Systems Research and Behavioral Science
Syst. Res. **17**, 205–228 (2000)

■ *Research Paper*

An Integration of Systems Science Methods and Object-oriented Analysis for Determining Organizational Information Requirements

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This research explores how systems science and an object-oriented methodology can be used together to increase the effectiveness of organizational requirements analysis for information systems (IS) development. Organizational failure of IS development is defined as a gap between what the users expect from an information provision system and how well these expectations are met by the perceived performance of the delivered system. Problems leading to this expectation–perception gap are identified and modelled as five interrelated discrepancies or gaps throughout the process of IS development. These gaps could be bridged by using systems science methods and object-oriented analysis. A wider framework which incorporates elements of both methodologies is formulated and applied to a real-world case. Lessons are generated from reflections upon what has been done and how it was done. Possible ways to integrate object-oriented analysis with systems science methods are suggested. Copyright © 2000 John Wiley & Sons, Ltd.

Keywords systems science; soft systems methods; object-oriented analysis; information systems development; requirements analysis

INTRODUCTION

The subject of information systems grew out of computer science to fill a gap created by the failure of machine-code programmers to understand and solve user problems (Parnas, 1997). As pointed out by Stamper (1973): 'On the one side, stand the technologists, most of whom have no idea of the complexity of organizations. On the other side, stand the managers and administrators who are unable to translate their problems into feasible demands upon technology.' It was an attempt to bridge technological solutions with organizational problems that started information systems (IS) work.

Some might say that despite the plethora of information systems development (ISD) tools and methodologies that have become available since 1973, little has changed in relation to bridging the gap between users' expectations of system capability and how well these expectations are met by the perceived performance of

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delivered information systems (Ewusi-Mensah, 1997). Indeed, the increasing rate of development of technology might even be fuelling higher expectations by users which information system developers are finding increasingly difficult to meet. Such a gap between stakeholders' expectations expressed in some standards and the perception of the delivered system is defined as an IS failure (Lyytinen, 1988a, 1988b; Ramprasad *et al.*, 1993; Shand, 1994).

AN EXPECTATION–PERCEPTION GAP ANALYSIS OF IS FAILURE

The expectation–perception failure of IS development can be understood and analysed by a gap model as illustrated in Figure 1. The model features discrepancies or gaps that need to be closed in order to achieve success in IS development projects. Here, IS failure is defined as a gap between users' expectation and perception of the performance of a delivered system. The expectation–perception gap (Gap 6) is in turn caused by five interrelated gaps (Gap 1 to Gap 5) throughout the process of IS development.

Cognition Gap (Gap 1)

The cognition gap (Gap 1) is a difference between 'what the users need' and 'what the

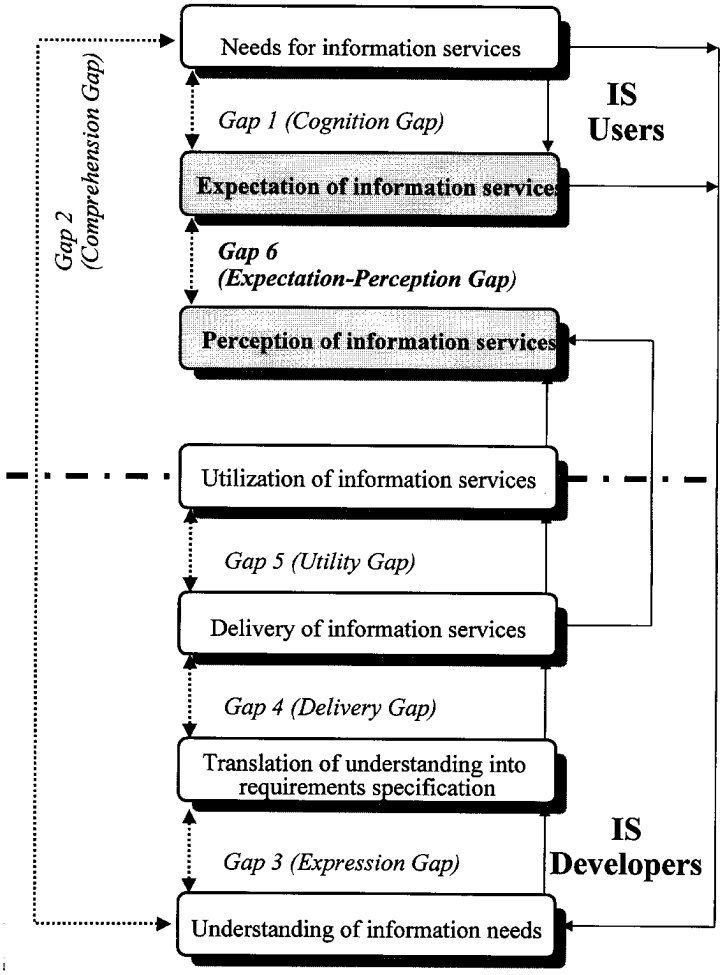


Figure 1. A gap analysis model of organizational failure of IS development

users think they need'. Factors contributing to this gap include:

- Users' requirements analysis is not based on realism. Needs do not exist 'out there' but are constructs perceived by users through a cognitive framework. Needs are not easily articulated as they are products of human minds (Ackoff, 1967; West, 1992).
- Users, being humans, have limitation in information processing and bias (such as representative bias, availability bias and confirmatory bias) in their selection of and demand for information (Miller, 1956; Corner *et al.*, 1994).
- Systems users are embedded in a constantly changing organizational environment which is often unpredictable and it is virtually impossible for them to produce a set of unalterable requirements specifications (Land, 1987; Avison *et al.*, 1994).

Comprehension Gap (Gap 2)

The comprehension gap (Gap 2) is a difference between 'what the users need' and 'what the developers think the users need'. There are various obstacles that may inhibit IS professionals from gaining a comprehensive picture of user expectations. For example:

- Information systems development should be 'inside-out' rather than 'outside-in'. IS developers, on their own, would not know what users need and deliver that (Ives and Olson, 1984; Winograd, 1995).
- Requirements, in most cases, originate from a heap of stakeholders with diverse interests rather than a coherent user group (McKeen *et al.*, 1994; Shand, 1994).
- Information needs are value-laden and culture-bound. No one could understand a culture and value unless he/she is inside the culture and shares the same value (Lewis, 1994; Butterfield and Pendegraft, 1996).
- There are communication barriers between developers and users due to their differences in background, concerns and language (Kaiser and King, 1982; Verrijn-Stuart and Anzenhofer, 1988).

Expression Gap (Gap 3)

The expression gap (Gap 3) is a difference between 'the developers' understanding of users' needs' and 'the translation of developers' understanding into a requirements specification'. This expression gap could be a result of several phenomena, such as:

- An IS developer's mental constructs (e.g. perceptual processes, values, ethics, motives, prejudices, intellectual ability, experience) have an effect on the understanding he/she gained from the situation. It is, very often, those mental constructs rather than the expertise of a developer that determine the relevance and importance of elicited users' requirements. The filtering and transformation criteria depend mainly on what the developer perceives to be feasible (Hirschheim and Schafer, 1988, Stacy and MacMillian, 1995).
- When IS developers translate their understanding of business tasks into technical functions, they map human activities, objects and events into 'processes', 'data format' and 'data structure'. Yet, these graphical expressions are not the actual world. No model or modelling technique is capable of capturing the degree of complexity of an organization's requirements (Wahlström, 1994; Lohse *et al.*, 1995).

Delivery Gap (Gap 4)

The delivery gap (Gap 4) indicates discrepancies in the ability of IS developers to transform users' requirements specifications into an operational system. This system construction process has long been a focus of IS research. Issues that may bridge the gap between 'a system as specified' and 'a system as delivered' are studied under two disciplines:

- *Project management* — the planning, organizing and controlling of resources (human and technical) to maintain crucial conditions of a

project development so that the target information system can be delivered within a specified performance, in time and in cost (Cleland and King, 1983; Thomsett, 1993).
- *Software systems engineering* — the employment of formal and rigorous methods to ensure essential attributes (e.g. conformity, functionality, efficiency, reliability, maintainability, flexibility and security) of the deliverables of a software system project are kept within a specified standard (Boehm, 1981; Humphrey, 1995).

Utility Gap (Gap 5)

The utility gap (Gap 5) measures the extent to which the utilization of an operating system is consistent with the design intent of its systems developers. Research indicates that the differences between 'a system delivered' and 'a system in use' may have the following causes:

- Technologies are socially constructed and will be socially reconstructed. Users can mediate technological effects, adapt systems to their needs, resist them or choose not to use them at all (Perrow, 1983; Jönsson and Grönlund, 1988).
- The time–space discontinuity between the design and use of an information system can lead to different interpretations of the role and utility of the underlying technology (Orlikowski, 1992; Griffith and Northcraft, 1996).
- Technology implementation is a transfer of knowledge rather than the physical devices. Users' perceived performance of an information system are not based on its delivery functions but the usable functions. Training and education on the use of technology are as important as the construction of the technology (Smithson and Land, 1986; Olfman and Mandviwalla, 1994).

