The Concept of a Design and Planning Platform

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Abstract

Various models have been proposed for design and planning activities. However, it is difficult to grasp their individual total images because their positions and meanings in actual design or planning activities are not necessarily made clear. The author has carried out studies to clarify the individual positions of these design and planning activity models and to understand their structures and behaviors.

Furthermore, the author, based on analyses, proposes to systematize various design and planning activity models into a tool called a design and planning platform. This tool will be included into a social human activity model proposed by the author based on the concept called the natural division of labor. This concept insists that the distribution of authority and responsibility should be the principle.

Keywords

Design, planning, deployment, evaluation, internal structure, business process, human protocol

1 Introduction

Recently, such concepts as intelligent activities, distributed and autonomous systems, and organizational intelligence^{*1} have attracted the attention of the world. This indicates that the current trend is to focus on both human activities and man-machine systems which includes social human activities. And an integrated understanding of these two is being requested. Integration represented by the OSI reference model for communication consisting of 7 layers (ISO 1984) is being actually developed. However, such frameworks are mostly confined to those for machines, and a framework for human activities and man-machine systems, comparable with those for machines, has not appeared yet.

^{*1} Organizational intelligence is the title of a session at The International Conference on Economics/Management and Information Technology (CEMIT) '92, and is also the name of a new paradigm being proposed by Dr. T. Matsuda, former presidents of the Tokyo Institute of Technology and the Sanno Institute (and also former V.P. of IFORS), becoming the object of attention in recent years (Umibe, 1991)

The author considers that this trend mentioned above can be summarized as an organism-oriented trend which has spread out into numerous branches. These branches can be classified into four categories: biological models, pseudo-biological models, pseudo-human activity models, and human activity models, and the approach by a human activity model is most promising at present. Among the human activities which can be classified into philosophical, social, and biological aspects, the understanding of social human activities is most expected, because social human activities are exactly those human activities and man-machine systems mentioned above.

The author has already proposed a framework for social human activities named a social human activity model obtained by the study of actual social human activities (Atsumi, 1993a). This social human activity model is expected to be able to integrate the domains and hierarchies of various social human activities by providing interfaces for them, because it is based on social human activities.

However, the proposed model up till now has left design and planning activities unsettled. Although various models have been proposed for design and planning activities, it is still difficult to grasp their individual total images because their positions and meanings

in actual design and planning activities have not necessarily been made clear. Consequently, some models will be analyzed for their integrated understanding and the feasibility of actual applications through making clear their positions, structures, and behaviors.

Figure 1 External Functions of an Order Cell.

Figure 2 Order Cell Model.

2 Social Human Activity Model

The author has already proposed the concept called the natural division of labor which insists that the distribution of authority and responsibility should be the principle and centralization should be limited only when it is proven to be effective (Atsumi, 1993a). Here, the activity unit of social human activities is each modular unit of the division of labor, i.e. the unit exchanging orders, which is called an order cell, and the external function of which is defined as exchanging orders with each other, as shown in Figure 1. The internal function is defined as having a set of missions which are unfinished orders and a set of all the functions necessary to carry them out, and has the form of processing orders. And, it asserts that social human activities can be represented by a hierarchy of order cells, which is an expression of a social human activity model in a broad

sense and named an order model. The order model employs orders as unique objects to be processed and consist of units of a single unique structure for processing such unique objects. It is applicable to all the necessary functions extending from management to services for all layers from a public or private organization to an equipment control device.

Furthermore, the author has already proposed an operational internal structure (Figure 2) of an order cell in which the human protocol based on the principles of social human activities presenting a framework is located on one end, and theoretical models based on the principles of science giving logical meaning on the opposite end, and various applications are assumed to exist between them. This structure is named an order cell model, which expresses a social human activity model in a narrow sense.

