

## MULTI-STRATA MODELING IN MCM AND CLM FOR COLLABORATIVE ENGINEERING

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**Abstract:** In order to analyze collaboration of people, the author enhances the modeling techniques with specific constructs for the multiple strata in Multi-Context Map (MCM) and Collaborative Linkage Map (CLM). The first is the collaboration stratum where a collection of collaboration tasks is enumerated as top view for systems analysis. The second is the workflow stratum where, for each of collaboration tasks, workflow of request is clarified, and collaborators, tokens, material and information are enumerated. The third is the state transition stratum where state transitions for collaborators, material and information are clarified.

**Key words:** Multi-Strata Modeling, Collaborative Engineering

### 1. INTRODUCTION

Collaboration tasks are often observed in various fields. Collaboration task is an activity which involves multiple participants with a shared goal including individuals, personnel, organizations and facilities with different roles or perspectives in the process. Collaboration task is not a completely concurrent but appropriately coordinated process, because all of the participants in the process do not always produce, assemble, or modify material and/or information in a simultaneous and parallel manner.

To grasp collaboration tasks effectively, it is very important to analyze what workflows are, what multiple participants, i.e., collaborators, are doing, which position they are in, and how they communicate with each other, and

how material and/or information are dealt with. When monolithic view or single strata modeling is adopted, the interrelationships between various entities and actions such as participants, workflows, materials, information resources, events, positions, communications are often mixed into a single description. Multi-strata modeling view is very effective for analyzing systems with collaboration tasks by distinguishing, stratification, categorizing, and scope or concept localization of these entities, actions and interrelationship, and by controlling the advancement of systems analysis in stepwise fashion from top view.

A system can be regarded as a collection of collaboration tasks. A collaboration task can be analyzed and modeled by focusing on two sides, general workflow (e.g., [5]) and state transitions. A workflow can be regarded as a collection of contexts, each of which switches one after another among the participants according to the differences of their perspectives. State transitions can represent the behavior of components participating in workflow. The authors devised Multi-Context Map (MCM) [4] for the description of workflow and Collaboration Linkage Map (CLM) [1] for the description of state transitions. MCM specifies the feasibility of the collaboration as well as contextual switches among collaborators. CLM specifies state transitions of collaborators and state transitions of material and information that are transferred among collaborators. Analyzing or modeling process in MCM and CLM enables to advance systems analysis in stepwise fashion from top view by multiple strata structure with collaboration tasks, workflows and state transitions.

## **2. CONCEPT OF CONTEXT AND WORKFLOW**

Where an activity is performed in collaboration, there exist two types of collaborators, i.e., clients and servers with their own perspectives. Perspectives are views, opinions, or positions for the activity. Clients and servers represent requestors and performer, respectively. They are individuals, personnel, organizations and facilities or combinations. The authors call an activity by clients and servers with perspectives “context”. Clients and servers are collaborators of the context. The authors’ method is a method to systematically analyze collaboration tasks among perspectives that perform collaboration in the systems, and information and materials dealt in collaboration.

Context Map (CM) as a minimum element is shown in Figure 1. Two perspectives sandwich the context. The perspectives on the left and right of the context are called the “left-hand perspective by client” and the “right-hand perspective by server”, respectively. This situation represents where

perspectives collaborate with each other, like exchanging information, asking someone to do the job, or so on.

The context deals with three types of entities, - token, material and information – as inputs and outputs. Token represents fact or event, which is mutually recognized and acknowledged by two perspectives. Material represents an entity that is physical and has mass or weight. Information represents an entity that is logical. In the context, resources are used by left-hand perspective by client and the right-hand perspective by server.

CMs are combined as a network to build “Multi-Context Map (MCM)”. A MCM can represent a workflow of a collaboration task. In the MCM as shown in Figure 2, the client for the first CM gives a request to the server, and then, the server, as the client for the second CM, gives a request to the server of the second CM. Workflow of request in collaboration task looks like relay of baton.