Expectation–Perception Gap (Gap 6)

The expectation–perception gap (Gap 6) is a function of gaps 1, 2, 3, 4 and 5. We may thus argue that information systems failure (defined as users' expectation mismatch) results for one or more of the following reasons:

(1) users' inability to cogitate upon their information needs;
(2) developers' inability to comprehend users' information needs;
(3) developers' inability to translate the perceived information needs of users into requirements specifications;
(4) developers' inability to transform specified needs for information provision into systems deliverables;
(5) users' inability to utilize the delivered systems to satisfy their information needs.

In this way, the key to achieving success in information systems development is to keep Gap 6 closed by closing Gaps 1 through 5. Bridging the gaps requires IS professional to take a radical shift from being the proprietor of information systems and products to being service providers to end-users (Farwell *et al.*, 1992).

AN ORGANIZATIONAL VIEW OF IS DEVELOPMENT

The expectation–perception mismatch or organizational failure of IS development discussed leads to resources being spent on refining systems or, worse, delivering systems which are simply not used by their host organization. The most common explanation of this failure is the reliance of IS developers on a product-centred perspective for systems development which assumes that user needs can be defined and that solutions to these needs can be engineered using an appropriate systems development methodology. However, as organizations increasingly question their purpose and processes and as boundaries between organizations become increasingly fuzzy and vague, it is no longer possible to start with the notion that it is necessary to create or computerize an information system. IS development has to be seen as a continuous process which is led by the human activity system in the organization which the information system will serve (Checkland and Holwell, 1993; Winter *et al.*, 1995; Robinson,

1996). Any and every information system can always be thought about as entailing a pair of systems: one a system which is served (the organizational activity system); the other a system which does the serving (the information technology system) as shown in Figure 2 (Winter *et al.*, 1995). Whenever one system serves or supports another, it is a very basic principle that the necessary features of the system which services can be worked out only on the basis of a prior account of the system served.

The whole process of IS development implied by the served–server concept is elaborated in a POM model (Checkland and Holwell, 1998) as shown in Figure 3. It is a model which relates to the *processes* in which *organization meanings* are established and lead to information support for people undertaking purposeful action.

Element 1 consists of the people as individuals and as group members, element 2 of data-rich world they perceive selectively through their various assumptions. The organizational discourse (element 3) is the arena in which meaning is created inter-subjectively, leading to the attributions of meaning which yield information and knowledge, element 4. The meaning attribution is a very complex social process embodying politics as well as rational instrumental decision-taking. Organizations have to enable assemblies of related meanings, intentions and accommodations between conflicting interests to emerge (element 5) so that purposeful action (element 6) can be taken. Formally organized information systems (element 7a) based on information technology (IT) such as computers and telecommunications (element 7b) support organization members in conceptualizing their world, finding accommodations, forming intentions and taking action (elements 5 and 6). Professional knowledge (element 7c) is also needed to operate, maintain and modify the IT-based information systems.

The POM model (Figure 3) can be seen to contain three parts which are in a particular kind of relationship with each other. Elements 1–5 describe the organizational context in which people create meanings and intentions; this leads to purposeful action being taken (element 6). Element 7 provides what would be described as 'information support'. Figure 4 shows this structure and the general requirements for an IS development follow from it. In the general case, there are four logical stages of a good ISD

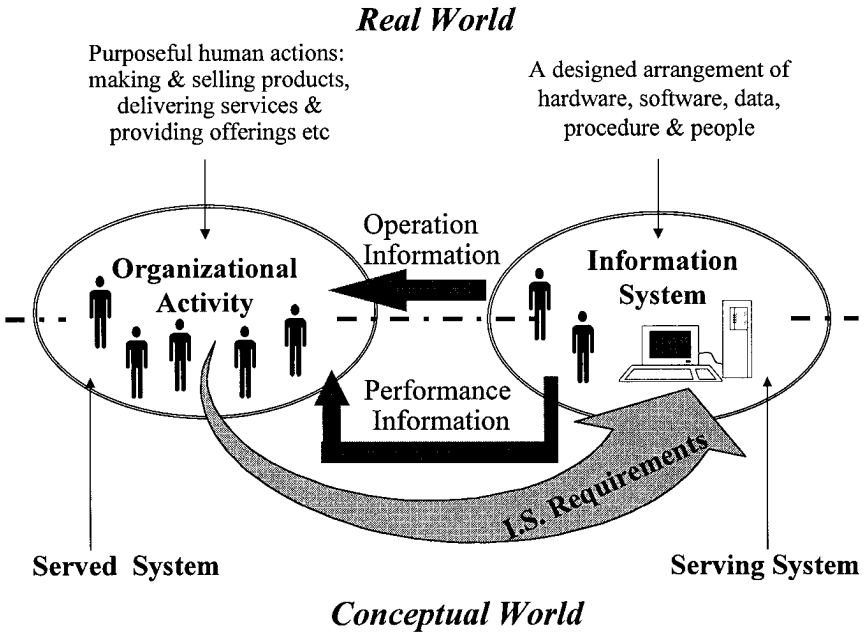


Figure 2. The served–server concept (Winter et al., 1995)

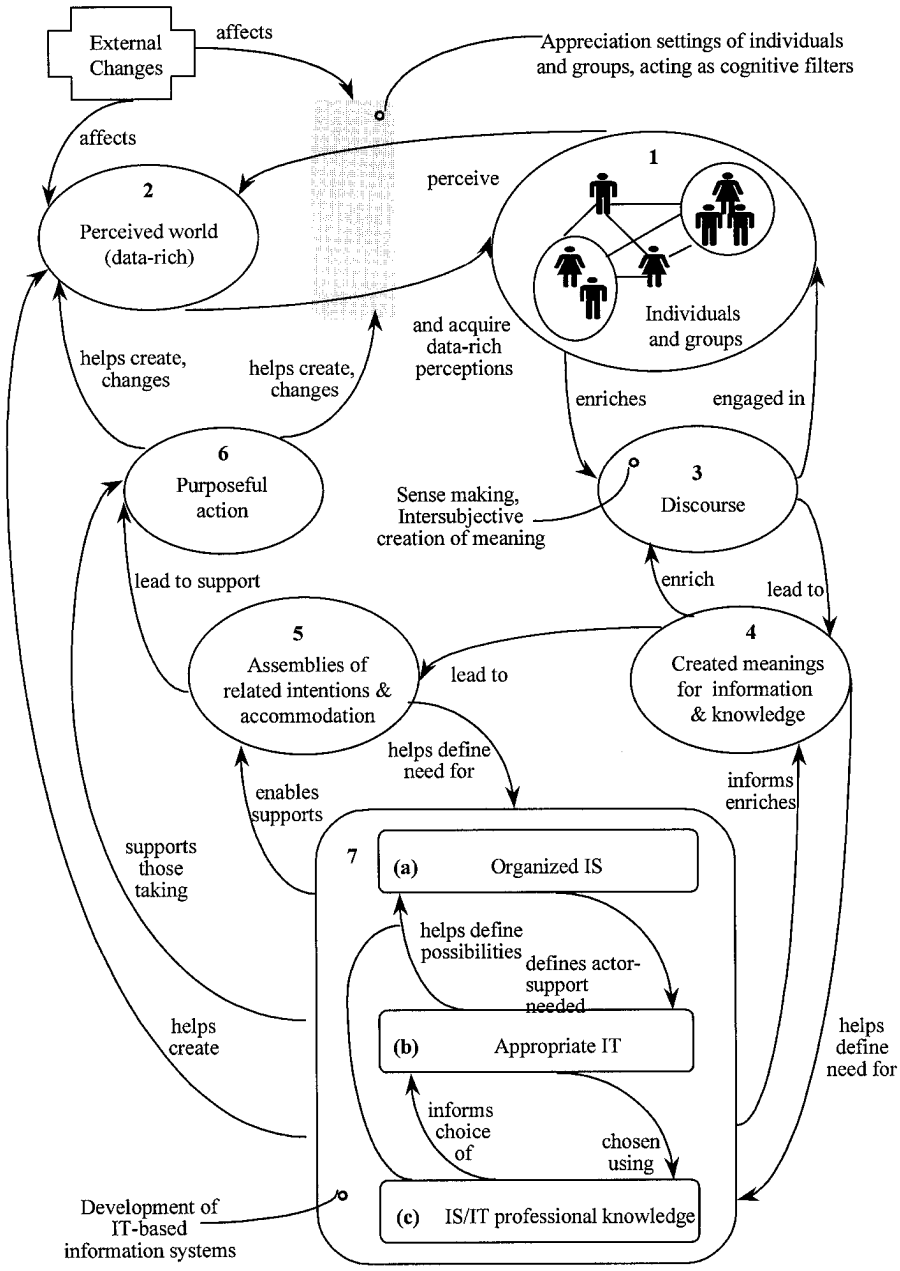


Figure 3. The 'POM' model (Checkland and Holwell, 1998)

process, each stage being contingent on the preceding ones (Checkland and Holwell, 1993):