Various concepts have currently been proposed for computer integrated manufacturing systems, such as the Purdue Enterprise Reference Architecture (Williams, 1994), the Integrated Enterprise Modelling (Mertins, 1991), and the CIMOSA Model (AMICE, 1993). However, they are all top-down models and instruct very few about the internal structure of individual business processes. This is very disappointing to a practitioner. A simple and unique internal structure applicable to all business processes including design and planning activities is indispensable for making such enterprise models easy to apply. Also, the so-called work flow system, concurrent engineering, or continuous acquisition and life cycle support (CALS) is not an exception for the lack of an internal structure of individual business processes. The author insists to focus on the internal structure of business processes.

3 Human Protocol

The human protocol (Atsumi, 1992 & 1993a) has a multilayer structure following the 7 layer OSI reference model for communication (ISO 1984). The real world for the multilayer structure of the human protocol is considered to be that of office work by humans, by which the author has proposed such layers of process categories consisting of operation, work, procedure, strategy, and goal. The basic principle throughout the above categories is explosion, and orders are exchanged between the above layers, and processed by them. The procedure for constructing individual layers, based on the principle of focusing on human experience, is to select the representing real world, to establish its corresponding model, and to construct the operating system.

The real world for the first layer is operations on the desk, and the model is office automation (OA). The user interface is an operational user interface (OUI), represented by the well known graphical user interface (GUI), and the operating systems are various existing window systems.

For the second layer, the real world is office work by handwriting, and the model is business work. The user interface is a clerical user interface (CUI), and the operating system is a worksheet program (WSP) (Atsumi, 1991a & b, 1993b).

For the third layer, the real world is production control, and the model is order processing control. The user interface is a planning user interface (PUI), and the operating system is order processing control (ODPC) (Atsumi, 1993c).

For the fourth and fifth layers, the author focuses on design activities as the real world. Design activities, which can be considered as a kind of planning activities, are a major portion of intelligent activities including planning activities performed in public and private organizations, and have been processing a large mass of information in routine work. By due to this reason, various processing methods have been developed and practiced in design activities.

4 Quality Function Deployment and General Design Theory

Quality function deployment by S. Mizuno and Y. Akao (Mizuno, 1978, Akao, 1990) is discussed in order to prepare a tool for analyzing various design and planning activity models. Quality function deployment has its origin in the quality control activities of Japan. Those people who were not satisfied in merely achieving given quality standards, traced back to the origin of the quality standards and went into the domain of product design, and furthermore into the domain of product planning. Their activities have developed quality function deployment into an integrated design method which extends from quality planning and design to work standards in the shop.

Quality function deployment is constituted by:

- quality deployment in a narrow sense,
- technology deployment,
- cost deployment,
- reliability deployment,
- and quality function deployment in a narrow sense.

Quality deployment in a narrow sense, which is the most essential among these five constituents, consists of:

- demanded quality deployment and quality planning,
- quality characteristic deployment and quality design,
- parts deployment,
- and process deployment.

Quality deployment in a narrow sense, which converts the degrees of importance of the consumers' demands to those of the component parts using matrix, has been systematically established and has the possibility to be the nucleus of various design and planning methods. Accordingly, the author has tried to extend the concept of quality deployment.

T. Ohfuji² has an idea to generalize quality deployment by deleting the word "quality" from "demanded quality" and changing it to "demands." According to this idea, the word "quality" will be completely deleted from the description of quality deployment.

Also, constraint deployment, which consists only of technology deployment, cost deployment, and reliability deployment up till now will be extended to include all the constraints of the product aspect, organization aspect, and social aspect.

Furthermore, the general design theory proposed by H. Yoshikawa (Yoshikawa, 1979) models design activities as mapping from a function space to an attribute space. In his general design theory, an entity is defined as a matter which exists, existed, and will exist, and an attribute is defined as various physical and scientific characteristics, and behavior is defined as the change in an attribute with time. Function is defined as those characteristics abstracted by applying a certain rule to an attribute and behavior. Such definitions will be extended so that design and planning activities are defined as mapping from an original set to an object set. They include those activities generating all or a part of an original set, object set, or mapping function for applying the design activity model of the general design theory to design and planning activities.