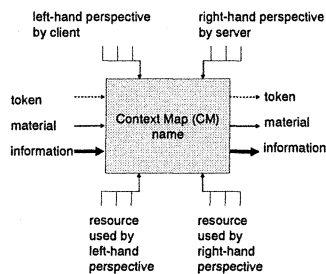


Figure 1. Context Map (CM): General

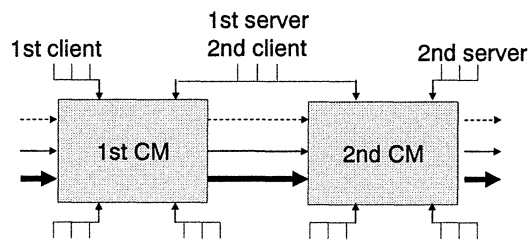


Figure 2. Multi-Context Map (MCM)

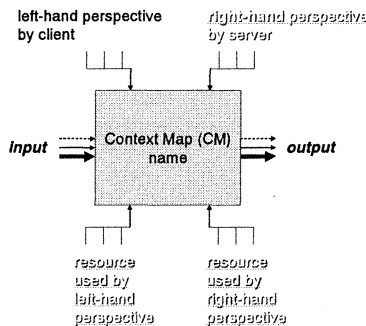
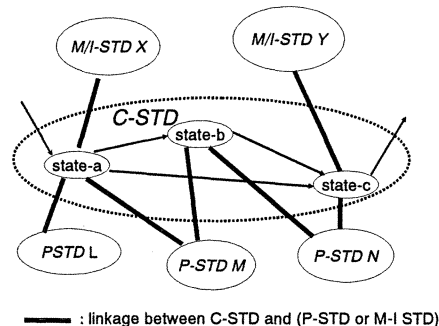


Figure 3. Context Map (CM): Top View



— : linkage between C-STD and (P-STD or M-I STD)

Figure 4. Collaborative Linkage Map

The top views of system can be analyzed from the viewpoint of collaborations. A system is considered to be a collection of collaboration tasks. At the first stage of systems analysis, the existence of collaboration tasks is recognized, and corresponding candidate contexts in top view are enumerated. Such a context is described in “Candidate Context Map (CCM)” as shown in Figure 3. The left-hand perspective by client should be identified, but the right-hand perspective by server may not always be. The

differences of token, material and information may not always be identified as inputs and outputs.

### **3. CONCEPT OF STATE TRANSITION OF COLLABORATION COMPONENT**

The workflow described in MCM can be mapped into a state transition diagram (STD). This STD is called “Collaboration STD (C-STD)”. In a workflow, material, information, client and server have various behaviors in active or passive fashion. The behaviors of all of those can be mapped into STDs. STD for material and information is called “M/I-STD”. STD for client and server is called “Personnel STD (P-STD)”. Personnel mean individuals, organizations and facilities. Integration of C-STD, M/I-STD and P-STD is called “Collaborative Linkage Map (CLM)” as shown in Figure 4.

Both P-STD and M-STD represent situations by three types of states. “Enaction state” represents the situation that P-STD is acting on the M-STD and connects both STDs with Collaboration-State. “Commission-state” is defined when one P-STD has any kind of relations with other P-STDs and the information exchanged in such situation is defined as “Communication-Inventory”. “Dormant state” is the state neither of them and does not have any relationships to other state diagrams.

### **4. MULTI-STRATA IN MCM AND CLM MODELING**

Modeling in MCM and CLM for collaborative engineering has three-strata as shown in Figure 5. The first is the “collaboration stratum” where a collection of collaboration tasks is enumerated as top view for systems analysis. The second is the “workflow stratum” where, for each of collaboration tasks, a corresponding workflow is clarified, and collaborators, tokens, material and information are enumerated. The third is the “state transition stratum” where state transitions for collaborators, material and information are clarified.

#### **4.1 COLLABORATION STRATUM**

The existence of collaboration tasks is recognized. For each of collaboration tasks, a corresponding candidate context in top view is enumerated as Candidate Context Map (CCM). For CCM, the left-hand perspective by client should be identified, but the right-hand perspective by

server may not always be. The differences of token, material and information may not always be identified in CCM.

## 4.2 WORKFLOW STRATUM

For each of collaboration tasks by CCM, a corresponding workflow is constructed by MCM (i.e., network by one or more CMs). The left-hand perspective of CCM becomes the left-hand perspective of the first CM in MCM. Its right-hand perspective should be clarified and becomes the left-hand perspective of the second CM. The situation follows like this to the downstream. The structure of MCM is not only straightforward but also a network one where branch, parallel and loop patterns are permitted. For each CM, perspectives should be determined. For the connecting CMs, token, material and information should be determined.