(1) to establish the views of the organization and its purposes which are relevant to the people in the organization;
(2) to conceptualize the set of meaningful activities necessary to pursue these purposes;
(3) to explore, with the people concerned, the information they feel they need to carry out the activities, and to monitor and control it;

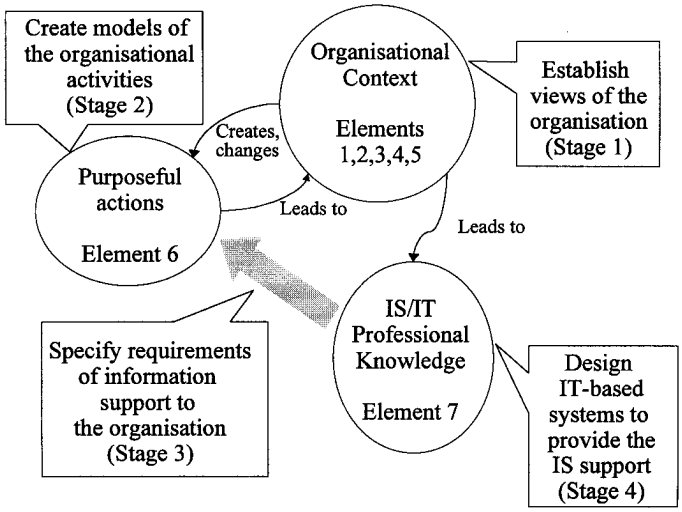


Figure 4. The core structure of the POM model and its implications on ISD process

(4) to consider the data (structure, manipulation) and technologies which could in principle provide the required information.

AN INTEGRATED ISD FRAMEWORK FOR REQUIREMENTS ANALYSIS

The concept implied by the POM model is contrary to the conventional wisdom about the process of IS development. What is noticeable in most ISD literature is a rapid concentration on the technology-based data-processing system, with only scant or superficial attention paid to the action which will be served by it. IS work is assumed to move quickly to consideration of 'the proposed system' (Zwass, 1992), the 'new or improved information system' (O'Brien, 1994) or 'the problems of the current system' (Schultheis and Sumner, 1995). The purposeful action supported by the IT system is often taken as given. The much-used phrase 'systems development life cycle (SDLC)', as argued by Clark and Lehaney (1997) and Winter *et al.* (1995), refers really only the 'computer systems development life cycle'. It follows therefore that the 'systems requirements' are just the 'requirements' for the computer system (i.e. parts of the serving system). The requirements of the context or human activity of the organization in which the computer system will operate (i.e. the served system) are not made explicit, or are even ignored. Despite the greater importance of the human rather than the technical aspects of an information system, the former receive far less attention from ISD methodologies (Galliers, 1987). A reliance by many ISDMs on interviews, comments and documentation is not necessarily sufficient for determining organizational information requirements for IS development.

A number of writers have argued that the difficulties of organizational requirements analysis could be alleviated if a systems science methodology such as the soft systems methodology (SSM) is combined with more traditional ISDMs (Lewis, 1993; Stowell, 1995; Savage and Mingers, 1996). SSM (Checkland, 1981; Checkland and Scholes, 1990; Checkland and Holwell, 1998) could be very useful in addressing the failure of ISDMs to explore user requirements fully as it recognizes the importance of the cultural and social values of individuals and groups in the organization, which can lead to a multiplicity of viewpoints concerning the purpose of information systems.

This paper proposes a wider framework for linking SSM and Martin–Odell object-oriented analysis (OOA). The integration approach taken has been to embed the modelling techniques of OOA within SSM. The four stages of the wider

framework (Figure 5) are organized under the principles of ISD implied by the POM model (Figure 4). Its elements follow two interacting streams of analysis (Checkland and Tsouvalis, 1996):

(1) a logic-based stream of analysis; and
(2) a stream of culture analysis.

The culture analysis is done by treating information systems development as a social and political process. It is believed the understanding of myths, meanings, values, norms, people's interests and the exercise of power are of crucial importance to the successful implementation of IT-based systems and should be exercised throughout the cycle of IS development.

The logic-driven analysis ensures that any technological changes to be implemented will not violate, contradict or run counter to the logic that has gone into the systems analysis. The purposeful organizational activities are conceptualized as models, from which categories of information requirements (Wilson, 1984, 1990) are derived. Object structure and object behaviour diagrams are developed from the SSM models at a conceptual level. The information categories and object models are cross-checked and considered together during the debate on desirable and feasible changes. Depending on the outcome of the debate, particular sets of object models will form the basis for the design and implementation of IT-based information systems.

THE APPLICATION OF THE INTEGRATED ISD FRAMEWORK

The integrated ISD framework shown in Figure 5 has been applied by the author in a real-world case to determine the information requirements of the Labour Relations Division (LRD) of the Labour Department of Hong Kong. A requirements specification was generated at the end of the project and delivered to the LRD for subsequent design and construction of technological-based information systems.

Familiarization with the Organizational Context

The study started with an explanation of the perceived problem situation of the LRD, including its social and political nature. The LRD is a branch of the Civil Service specializing in labour administration. It aims to enforce the Employment Ordinance (Cap 25, Laws of Hong Kong) by conciliating disputes and taking prosecution actions against unscrupulous employers/employees. The recent labour issues such as record high unemployment, closure of many business operations, relocation of industrial establishments to mainland China, importation of labourers, changes in legal standards, increase in awareness of the public towards their legal entitlements in labour law and central government's performance pledge all render the LRD able to work efficiently with a minimum allowable amount of mistakes. The Division also faced crises and challenges brought by the change of status of Hong Kong from a British Colony to a Special Administrative Region of the People's Republic of China in 1997. The environment has prompted the LRD to rethink its role in the community and take a proactive approach in all matters that fall within its jurisdiction. The myriad facts and perception of the problem situation of the LRD is described pictorially in a 'rich picture' (Checkland, 1985) as shown in Figure 6.

Formulation of Relevant Systems of Purposeful Activities

From the understanding of the situation built in stage one, several issues of concern have become evident. The project team then proceeded to conceptualize the systems which seem relevant to the chosen areas of concern. The integrated framework makes use of a particular kind of systems model, 'human activity system' (Checkland, 1981) to make sense of a particular view of the problem situation. Each human activity system is defined by a 'root definition' (Checkland, 1981). A root definition is constructed by

