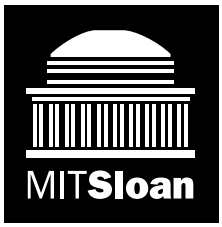

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Useful Descriptions of Organizational Processes: Collecting Data for the Process Handbook

by

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ABSTRACT

This paper describes a data collection methodology for business process analysis. Unlike static objects, business processes are semi-repetitive sequences of events that are often widely distributed in time and space, with ambiguous boundaries. To redesign or even just describe a business process requires an approach that is sensitive to these aspects of the phenomena.

The method described here is intended to generate semi-formal process representations suitable for inclusion in a "handbook" of organizational processes. Using basic techniques of ethnographic interviewing and observation, the method helps users map decomposition, specialization, and dependency relationships at an intermediate level of abstraction meaningful to participants. By connecting new process descriptions to an existing taxonomy of similar descriptions in the Handbook, this method helps build a common vocabulary for process description and analysis.

INTRODUCTION

The ability to measure and make comparisons is fundamental to any empirical science. In the social sciences, scholars are becoming increasingly concerned with the study of processes (Abbott, 1992), but our empirical techniques lag considerably behind those we have developed for measuring and comparing the properties of static entities (Abell, 1987; Heise, 1989; Abbott, 1991). In the realm of computer supported cooperative work, one problem we face is that business processes are essentially sequences of events distributed in time and space; typical business processes can take days or weeks to complete, and they frequently cross organizational or physical boundaries. For these reasons, business processes cannot easily be observed at one point in time or in a single location. Furthermore, business processes are enacted through the use of specialized actions and language that are meaningful to the participants, but may not be easily translated to a common vocabulary for purposes of comparison. These basic features of business processes make their description and comparison a particularly challenging methodological problem. It also makes it difficult to redesign existing processes or systems to support them.

The approach we propose here relies on basic techniques of ethnographic interviewing and observation to collect data. These data are then organized using concepts of decomposition and specialization to create reliable, valid process descriptions. This method generates semi-formal representations that are suitable for inclusion in a "handbook" of organizational processes (Malone et al. 1999). The Process Handbook can be used to analyze or redesign existing processes, to invent new processes, and to design computer support for processes. The basic approach described here, however, stands on its own as a method for collecting and organizing field data for the purpose of business process design or redesign.

The paper begins with a statement of the problems posed by the Process Handbook, followed by a discussion of the theoretical considerations involved in creating appropriate process representations. We then describe our methodology for collecting process data and discuss the strengths and limitations of our technique. The methodology is illustrated using examples from the supply chain in the athletic footwear industry.

A Handbook of Organizational Processes

System designers have long realized the importance of understanding work processes, and have developed a wide range of techniques for analyzing them (Curtis, Kellner and Over, 1992). Traditional systems analysis techniques (Yourdon, 1989), however, are often too detailed to be

useful in the problem of process redesign. Hammer and Champy (1992, p. 129) argue that teams engaged in a redesign effort often get bogged down with analyzing the status quo:

> One of the most frequently committed errors in reengineering is that ... reengineering teams try to analyze a process in agonizing detail rather than attempting to understand it. People are prone to analyze because it is a familiar activity. We know how to do it. It also feels good, because analysis gives us the illusion of progress.

While it may feel good, we believe it is pointless to spend a lot of energy mapping out how a particular activity is accomplished if you have not yet decided whether that activity should be outsourced, combined with another activity, or perhaps eliminated altogether. What is needed, instead, is a technique that allows the analyst to develop an understanding of the critical activities in the process and their interdependencies. In particular, the method should reveal important dependencies between steps and suggest ways that these dependencies can be better coordinated. We believe this type of description will be most useful for the design of systems to support work processes.

To implement this approach, Malone et al. (1999) are developing a "handbook" of organizational processes that encodes descriptions of a wide variety of business processes, including order entry and fulfillment, product development, sales and marketing, and so on. This handbook is intended to support the improved design of processes and the systems that support them. The representation used in the handbook combines three basic concepts in a novel way to create a taxonomy of processes:

(1) Decomposition. Processes are decomposed into activities, which may in turn be further decomposed into subactivities. Decomposition allows the nesting of processes within processes, and allows the handbook to share and re-use process descriptions throughout the taxonomy.

(2) Specialization. Processes (and activities) are also specialized in a manner similar to a traditional type hierarchy. Unlike a simple object hierarchy, each node is itself a complex entity that inherits a decomposition from its parents.

(3) Dependencies. Malone and Crowston (1991; 1994) define coordination as "managing dependencies." The Handbook represents dependencies between activities in order to suggest ways in which these dependencies can be better managed through the use of information systems. Dependencies are also inherited through the specialization hierarchy.