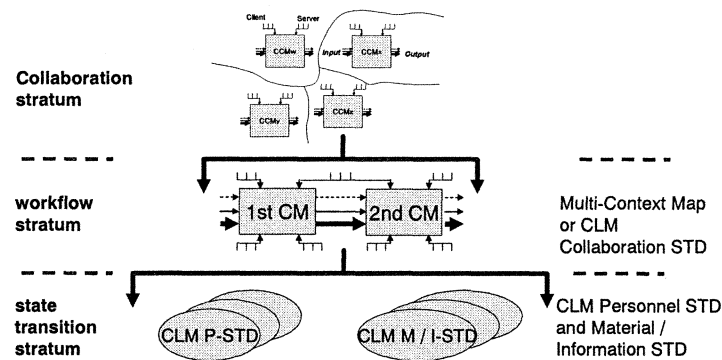


Figure 5. Multi-Strata in MCM and CLM

Junctions are provided for various network structures to show the behavior of the workflow clearly. Branch junction defines the situation that one thing goes only to the one of the outputs and it depends on the condition where to go. Duplication junction copies the input to all of the outputs. Decomposition junction decomposes its input, which means one thing breaks, into two or more outputs. Synchronization junction waits all the supposed multiple inputs come before producing the output. Serialization junction joins the multiple inputs to the output like a flow in the river.

## 4.3 STATE TRANSITION STRATUM

The workflow described in MCM can be mapped into a Collaboration STD (C-STD). While a request on workflow is processed, material,

information, client and server have state transitions actively or passively. The behaviors of all of those can be mapped into P-STDs and M/I STDs.

## **5. EXAMPLE OF MULTI-STRATA**

Figure 6 shows Collaboration Stratum for Academic Affair. “Allocate”, “Enter Registration”, “Lecture”, “Make Exercise for Report”, “Submit Report” and “Certificate” are enumerated as CCMs. Figure 7 shows Workflow Stratum for “Certificate” in Academic Affair. “Determine Certificate”, “Send Certificate” and “Send Failure Notification” are enumerated as CMs. All parameters for these CMs are specified. These CMs are connected into MCM as workflow. Figure 8 shows State Transition Stratum for “Certificate” in Academic Affair. C-STD corresponds to the MCM. P-STDs are specified for “Lecturer”, “Clerk for Certification” and “Clerk for Sending”. M/I STDs are specified for “List of Marks”, “Member List”, “Certificate” and “Failure Notification”.

## **6. CONCLUDING REMARKS**

In order to analyze collaboration of people, the author enhances the modeling techniques with specific constructs for the multiple strata in MCM and CLM. Constructs in MCM and CLM can be organized in different strata with distinct connotations. Each stratum defines a certain group of those constructs with particular semantic content (e.g. collaboration, workflow, and state transitions of resources). In collaborative engineering, it is defined as strata to provide different views of a system. The relationships among stratum are not represented appropriately in homogeneous hierarchical structure of diagrams.

MCM and CLM Editors are developed to support to analyze collaboration task [2]. Extraction process of E-R model from MCM and CLM is developed [3].

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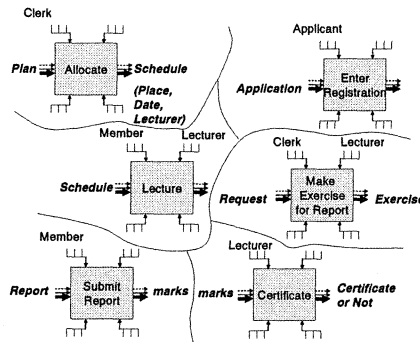