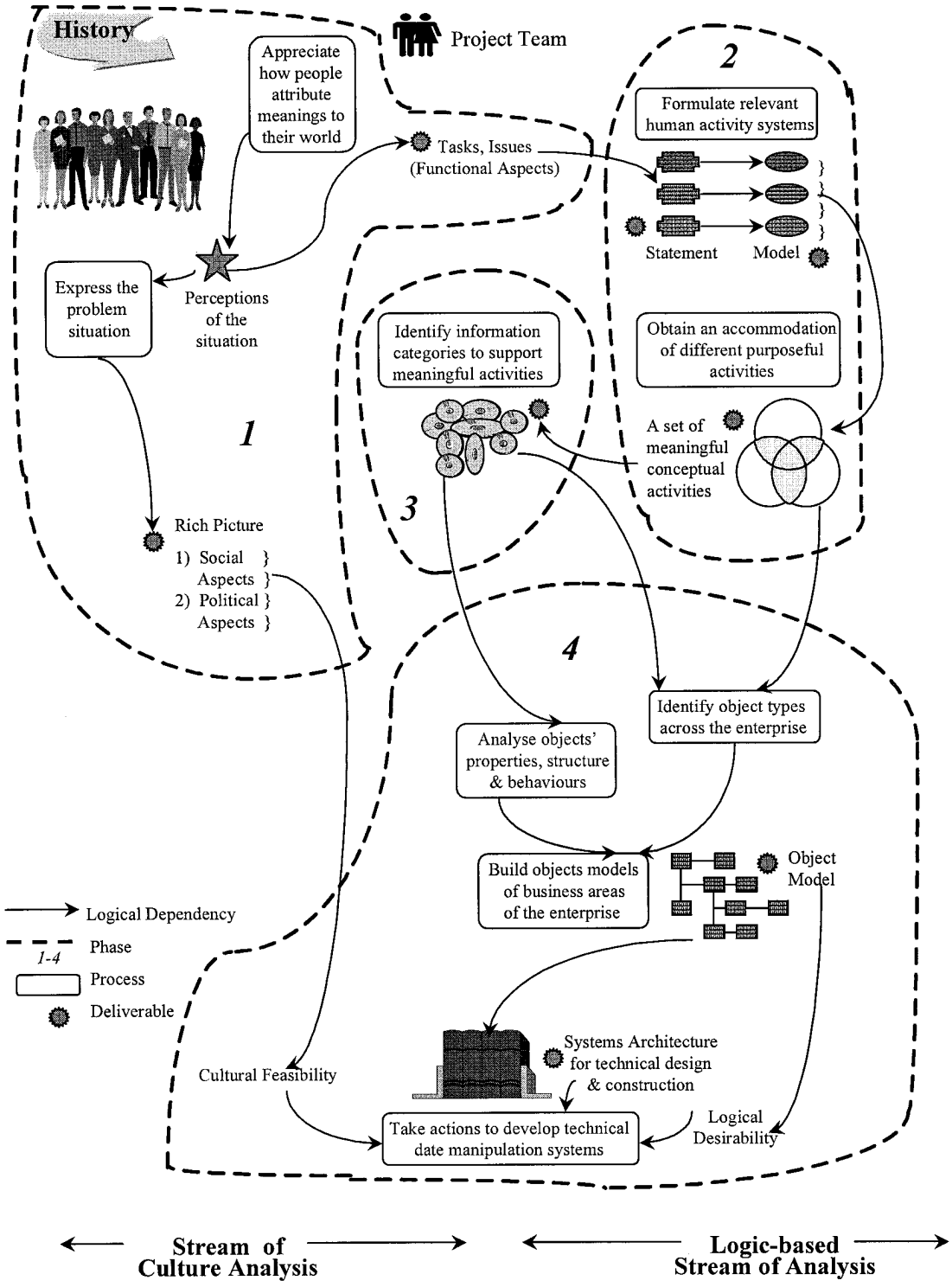


Figure 5. A wider framework for information requirements determination

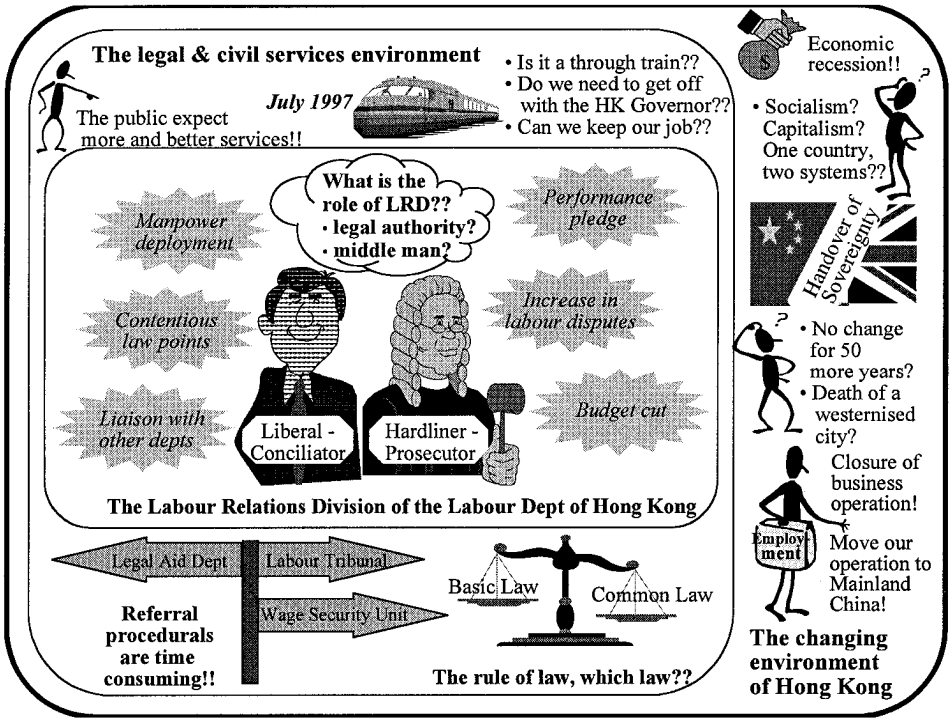


Figure 6. A rich picture of the Labour Relations Division of the Labour Department

consciously considering the six elements of the mnemonic CATWOE as explained in Figure 7.

The root definition is then expanded into 'conceptual models' (Checkland, 1981) which exhibit the 'minimum and necessary activities that the system must do in order to be the system so defined' (Checkland, 1981). Since a problem situation can be interpreted in many different ways, there are always different sets of root definitions and conceptual models. Staff members of the LRD were invited to participate in a brainstorming session during which everyone was asked to talk about the problem situation and provide a statement of the purpose which he/she perceived as essential for the running of the organization. After several debates and discussions, accommodations of ideas were reached. Two alternative views of the intentional

C	Customer	Who would be victims/beneficiaries of the purposeful activity?	Whom
A	Actor	Who would do the activity?	Who
T	Transformation	What is the purposeful activity expressed as: Input–T–Output?	What
W	Weltanschauung	What view of the world makes this definition meaningful?	Assumption
O	Owner	Who could stop this activity?	Answerable
E	Environmental	What constraints does this system take as given?	Environment

Figure 7. The CATWOE elements of a root definition

Root Definition: A Labour Relations Division owned and operated system to resolve labour disputes by providing conciliation services to the concerned employers and employees			
***C*ustomers of the system:** **Advantaged:** Employers, Employees	**Disadvantaged**	**Other stakeholders:** Labour Officers	
***A*ctors**	Labour officers, legal professionals & other supporting staff		
***T*ransformation**	**From:**	Needs of having resolutions for labour disputes	
	To:	Those needs satisfied by providing reconciliation services to the parties in disputes	
***W*eltanschauung**	It is possible to resolve labour disputes by getting consensus of concerned employers and employees through conciliation		
***O*wner:**	The Labour Relations Division of the Hong Kong Civil Service		
***E*nvironmental Constraints** **Constraints imposed by environment**		**Constraints accepted in modelling**	
• That conciliation arrangements will be subject to the consensus of the parties in disputes		• Claims of Labour disputes will be lodged by either employers or employees • Contentious law points of the labour legislation will be clarified during conciliation meetings	

Figure 8a. System definition of 'a system to resolve labour disputes'

Root Definition: A Labour Relations Division owned and operated system to enforce labour legislation by taking prosecution actions against unscrupulous employers and employees			
***C*ustomers of the system:** **Disdvantaged:** Unscrupulous employers/employees	**Advantaged**	**Other stakeholders:** Labour Officers	
***A*ctors**	Labour officers, legal professionals & other supporting staff		
***T*ransformation**	**From:**	Needs of enforcing labour legislation	
	To:	Those needs satisfied by taking prosecution actions against the unscrupulous parties concerned	
***W*eltanschauung**	It is possible to enforce labour legislation by taking prosecution actions against unscrupulous employers and employees		
***O*wner:**	The Labour Relations Division of the Hong Kong Civil Service		
***E*nvironmental Constraints** **Constraints imposed by environment**		**Constraints accepted in modelling**	
• That prosecution actions will be taken within the jurisdiction of the Labour Relations Division		• Prosecution cases will involve employers or employees who have offended the labour law • Prosecution actions will be taken under the legal advice from legal professionals	

Figure 8b. System definition of 'a system to enforce labour legislation'