By such an extended general design theory, extended quality deployment can be defined as a downward design and planning activity model, which generates an original set: (demand deployment), determines the type of mapping function: (characteristic deployment), establishes a mapping function: (characteristics), maps an original set: (demand deployment) to an object set: (parts deployment) generated beforehand. Anything can be

² Tadashi Ohfuji: Assistant Professor, Faculty of Engineering, Tamagawa University

included into demands unlimitedly. Concepts, processes, and actions can be included into parts since parts are extended to include documents/information, work/services in addition to the so-called mechanical or physical type of parts. Furthermore, a mapping function can be regarded as a scenario.

5 Integrated Model

The following methods, which can integrate a series of design or planning activities, will be analyzed.

5.1 Soft Systems Methodology

P. Checkland has proposed Soft Systems Methodology (SSM) as a tool for the perpetual improvement of a human activity system. He has defined SSM as “a set of activities linked together in a logical structure to constitute a purposeful whole.” (Rosenhead, 1989).

Soft Systems Methodology can be considered to be a method which

- hierarchically generates root definitions: (demands and demanders),
- builds a conceptual model: (a combination of demand deployment, characteristic deployment, constraint deployment, and parts deployment),
- analyzes by comparing the model with reality, and defines changes.

The value of this method lies in the fact that it hierarchically designs or plans downwards or upwards, and finds out a culturally feasible solution by laying emphasis on the persons concerned, their power, norms of behavior, and the basic cultural values.

5.2 Strategic Choice Approach

J. Friend has proposed a procedure to deal with uncertainties, insisting that the routing of any non-routine decision process is governed by the perceptions of three types of uncertainties; they are uncertainty pertaining to the working environment, uncertainty pertaining to guiding values, and uncertainty pertaining to the related decision fields (Rosenhead, 1989).

The strategic choice approach can be considered to be a method which

- deploys the decision areas: (characteristic deployment),
- extracts available options: (might-be characteristic values),
- identifies feasible decision schemes: (combinations of parts deployment and characteristic values, that is, scenarios),
- compares feasible decision schemes: (determination of the degrees of importance) for comparison areas: (demand deployment),

and then, using the results derived above,

- identifies and compares uncertainty areas for comparison areas: (demand deployment and planning),
- decides present actions and explorations promising an advantageous future decision space: (scenario regarding future decision space, present actions, and present explorations as characteristics).

This approach intends to control uncertainty through the process of two stages consisting of the first stage clarifying the structure of the problem upwards, and the second stage making decisions downwards.

5.3 Robustness Analysis

J. Rosenhead has proposed to cope with uncertainty by using robustness, regarding planning under certainty as sequential decisions, that is, planning with uncertainty consisting of present decisions and the remaining future (Rosenhead, 1989).

The robustness of any initial decision is defined to be the number of acceptable options of the planning horizon with which it is compatible, expressed as a ratio of the total number of acceptable options at the planning horizon.

Robustness analysis can be considered to be a method which

- generates a tree of decisions: (candidate characteristic values) of multi-stage: (characteristics) for the target situation: (parts deployment),
- values: (planning) options: (parts compositions) for individual targets: (demand deployment),

and then, by using the results derived above,

- makes the decision: (characteristic values) of the present state: (characteristics) expected to be more flexible and desirable selections in the future: (demands).

This analysis is a method similar to the one described in paragraph 5.2 using a two stage process consisting of the first stage clarifying the structure of a problem upwards, and the second stage making decisions downwards, but different from the one described in paragraph 5.2 in that it simplifies evaluation by using the number of options.

5.4 Metagame Analysis

N. Howard has proposed to apply metagame analysis which takes strategy and human relations into consideration to a situation in which individual actors choose their options in order to win against others (Rosenhead, 1989).

This metagame analysis can be considered to be a method which

- clarifies the situation by preparing a list of actors: (parts deployment) and their options: (parts characteristic values),
- finds feasible scenarios: (characteristic values) by combining the options,
- draws a strategic map, a diagram of transitions among scenarios: (stability analysis of characteristic values) by finding out changes of scenarios preferred by actors and countermeasures against such
- changes through the preferences of scenarios of individual actors,

and then, using the strategic map,

- finds the conditions: (characteristic values) to realize the scenario: (demands) preferred by a certain actor by introducing preference change, irrationality, deceit, or rational argument in the common interest: (characteristics).

