocal expectations between actors are clearly stated.

The motivation matrix, introduced in the EU-funded HiCS project, is a technique that visualises the functional relation between all the actors participating in a production system. Filling up the cells in the motivation matrix forces the designer and each actor to reflect upon the specific role of each participant. This representation technique is heavily depending on the text filled in to the matrix. The textual orientation therefore requires careful reading to extract the information from the map. The Motivation Matrix is mainly targeted at internal users and the perspective is primarily technical, the matrix being the structural basis for the mutual cooperation and negotiation among the actors.

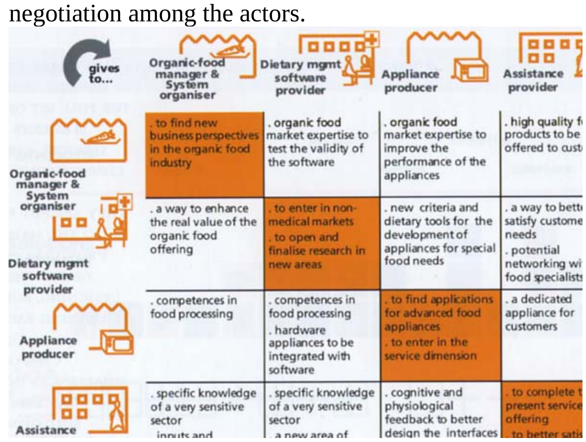


Figure 3 the Motivation Matrix lists actors expectations when cooperating with each other. Source (Manzini, Collina et al. 2004)

INTERPRETING QUALITATIVE DATA

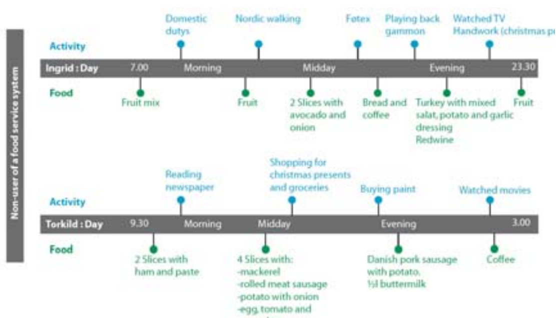
The use of anthropologic and ethnographic techniques in the analytical phase is increasingly becoming part of the designers' competences. Several studies proposed the use of video-techniques (Buur and Soendergaard 2000; Kumar and Whitney 2003; Kumar 2004) or techniques to capture pieces of people life, such as cultural probes.(Gaver 1999). The use of such techniques produces a mass of qualitative data which need to be interpreted and filtered, in order to define usable requirements for a design project. This filter can consist of software tools (Kumar and Whitney 2003), card games (Buur and Soendergaard 2000) or graphical representations of critical factors, such as time sequences and daily routines (Figure 4). This kind of representations is an essential tool to mediate the cooperation between the actors in a network, translating qualitative and sociological studies into operational elements to work with.

Figure 4 Information from cultural probes can be filtered through time sequences describing the typical day of potential users. The picture refers to a project to provide meals to elderly people. On the upper part of the daily sequence the ordinary activities are listed. The lower part, instead, reports routine activities related to food consumption

DESIGN AND DEVELOPMENT PHASES

IDEF0

IDEF0 is a method to represent a sequential view of a system through examining an event and unfolding it into sequences of sub events. This allows for the organisation of tasks by inputs, outputs, controls and mechanisms for each task to be performed. This technical representation technique is a way for the designer to analyse the system in details, without loosing sight on the overall systemic configuration. The



use of the technique depends on viewpoints and the purposes, and therefore each representation requires a stated viewpoint and clear idea of the task to be performed by the system. The format is based on well defined rules, it is flow oriented and directional. This helps the interpretation once the rules are clear. IDEF0 is widely used to gain overview and understanding of the main tasks performed by the system.

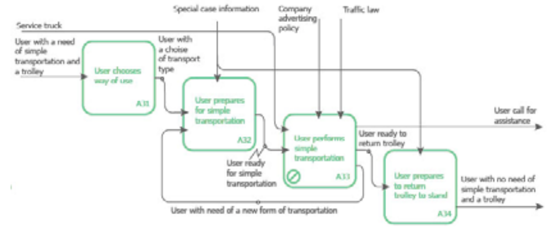


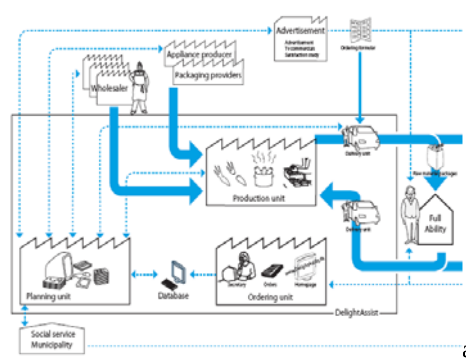
Figure 5 IDEF0, as used in a students' project on a shared bicycle trailer service. The service is described as a "production system" in which the customer is co-producer (Jepsen 2003)

SYSTEM PLATFORMS

In designing PSS, several factors are subjective and heavily dependant on individual behaviour, specific needs or technical conditions. The final output of a systemic interaction between the actors cannot be fixed in advance. When shifting from products to PSS, the final outcome of a design intervention is likely to consist of semi-finished solutions, rather than on finished material products.

This approach is not new to industrial production, which has introduced product platforms, in order to create families of products with the largest possible variation, given certain structural, material and technological settings. Product platforms support modular subdivision of products' components. Given a platform and a set of modular components different architectures can be generated, in which the variation depends on the possibility to put together the components according to different combinations.