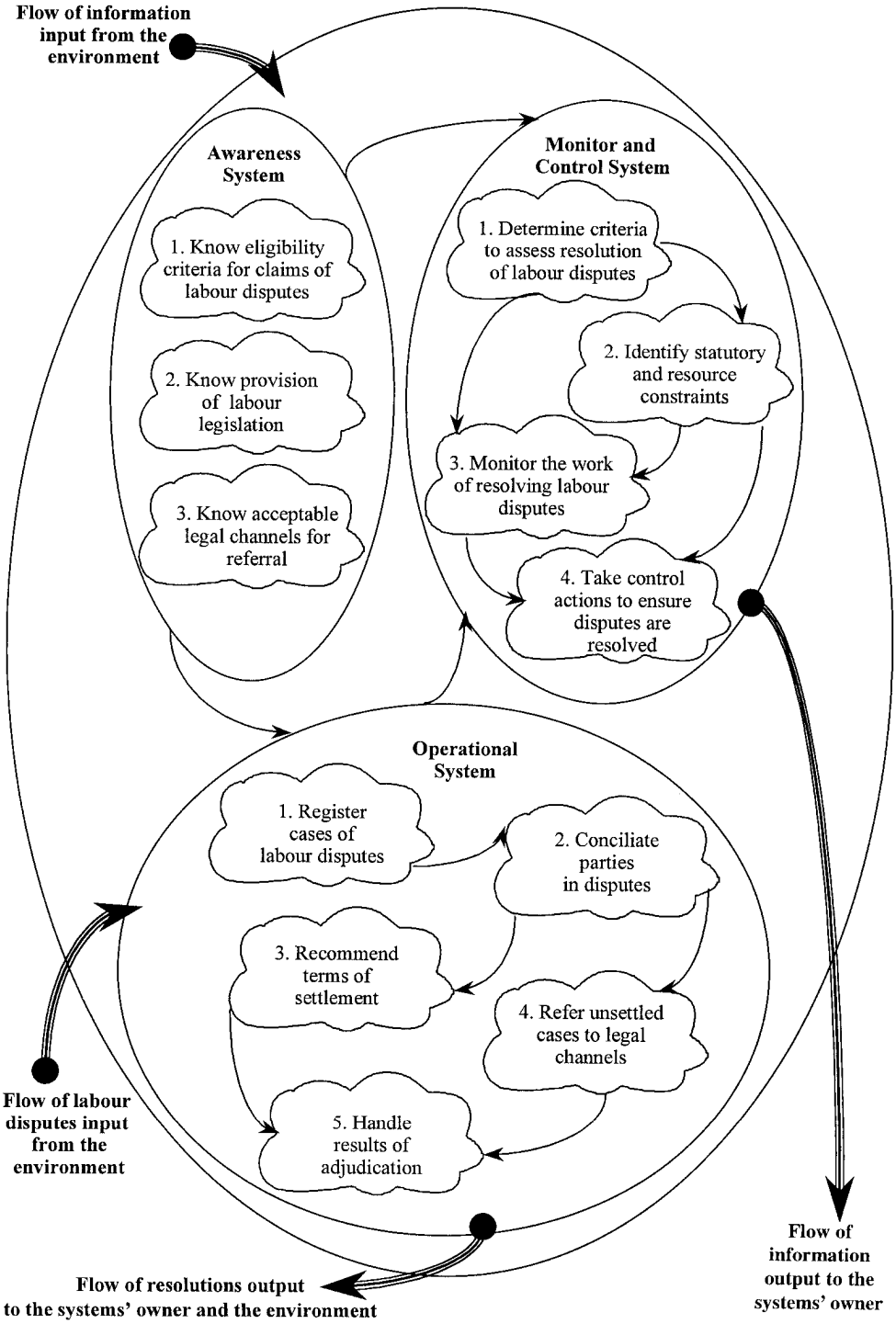


Figure 9a. The conceptual model of a system to resolve labour disputes

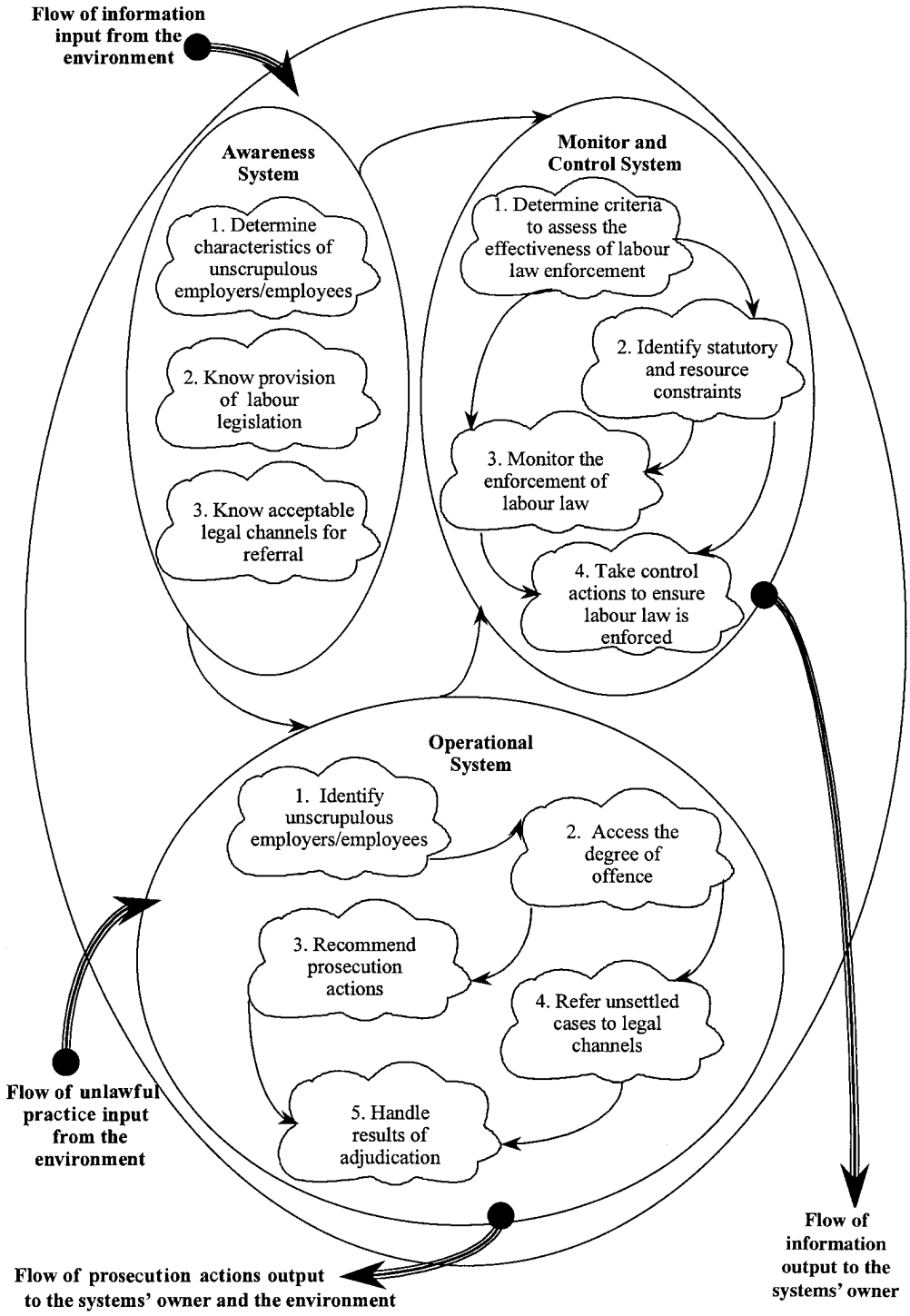


Figure 9b. The conceptual model of a system to enforce labour legislation

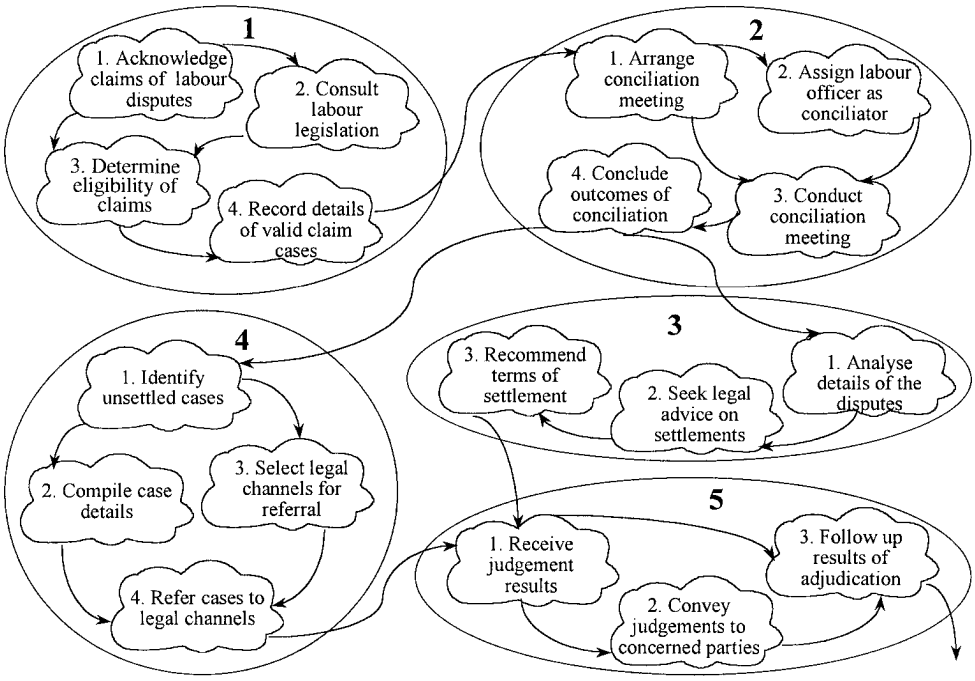


Figure 10. lower-level models of a system to resolve labour disputes

action of the LRD were considered to be meaningful to the investigation:

- a liberal's view — the LRD could be a system to resolve labour disputes;
- a hardliner's view — the LRD could be a system to enforce labour legislation.