This analysis intends to process the situation of decision making by multiple actors, considering it as a state transition, by using a two stage process consisting of the first stage clarifying the structure of the problem upwards, and the second stage making decisions downwards.

5.5 Hypergame Analysis

P. Bennet, et al., have proposed to apply hypergame analysis to the analysis of the world of decision making by multiple players individually, which presumes that the players concerned holding different views of the situations make decisions affecting the well-being of others for the purpose of advancing their own aims and interests under a pluralist view of the world (Rosenhead, 1989).

The above presumptions lead to a basic hypergame model, in which there are separate games for individual players who specify the strategies, preferences, and presumed results of all players concerned. Furthermore, the model is expanded to include radical differences in the perceptions among players. These differences consist of the definitions of the games in quite different terms, disagreement of the extent of the relevant parties, and disagreement about the authorship of actions.

This hypergame analysis can be considered to be a method which

- identifies players: (parts deployment), finds out options: (parts characteristic values),
 - selects scenarios: (characteristic values) through the elimination of infeasible solutions, stability analysis using the order of preference, and analysis of the implementation sequence,
- and then, using the results obtained above,
- structures the hyper game models,
 - analyzes to obtain the preferred result: (demands),
 - and new ideas: (characteristics) are introduced if a preferred result is not obtained.

This analysis intends to apply the hypergame analysis having separate games for individual players to the world of decision making by individual multiple players by use of a two stage process clarifying the structure of the problem upwards, and the second stage making decisions downwards.

The description for analyzing individual players by using a view of the world: (demand deployment), actions: (parts deployment), options: (parts characteristic values), scenarios: (characteristic values), and decision areas: (characteristic deployment) according to the extended quality deployment will explicitly express the world of pluralism to make the analysis more easy.

5.6 Taguchi Method

G. Taguchi has proposed quality engineering (Taguchi, 1986 & 1988), which determines the parameters for design, tolerances based on the concepts to maximize the signal-to-noise ratio (S/N ratio), and to minimize loss and to balance quality and cost.

The S/N ratio is defined as the ratio of the mean response value by a controllable factor against the variance of responses due to uncontrollable factors. Quality is defined as the mean actual economical loss (the loss function), regarding quality as the loss to customers.

The Taguchi method can be considered to be a method which

- determines the level of factors: (characteristic values) based on the S/N ratio,
- and evaluates the adequacy of the selection of factors: (characteristic deployment) by the amount of interactions among the factors in parameter design,
- determines the parameters for design: (characteristic values) according to the principle of minimizing overall loss: (characteristics), and the tolerance: (characteristic values) by balancing quality and cost: (characteristics) in tolerance design.

This method provides an effective tool for processing the successive characteristic deployment, and is noticed in that it evaluates the adequacy of the characteristic deployment itself.

5.7 Metamodel Mechanism

Kiriyama, et al., have proposed to integrate various design object models for different physical aspects. This is based on the knowledge of the relations among the concepts which are used in the theories expressing physical aspects, which is named a metamodel mechanism (Kiriyama, 1991).

The metamodel mechanism can be considered to be a method which automatically transforms

- a primary model: (demand deployment) into a central model: (characteristic deployment and characteristic values),
- a central model into various aspect models: (parts deployment considering their individual aspects and their details as component parts).