The logical structure of product platforms could also be used when dealing with systemic solutions. A platform for a systemic solution should put together different actors (service providers, manufacturers, institutional actors and final users) and describe each actor's competences, as well as the interactions (material and immaterial flows) which generate specific system architectures.



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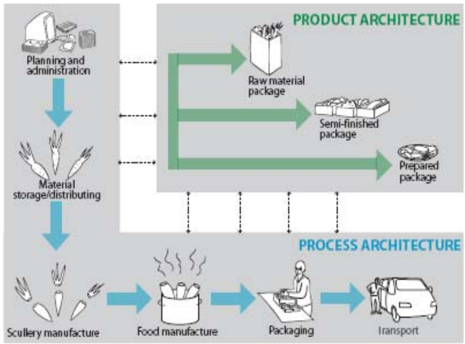

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Figure 6 In this project for a food system for elderly people the students used the platform representation to organise actors and flows, both inside and outside the system (a). From this representation the student synthesized a system architecture (b)((Nilsen, Ohana et al. 2006)

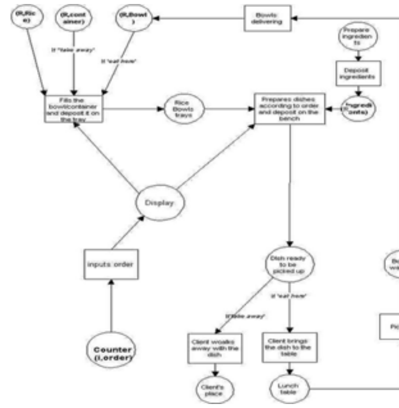
Platforms' representation does not have any fixed format, and thus icons and layout are variables that give the designer the possibility to emphasise certain aspects of the system. This kind of representation can have a more colloquial language, when used to represent the system to final customers or actors which are not familiar with other technical tools, such as IDEF0. For this reason it can support the cooperation of designers and all the actors involved in the system in the construction of different architectures, sometimes using the representation as a tool in the negotiation process or in the earliest phases of concept development.

USE CASES

Representation tools are needed for a detailed representation of each functionality of the system. Use cases will visualize actions in a service step by step, allowing for a deeper understanding of the system in its details.

This method, not new to designers, can be used when representing specific functionalities in a systemic solution, although the translation of use cases from software technology into the design discipline requires that more information is specified: while information architects employ use cases to specify logical sequences of actions, systemic solutions will require that other characteristics of the system in each use case are specified, such as time sequences, characteristics of the space, nature of flows, etc. The user is the main actor in most use cases; each step of his/her action involves the use of tools, components and procedures in the system.

The graphical representation of use cases is the *blueprint* (Shostack 1982) of a PSS. Likewise blueprints in product design and architecture, in fact, a use case provides technical information about the specific functions and sequence of actions in a PSS. According to the background and the knowledge of whom the designer is communicating to, use cases could be represented through Pert charts (Figure 7), flow charts or other specific technical representations.



b

Figure 7 different representations of a blueprint for a Japanese takeaway restaurant. a) using a Pert Chart,

It is however very important to emphasise that in most cases the final users are *co-workers* in the production process for systemic solutions (Normann and Ramirez 1994; Normann 2000) and will therefore need specific attention. One should not assume that final users are familiar with any of the formalised languages that are commonly used to communicate among technical people. When directed to final users, visual representation of use cases should use more colloquial notations. If needed this kind of representation could be linked to information about the system's behaviour corresponding to each step of users' action.

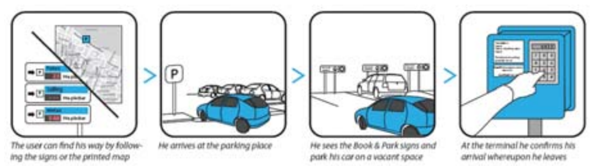


Figure 8 Details of a use case illustrating a Book & part service System. (source (Frøsig, Gauthier et al. 2006)

DISCUSSION

The tools illustrated in the previous paragraphs are just a little example of the wide range of tools that can be used when working on PSS. In fact the question of defining new representation techniques to work in a systemic context is an open ended question. As far as those techniques are available in the designer's toolbox, there cannot be any prescriptive indications about how those tools should be used, nor standardised ways of using those tools. A large part of those tools, such as actor mapping, could be used to analyse the system (therefore in a sort of problem space) or to make hypothesis of how a recombination of existing elements could generate a new solution (in a sort of solution space) (Figure 2).

The same tool, used in different occasions could have very different shapes: use cases, for instance, could be shaped as a simple story in plain language in the sketch phase, in order to elicit requirements, and could be reused later on in the development process, as a detailed graphic representation of the system to be used as the basis for the real *production* phase of a product service system, that is the phase in which service providers (Figure 7) and final users (**Error! Reference source not**

found.) will have to work out their own solution architecture.

Finally the shape of the tools also depends on the reason why the tools are used. If used in the sketch phase, those tools are essential to *negotiate* the interaction between the actors. A truly cooperative process involving a network of actors could make use of a set of symbols and flows, in order to organise different platform configurations and eventually choose the most appropriate one. Later on in the process platform configurations could be used in a more formalised way, to support the management phase of PSS (Figure 6).

CONCLUSION

This paper focuses on the critical role of representation technique in a new paradigmatic framework. Designers need new techniques to manages those communication aspects, especially in relation to the substantial role played by new actors, including final users. New languages, need to be introduced, in order to communicate new contents to such new actors.

The methodological approach this paper refers to is based on platform structures, on which old and new actors are supposed to interact. The designer is supposed to work as platform organiser, thus providing the basic communication tools to facilitate and support the design of systemic solutions. Although some of the methods described in this paper are already part of designer skills, further work is needed to integrate teaching, research and practice for a more complete development of an operative paradigm for the future system designers.

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