Root definitions (Figures 8a and 9a) were formulated for the two chosen relevant systems, with activity models (Figures 8b and 9b) showing the activities that each system would have to perform, if it was to be that system.

Determination of Information Needs to Support the Defined Purposeful Activities

Figures 8b and 9b illustrate the intentional actions, for which the staff members of the LRD undertaking them require information support. However, the models produced so far were not of sufficient detail to allow the project team to arrive at any requirements specification for subsequent IS construction. For each of the perceived systems, modelling would need to be done at the next resolution level. For example, the required activity 2 of Figure 8b is 'Conciliate parties in disputes'. There are many ways in which this might be achieved, and by conceptualizing systems to carry out that activity one will be better placed to understand what it is that must be done. The project team thus developed lower-level models, describing systems for each of the activities shown in Figures 8a and 9a. Figure 10 shows the decomposition of Figure 8a.

The lower-level conceptual models, once constructed, form 'a cogent basis for an information model upon which the information system design process itself can be related' (Wilson, 1990). Requirements analysis can be done by asking of each activity in the model the following questions:

- What information would have to be available to enable someone to do this activity? From what source would it be obtained?
- What information would be generated by doing this activity? To whom should it go?
- How do we know the activity is accomplished?

Activities from the model	Input Information needed	Source of input information	Output information generated	Recipient of output information
2.1 Arrange conciliation meeting	• Case record • Client • Available venue & time	• Activity 1.4 • Activity 1.4 • The control & monitor system	• Meeting schedule • Case record	• Activity 2.2 & Activity 2.3 • Activity 1.4
	Checklist for the completion of the activity • The conciliation meeting is scheduled • Clients are notified of the meeting schedule • Clients' availability is confirmed • The case record is updated			
2.2 Assign labour officer as conciliator	• Case record • Meeting schedule • Labour officer	• Activity 1.4 • Activity 2.1 • The control & monitor system	• Assigned labour officer (conciliator) • Case record	• Activity 2.3 • Activity 1.4
	Checklist for the completion of the activity • A labour officer is assigned as the conciliator • The case record is updated			
2.3 Conduct conciliation meeting	• Meeting schedule • Conciliator • Case record • Client • Labour legislation	• Activity 2.1 • Activity 2.2 • Activity 1.4 • Activity 1.4 • The awareness system	• Interview record • Clarification of law points	• Activity 2.4 • Activity 2.4
	Checklist for the completion of the activity • The conciliation meeting is conducted • Clients are interviewed • Contentious law points are clarified			
2.4 Conclude outcomes of conciliation meeting	• Interview record • Clarification of law points • Case record	• Activity 2.3 • Activity 2.3 • Activity 1.4	• Recommendation of settlement • Referral to legal professionals • Request for further reconciliation meeting • Case record	• Activity 3.1 • Activity 4.1 • Activity 2.1 • Activity 1.4
	Checklist for the completion of the activity • Terms of settlement are recommended if a consensus has been reached • Cases of disputable nature are referred to legal professionals • Requests for further conciliation are filed for unsettled cases • The case record is updated			

Figure 11. An illustration of information requirements analysis

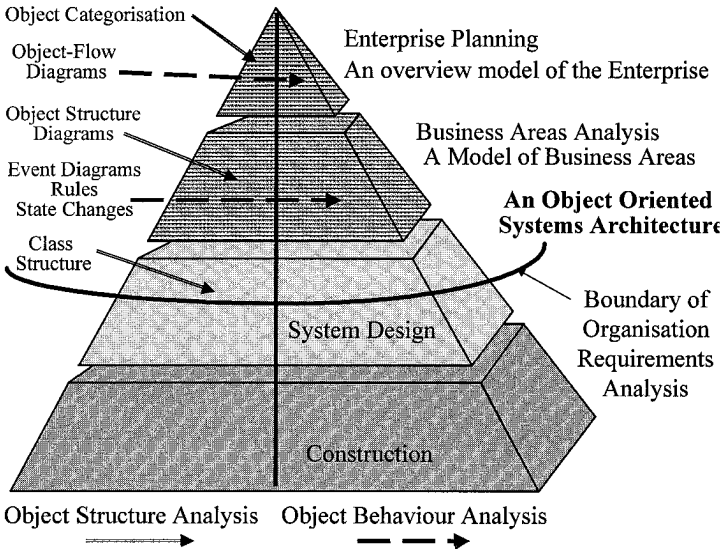


Figure 12. Object-oriented analysis (Martin and Odell, 1995)

The information requirements analysis of activities 2 'Conciliate parties in disputes' of Figure 8a is illustrated in Figure 11.

Consideration of Data and Technology that Could Yield the Required Information

The information requirements analysis turns an activity model into an information flow model. Given an information flow model which is agreed to be a necessary feature of the situation studied, we may now ask:

- What data structures could embody the required information?
- How should data be manipulated to yield the information flow?
- How could information technology be applied?

The linking of SSM to detailed design of an IT-based information system is accomplished by the adoption of object-oriented analysis (OOA) from Martin and Odell (1995). The methodology uses a top-down approach (Figure 12) to develop an object-oriented IS architecture for an organization.

The left-hand side of the pyramid in Figure 12 is concerned with the analysis of object structure; the right-hand side is concerned with the analysis of object behaviour. It starts with a model of an organization and then identifies the object types across the organization. Object relationships, properties and behaviours are specified. This organizational model is extended in greater detail as business areas are analysed. The resulting models are linked to object-oriented design and code generation. When separate information systems are built, they relate to the same systems architecture and, hence, should work together efficiently.

The main purpose of developing the wider integrated framework (Figure 5) is to enable the various steps of OOA performed under the guidance of systems science. The products of SSM define a baseline for the work undertaken in the modelling phase of OOA and the products of OOA are evaluated with this baseline, through a review process. The object-oriented diagrams (such as event diagrams, object flow diagrams and object structure diagrams) to a large extent are derived from the activities in an SSM model. Some modelling work done for the LRD projects are shown by way of illustration.

The scenario implied by one particular SSM conceptual model could be used to develop sequences of events during the execution of

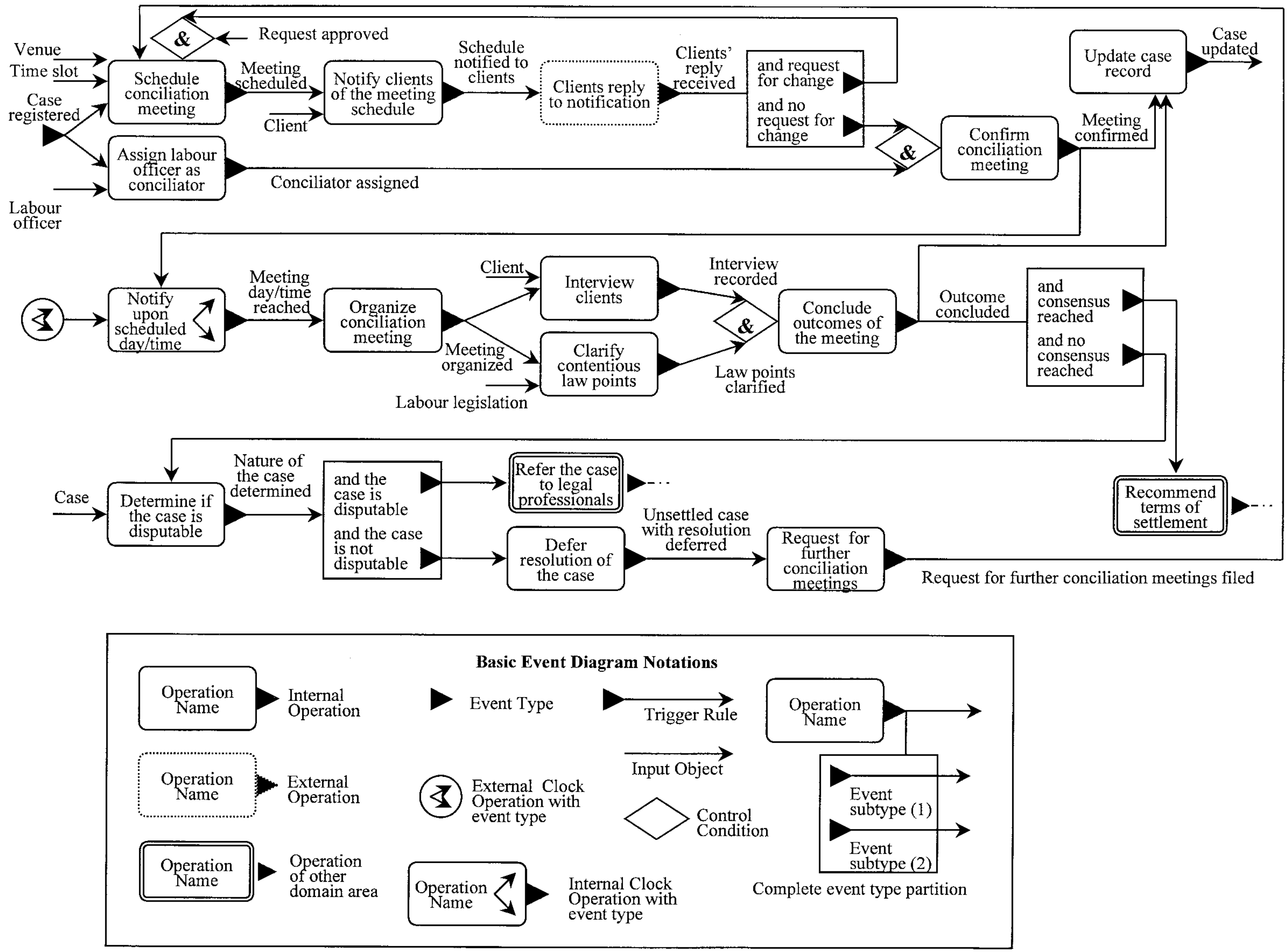


Figure 13. An Event Diagram of the domain area 'Conciliate parties in disputes'