Extended quality Deployment Method	Demand deployment	Planning	Characteristic deployment	Design/ Characteristic values	Parts deployment	Parts design/ Parts character- istic values	Remarks
Soft Systems Methodology	① Root definitions	② Conceptual models					
Strategic choice approach	③ Comparison areas	④ Comparison of schemes	① Decision areas	② Decision schemes			*1 The characteristics are as follows. · Future decision space · Present actions · Present explorations
	⑤ To identify and compare uncer- tainty areas		⑥ "Fixed charac- teristics *1"	⑦ Commitment package			
Robustness analysis	④ Multiple targets	⑤ To value (options)	① Multi-stage	② Decisions (of multi-stage)	③ Options		
	⑥ "More flexible and desirable selections in future"		⑦ "Present state"	⑧ Decision (of present state)			
Metagame analy- sis			④ Strategic map	③ Scenarios	① Actors	② Options	*2 The characteristics are as follows. · Preference change · Irrationality · Deceit · Rational argument in common interest
	⑤ "Scenario preferred by a certain actor"		⑥ "Fixed charac- teristics *2"	⑦ Conditions to realize			
Hypergame analysis	④ "Preferred result"			③ Scenarios	① Players	② Options	
Modified hypergame analysis	A view of the world		Decision areas	Scenarios	Actions	Options	Prepare for individual players, and integrate
Taguchi method			① Selection of factors	② Level of factors			Parameter design
			③ "Minimize overall loss"	④ Parameters for design			Tolerance design
			⑤ "Balance quality and cost"	⑥ Tolerance			
Metamodel mechanism	① Primary model	② Central model	③ Aspect model				

Remark: ①, ②, ③ indicates the operation sequence

Figure 3 Comparison of Integrated Models for Design and Planning.

This method can be generalized to apply it to a world in which logical mapping is possible, and should be applied as much as possible.

5.8 Comparison of Methods

A comparison of the individual methods with their respective processes for extended quality deployment is shown in Figure 3.

Figure 3 shows the following.

- The individual methods should not be discussed for the purpose of evaluating which are better, but should be selected for applying them according to the issue, object, or aspect, since they have their unique respective focuses.
- Extended quality deployment is effective for analyzing design and planning models.
- Fixed items shown with “...” in Figure 3 suggest the possibility of standardizing these items.

6 Design and Planning Platform

The fourth layer, “strategy”, and the fifth layer, “goal”, described in Section 3 will be studied based on the discussions in Section 4, and 5. To separate strategy and goal is irrational, as it can be seen from the case of a systematic diagram (Mizuno, 1988), which regards the means or procedures of the preceding step as goals or objectives. Accordingly, the fifth layer “goal” will be eliminated, considering input as the goal, and output as the strategy. The world of design and planning activities is selected as the real world for the fourth layer.

The basic processes of the real world are to generate all or a part of an original set, object set, or mapping function, and to map the original set to the object set according to the extended general design theory. These processes can be considered to be one or two dimensional deployment and its evaluation, as illustrated in Figure 3. They are to extract elements, to find interrelations among them, and to express the intention. Consequently, the model is a deployment and evaluation process (DEP).

As for the operating system, it seems impossible to adopt a unique method for the operating system, since actual design and planning activities consist of various combinations of various deployment and evaluation unit processes having interfaces to others, as shown in Figure 3. In the evaluation of methods, it is not sufficient that the method is equipped with many and powerful functions. It should rather be evaluated from whether it is easy and simple to use or not and whether it is applied widely or not and also whether the effectivity of the method itself can be increased by the advancement of the users' skill

Layer	Process	Real world	Model	User interface	Operating system
4th	Strategy	Design and planning	Deployment and evaluation process	Strategic user interface	Design and planning platform
3rd	Procedure	Production control	Order processing control	Planning user interface	Order processing control
2nd	Work	Office work by hand writing	Business work	Clerical user interface	Worksheet program
1st	Operation	Operation on desk	Office automation	Operational user interface	Various window systems

Figure 4 Structure of a Human Protocol.

through actual use or not. So, a method which appears rather primitive might be more useful. Furthermore, a diversity of methods should be provided to cope with complicated reality. Consequently, for an operating system, the author proposes a design and planning platform (DPP), which presents available methods, applicable fields, application limits, features, texts, manuals etc., for the individual stages of design and planning activities. A computer environment including tools and standardized item lists etc. necessary to apply the presented tools has also been provided.

Furthermore, design and planning activities have been brought under the support of the third layer represented by material allocation and sequence control, the second layer represented by document control, and the first layer represented by office automation through the incorporation of these activities into the fourth layer of human protocol. In other words, any consideration has become unnecessary for the third and less layers by their incorporation, whereas it should be noticed that the lack of consideration for the infrastructure mentioned above is the common deficiency throughout the analyzed methods. Namely, the desired result cannot be obtained through one trial, but the result will be gradually refined to the desired one through repeated trials in the practical use of these methods. Also, changes in design or planning are inevitable in all aspects of any applications to practical design or planning activities. Furthermore, the results of any design or planning activities become proofs for such matters as product liability, records for maintenance, and accumulation of experiences for reuse. Tools not providing such an infrastructure will result as a burden on their users.