This representational scheme has a number of properties that we believe are especially useful in the design of new processes and systems to support them. First, the representation is generative. For example, it generates new processes through the creation of specializations which inherit from multiple sources in the hierarchy. Second, it explicitly represents dependencies between activities, which are an important class of constraints on the configuration of a process (Pentland, 1995). Every dependency creates a need for coordination, and at the same time, creates an opportunity for choosing among alternative coordination mechanisms. For example, a shared resource dependency can be managed by a variety of different coordination mechanisms, including bidding, rationing, first come, first served, etc. If so desired, these coordination mechanisms might be embodied in CSCW applications. Finally, it represents processes in terms that are meaningful to participants. Too often, systems analysis and CSCW formalisms have strayed from simple, descriptive terminology that people doing the work can understand.

To be most useful, the Handbook must be populated with a substantial number of process descriptions. These descriptions must be collected in a way that allows consistent comparisons of processes in a wide variety of organizational contexts. Thus, the Process Handbook imposes a number of requirements for data collection that can be described as follows:

(1) Common vocabulary. Descriptions must be consistent with respect to a given vocabulary, but the problem is that the vocabulary is never a given. In general, it will reflect the terminology that organizational members and participants use to describe their work. The research team must then be able to abstract from these native descriptions to create a generic description that can be codified in the Handbook.

(2) Expandability. As we confront new situations, we will inevitably come across new kinds of activities that are qualitatively different from those in the existing vocabulary. To accommodate these activities, new categories of activities must be created, with the result that the vocabulary will grow. As it does so, it is critical that the proliferation of terminology not obscure underlying similarities between steps in processes that take place in different contexts.

(3) Appropriate level of abstraction and granularity It is important to locate levels of abstraction and granularity at which meaningful and useful descriptions can be formulated. In principle, one could attempt to translate processes into primitive elements at an extremely fine-grained level. However, attempts to codify an appropriate set of primitives have not fared especially well. For

example, Schank and Abelson's (1977) lexicon of eleven primitive acts proved difficult to apply in practice, because actual sequences of events allowed many different translations.

METHODOLOGY

The general approach we suggest for this problem involves the creation and elaboration of semantic domains of actions. Spradley (1979) provides a basic set of techniques for eliciting and confirming categories and distinctions between categories. There are three generic domains that underlie our method: decomposition, specialization, and dependency.

Decomposition. Every process analysis method includes some way to decompose a process into steps or sub-processes (Curtis et al, 1992). The general "part of" relation translates into a "steps in" relation. For example, grinding beans and boiling water are steps in making coffee. One difficulty in process decomposition, of course, is limiting the analysis to meaningful units. By using ethnographically based descriptions (rather than arbitrary analytical techniques of the kind that might be employed in a time-motion study), the language of the informants provides a natural limit on the level of detail.

Specialization. When applied to the domain of actions, the familiar "kind of..." relation becomes "ways to..." Thus, for any given action, we find that there may be several more specific ways to accomplish it. In the process of making coffee, there are many ways to infuse the coffee and the water (e.g., drip, perk, espresso machine, etc.) There are several different ways to grind beans or boil water, as well. Alternatively, the whole process of making coffee can be seen as a specialization of a more generic process of preparing hot beverages.

Dependencies. Dependencies are a familiar part of organization theory and design (Thompson, 1967). The "depends on..." relation is also, implicitly or explicitly, a part of many process modeling methods (Curtis et al, 1992). But unlike "part of" and "kind of", "depends on" is a more subtle kind of relation that takes considerably more effort to uncover and specify. This is because dependencies are more often taken for granted; as long as things work smoothly, we often fail to realize the dependencies that are at play. Eliciting dependencies from informants through purely interview-based techniques may therefore be difficult, so additional methods are required.

Using ethnographically generated descriptions of processes has the advantage of making the descriptions meaningful to participants (unlike some more formal techniques). However, it tends to encourage the proliferation of idiosyncratic terminology. This makes it difficult to build a common vocabulary of the kind needed to make process descriptions comparable and useful for the generation of new alternatives. This difficulty is addressed below in the discussion of "top-down" versus "bottom-up" approaches to process description.

Unit of analysis

One of the critical issues in developing an entry in the Process Handbook (or any kind of process map) is to define the limits of the process under consideration. In principle, one could trace the production of goods from raw mineral extraction to final disposal, but in practice, one needs to limit the scope of analysis. For example, one could focus on those aspects of the process which are potentially under the control of the organization in question, thereby limiting the analysis to the formal boundaries of the organization. This criterion, however, would cut off portions of the process which are clearly relevant to the performance measures in question. For most business processes, there is a great deal of interdependence across organizational boundaries. One of the challenges in process analysis and design is to identify those dependencies and manage them more effectively.