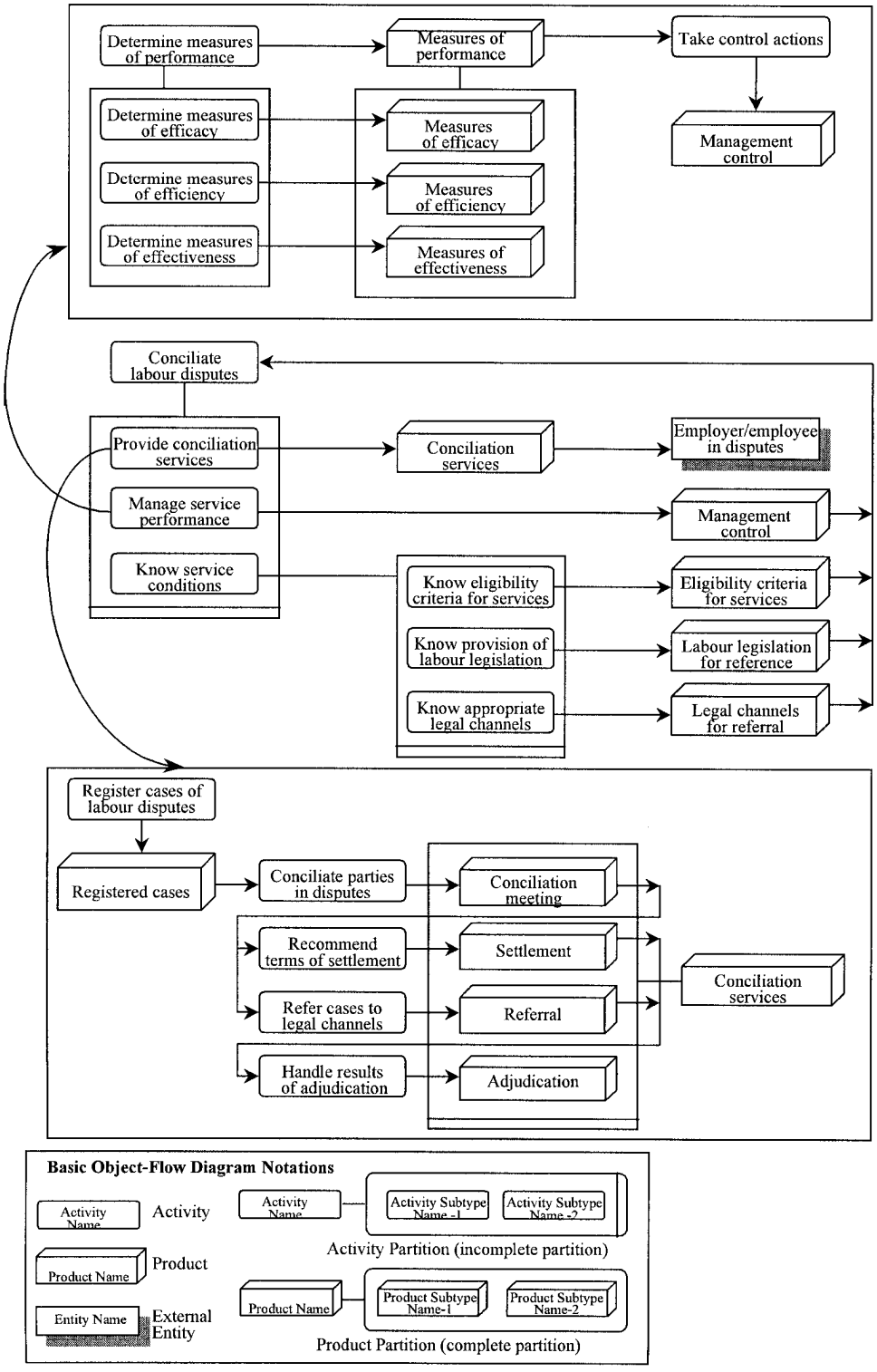


Figure 14. The object-flow diagram of the work of the LRD

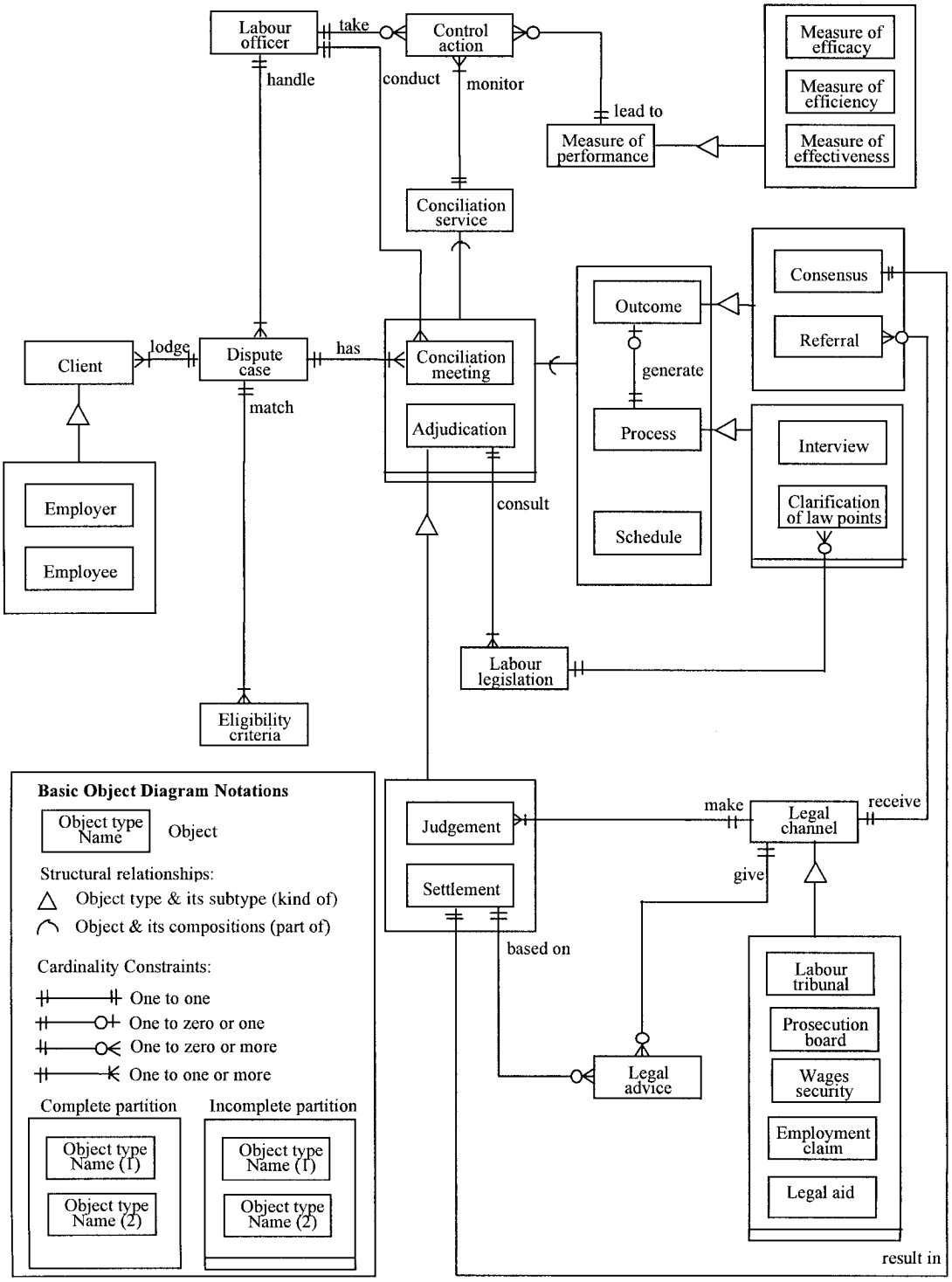


Figure 15. The object diagram of the Labour Relations Division

Necessary ISD process implied by the POM model	Issues crucial to ISD suggested by the Gap Model	Comparisons between ISD using Object-Oriented Analysis (OOA) and ISD using the wider integrated framework (WIF)
Establish views of the organization	• Gap one — the Cognition Gap • Gap two — the Comprehension Gap	• OOA works with a particular image of the organization (a unitary view), namely the image of goal-seeking mechanisms. Analysis with WIF is based on the assumption that organizations are ever-changing social constructs and can be understood in many different ways (multi-perceptions) • OOA is concerned mainly with the functions of an organization (functionalism). WIF investigates the hard facts as well as the soft issues of an organization (social relativism)
How is the issue/requirement addressed by OOA? • The 'enterprise planning' stage aims to create a high-level overview of the enterprise and identify high-level object types • Organizational concepts are structured and expressed in terms of goals, objectives, critical success factors, etc.		**How is the issue/requirement addressed by the WIF?** • Stage one aims to gain a deep understanding of the organization, including its purpose, structure, process, culture, social and political nature • An image of the organization as it is perceived by different people of the organization is captured in a 'rich picture'. Different perceptions leading to different assumptions about the meaning and purpose of the organization are explored
Create models of the organizational activities	• Gap one — the Cognition Gap • Gap two — the Comprehension Gap	• With OOA, organizational activities are thought of as a hierarchy of business functions (reductionism). With WIF, organizational activities are conceptualized as a set of human actions linked together according to their dependent relationships so that the whole would be purposeful (holism) • The models of business functional areas of OOA are assumed to be the models of the real-world organization (realism). The human activity systems of WIF are considered to be models relevant to the real world organization (nominalism)
How is the issue/requirement addressed by OOA? • The top-level enterprise model is broken down into business areas through a technique known as 'functional decomposition'. A business functional area is fulfilled by enterprise activities • Object-flow diagrams are built to represent key enterprise activities linked by the 'products' that activities produce and exchange		**How is the issue/requirement addressed by the WIF?** • The purposeful actions performed by people in the organization are conceptualized as different 'human activity systems' • Each human activity system is concisely described by a 'root definition' and CATWOE declaration. Conceptual models are developed to give an account of the activities that the system must do in order to be the system named in the definition
Specify requirements of information support to the organization	• Gap one — the Cognition Gap • Gap two — the Comprehension Gap	• Information requirements in OOA are requirements for information (objects) that are needed to build up the IT-based system (the serving system). Information requirements in WIF are requirements for information that are needed to support the primary organizational activities (the served system) • OOA focuses on the storage of information (technology-oriented). WIF is concerned with the meaning and use of information (people-oriented)

How is the issue/requirement addressed by OOA? • Information requirements analysis is done by studying the objects that underlie the organization. An object is something in which an organization stores information. • High-level object types are assumed to be identifiable from the enterprise model. The business area analysis provides more details about the objects. Each product in an object-flow diagram is taken to be a cluster of object types		**How is the issue/requirement addressed by the WIF?** • Information requirements analysis is done by formal questioning of the organizational activities • Ask of each activity in the conceptual model: What information would have to be available to enable someone to do this activity? From what source would it be obtained? Similarly, ask: What information would be generated by doing this activity? To whom should it go? • Information flow models are converted from the models of organizational activities
Design IT-based systems to provide the IS support	• Gap three — the Expression Gap	• OOA specifies the design of IT-based systems in terms of objects and what happens to those objects. These OO models encapsulate knowledge about how the business people want to run the business • WIF embeds the design techniques of OOA within SSM. It aims to design IT-based systems that will yield the information flows required by the sets of activities that are relevant to the real-world actions based on a particular perception of the people in the organization.