In addition, there exist problem analyzing models used for making a structure, one dimensional deployment models used for expressing relations by distance, and two dimensional deployment models used for expressing relations by a matrix applicable in the individual stages of design and planning activities. And these models should be incorporated into the design and planning platform.

A problem analyzing model connects the nodes of ideas or thoughts with directed links. Cognitive mapping (Tolman, 1948) and relations diagram (Mizuno, 1988), both of which link the elements with logical relations, and an affinity diagram (Kawakita, 1970, Mizuno, 1988), which links the elements with mental relations, belong to this category.

A one dimensional deployment model expresses problems or circumstances with multiple items and distances among them. A systematic diagram (Mizuno, 1988) and process decision program chart (Mizuno, 1988), both of which locate items according to a family type logical distance, and an articulation aid system (Hori, 1994) and common quality demands (Nakajo, 1994), both of which locate items according to the mental distance, belong to this category.

A two dimensional deployment model generates a relation matrix between a pair of the results of one dimensional deployment. A matrix diagram (Mizuno, 1988), which is the most simple method, matrix data-analysis (Mizuno, 1988), which uses principal component analysis, and near decomposition of quality table (Shindo, 1993), which decompose the matrix into partial matrixes by the quantification method of type 3", belong to this category.

Above discussion gives a structure shown in Figure 4 to the human protocol.

7 Conclusion

The author has carried out studies to establish the fourth and fifth layers of the human protocol by clarifying design and planning activities and structuring them. These represent the internal structure of one of the social human activity models, i.e. the order cell model.

For this purpose, the author has extended the general design theory and quality function deployment, has analyzed various design and planning methods using extensions of these

methods, and has obtained the deployment and evaluation processes as a unified principle for these methods.

Consequently, the author has proposed to eliminate the fifth layer of the human protocol, and to make the real world, the model, and the operating system of the fourth layer, strategy, as design and planning, deployment and evaluation process, and design and planning platform, respectively.

There exist several discussions on design, planning and production control that they are different tasks of the same level. However, the author's interest only lies in their structures, and insists that design and planning have the same internal structure but production control has a different internal structure. Here, it should be noticed that the structure of production control is indispensable for design and production activities as their substructure, and planning required for production control can be executed on a design and planning platform.

The issues for further studies are to select methods and to prepare menus, tools, and standardized item lists for the individual stages of these design and planning activities.

Furthermore, the suggestion of the possibility of standardizing within the individual phases of the extended quality deployment stated at the last of Section 5 should be noticed. It implies the existence of internal structures in the individual phases. These structures should be studied before the practical application of the design and planning platform.

Also, most concepts currently proposed for computer integrated manufacturing etc. are attempting to directly describe complicated actual business processes or activities, and are being confronted with difficulties. The concepts proposed in this paper suggest that these difficulties are caused by neglecting the study of the structure of business processes. Namely, the author considers that the basic practice of business processes and their principles should be studied just like the Ohm's law in electricity. These principles should be systematized to establish a new technique, which can be called business process engineering.

8 Acknowledgments

This research was performed as a domestic feasibility study of a joint international research program on intelligent manufacturing systems (IMS). The author wishes to thank Mr. Fujio Umibe, a consultant, for reviewing the original manuscript and suggesting revisions in its English.

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10 Biography

Mr. Atsumi Ryo, born in 1939, master of mechanical engineering, has been interested in developing his social human activity model to overcome post-structuralism. He is at present engaged in the assessment of ISO9000 quality systems. He is an old practitioner engaged in system engineering (automated design, production process control, profit control, promotion of engineering work computerization, education and management of software forces), establishment of a nuclear quality assurance system and a power boiler production system, design of chemical process plants, project engineering of chemical process plants and power boilers, and procurement of cast and forged products.