Figure 6. Collaboration Stratum for Academic Affair

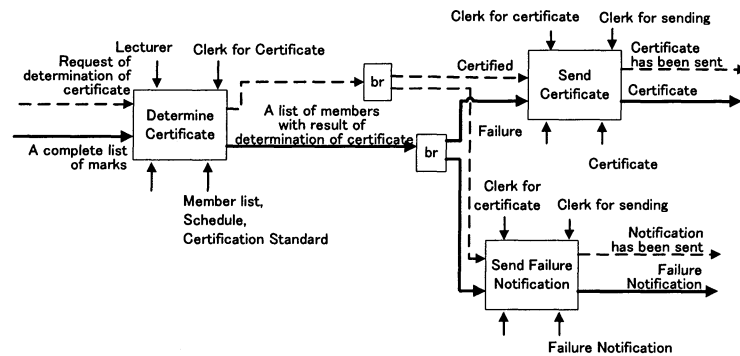


Figure 7. Workflow Stratum for Certificate in Academic Affair

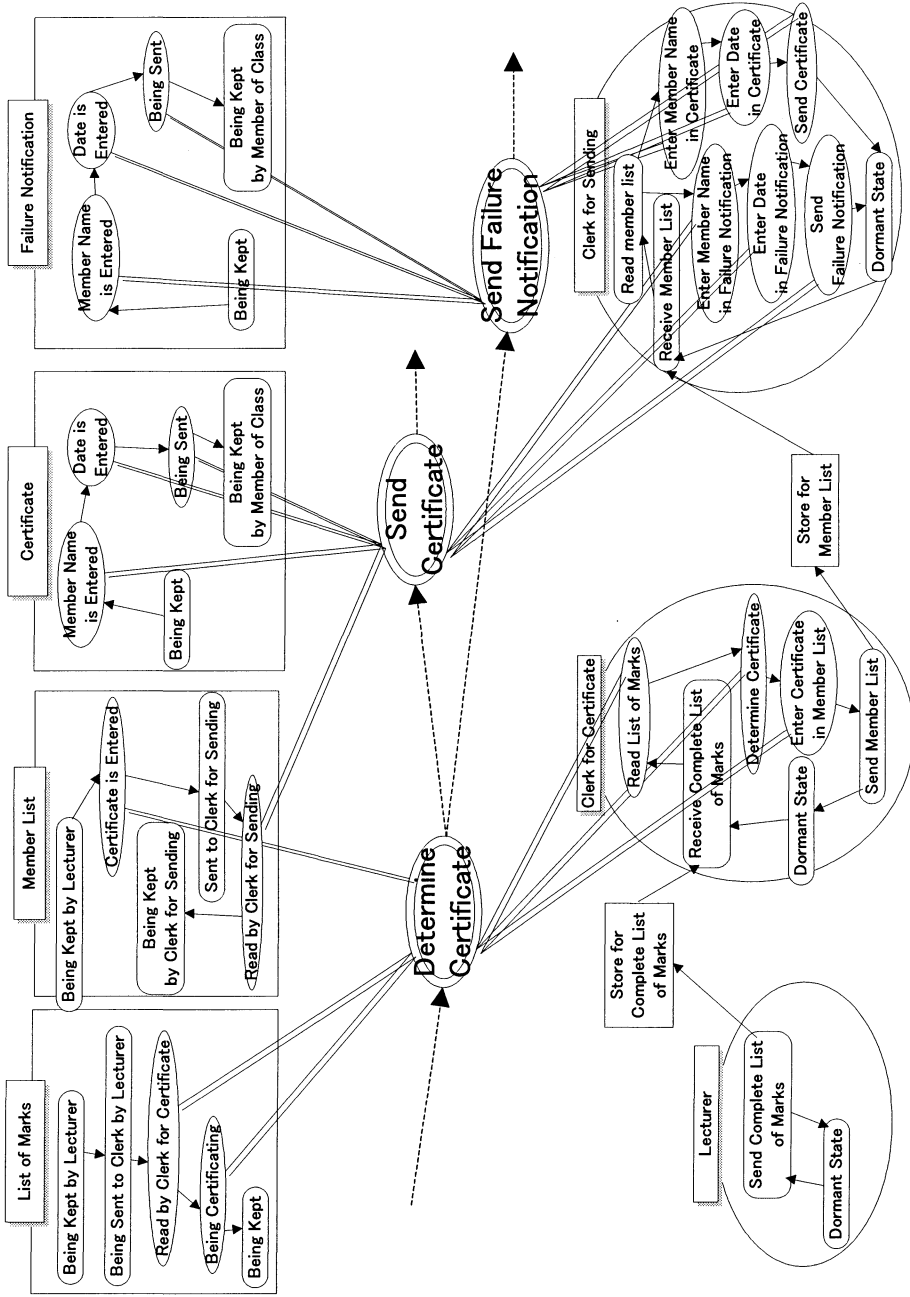


Figure 8. State Transition Stratum for Certificate in Academic Affair