How is the issue/requirement addressed by OOA? • IT-based systems are designed in terms of object structure and object behaviour • Object diagrams specify the structural aspect of objects. They give a static vision of the required objects and objects' relationships • Object flow diagrams and event diagrams describe the behavioural aspect of objects. The object flow diagrams produce a coherent overview of the processing requirements of the objects. The event diagrams specify the dynamics of the processes in terms of events, triggers, conditions and operations		**How is the issue/requirement addressed by the WIF?** • Design of IT-based systems is accomplished by the adoption of OOA. Tools, techniques and notations of OOA are used • The various steps of OOA are performed under the guidance of systems science. The products of SSM define a baseline for the work undertaken in the modelling phase of OOA and the products of OOA are evaluated with this baseline, through a review process

Figure 16. Comparison between ISD using OOA and the wider integrated framework

that activity of the LRD. The SSM information flow tables were useful in two ways:

(1) the checklist for completion of activities shows the noteworthy state changes (events) of an object when a task is performed;
(2) the sources and recipients of the information flow define the input/output objects of each event.

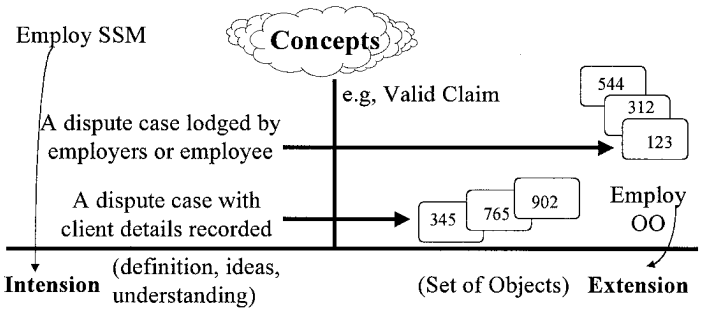
Figure 13 is an event diagram for the operation 'conciliate parties in disputes' constructed for the LRD project.

Most object types relevant to the operation of LRD (e.g. client, case, legal professional) could be identified from the nouns, noun phrases and adjectival noun phrases used in the root definitions, conceptual models and CATWOE declarations. This list of object types and the input/output information of the SSM information flow tables formed the baseline of the object structure diagram of the LRD. The object flow diagram of LRD was constructed by referring to the high-level conceptual models, rich picture and information flow table of SSM.

Figures 14 and 15 show the object flow diagram and object structure diagram of the LRD if it is viewed as a system to resolve labour disputes.

RESULTS OF USING THE WIDER INTEGRATED ISD FRAMEWORK

One of the main benefits that arose from the use of the integrated framework in the LRD project



Notes:
- Concepts are value-laden & culture-bounded
- Analysts must know the definition of every concept in a system
- If a concept is not useful for an organisation, it has no value
- A concept without a definition is not a concept
- A concept may have no object
- There could be a life cycle for a concept

Figure 17. The notion of concepts (adapted from Martin and Odell, 1995)

was an improved user requirements definition which was important to the successful implementation of the system. The effectiveness of the integrated framework was evaluated against the POM model (Figures 3 and 4) adopted from Checkland and Holwell (1998) and the expectation–perception gap model (Figure 1) discussed earlier. Figure 16 shows the comparisons between organizational requirements analysis using the integrated framework with SSM and via a conventional object-oriented method (Martin and Odell, 1995) without SSM.

Lessons were also drawn from the experience of using the wider integrated framework in the LRD project. A crucial aspect of the learning for the author is the rethinking of the notion of 'concept'. The first step in constructing an object-oriented model is to identify a set of fundamental concepts to describe the domain. 'Concepts shape our perception of reality' (Martin and Odell, 1995). However, there are no widely accepted rules for creating or evaluating the collections of concepts. Each concept has an intension and extension as shown in Figure 17.

The intention is a complete definition of the concept and the test that determines whether a concept applies to an object. Extension is the set of all objects to which a concept applies. SSM, as demonstrated by the LRD project, can be employed at the front-end to help users to visualize and define the intention of a concept. OOA can then be used at the back-end to determine which objects should be grouped under what concepts and how the objects relate to each other. Intension and extension are two sides of the same coin — the notion of concept includes both. Logically, concept formulation is the place where SSM interfaces with OOA.

CONCLUSION

The result of the LRD project implies that synergy occurs when different methodologies from different disciplines are employed in information systems development (Xu, 1995). An ISD project concerns an interplay of human, organization and technical factors which cannot be easily separated (Walsham *et al.*, 1988). Success in any aspect would reinforce the others. This complex interlinking may best be addressed by adopting a pluralistic approach which brings together the competence, effectiveness and strength of different methodologies. In the arena of information provision, 'the environment often forces different approaches to combine' (Churchman, 1968). SSM and OOA are viewed not as separate, self-contained methodologies to

IS development, but as approaches which can work together. A complementary application of SSM and OOA would provide more assistance (see Figure 15) to systems developers in bridging the expectation–perception gap (Figure 1) that causes many failure cases of ISD projects.

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