For this reason, a much better way to bound the process is to include any activity whose performance (or non-performance) is directly relevant to the performance measures of interest (e.g., cycle time, quality, cost, customer satisfaction). This definition is far more inclusive and clearly leaves a great deal of room for interpretation. The advantage of this definition is that it encourages the team to explore the broader context in which the process operates and not limit themselves to a particular formal organizational unit.

The definition of the process being analyzed has direct implications for who needs to be interviewed by the research team. If the process crosses organizational boundaries (either multiple departments in the same organization, or multiple organizations), then it becomes important to collect data from individuals in each relevant organizational unit. To accomplish data collection under these circumstances can be very difficult because organizations are sometimes quite reluctant to allow detailed scrutiny from individuals who are perceived to represent the interests of another organization. Although it may not always be possible to fully verify process descriptions under these circumstances, it is important to get at least some descriptive information concerning all the major activities in a process.

Interviews, Observation, Iterative Verification

For several reasons, a mix of data collection techniques is needed for process analysis. First, because business processes embody a great deal of specialized terminology and "local knowledge," research teams will be faced with the problem of uncovering and interpreting what is really going on and what it means to the people who are involved (Spradley 1979:5, 99). Descriptions will not always be

self-explanatory, so the research team may need to observe work in progress and enlist the help of participants in the process. Second, process descriptions are likely to be subject to the dangers of subjective verification even where multiple respondents are involved. In general, even the people involved may not know what happens up-stream or down-stream of their particular activity, although they may believe they do. For this reason, it is important to cross-check (or "triangulate") evidence from multiple sources to verify what is really happening (Yin 1989). Finally, it is likely that a research team's access to field sites will be by invitation only (Schein 1987:5). The role of the team with respect to the needs of the host organization can take many forms, but in general, data collection is facilitated when the researcher takes a helpful but non-evaluative stance towards members of the organization. This can be a difficult balance to strike in practice, but it is critical to maintain good relationships with process participants, since completion of a process analysis will probably require repeated contact over time.

For these reasons, three main techniques are required:

(1) semi-structured interviews;

(2) observation (or participant observation) where such approaches appear appropriate (this may include a range of activities, from "stapling oneself to an order" (Shapiro, Rangan, and Sviokla, 1992) to sitting in on meetings);

(3) iterative verification and triangulation.

Verification and triangulation are particularly important to this approach. In the sense intended here, "verification" refers to iterative verification of process descriptions with multiple individuals who participate in the process themselves. Since any organizational process is open to differing interpretations by each of its participants (Weick 1979, Daft and Weick 1984), subjective verification may be one of the strongest consistency controls available to field teams.

The dangers of subjective verification are well known, but it is important to recognize that iterative verification as described here achieves the same level of corroboration that managers and other professionals have available to understand observed behavior within their organizations. For them, low-level subjective consensus represents one key mechanism through which groups jointly interpret events (Daft and Weick 1984). Iterative, multi-source verification of process descriptions, in this view, represents the same level of reliability and generality that process designers face in actual practice. Triangulated verification (e.g., asking multiple process participants to verify process descriptions more than once as the descriptions are developed) offers not only an achievable means for checking descriptive fidelity but also represents a technique that very appropriately reflects real-world conditions (Nadler, Perkins, & Hanlon, 1983).

ACTIVITY REPRESENTATION TOOLS: ACTIVITY LISTS AND HIERARCHIES

This methodology recommends two tools for developing activity representations. The first is referred to here as an activity list; the second as a candidate activity hierarchy. The term "candidate" is used here, as elsewhere, to refer to a suggested Process Map that can only be considered a prototype because it has yet to be verified by process participants.

Activity lists

Activity lists are simple tables that serve as a guide to the interviewer in obtaining names and characteristics of activities. The structure of the list serves as a guide when designing semi-structured interviews. The list itself is intended to encourage who-what-when-where-how and how much questions during an interview and to help the interviewer organize the responses to these questions in a convenient way.

The elements in the activity list table, as shown in Figure 1, are defined in the following way:

Activity: an activity is the basic building block of a process description. Note that activities can have subactivities (as described below in the section on activity hierarchies).

Actor: this includes the list of entities who perform the given activity. Actors might be, among other things, individuals, departments, groups, or information systems.

Goal: this describes the purpose or objective of the activity, initially captured in the language of the respondent.

Artifacts: (inputs, outputs, and tools): We use the term artifacts here to suggest a broad view of the physical resources involved in an activity, including the inputs, the outputs, and any tools or intermediate materials that are required.

Activity	Actor(s)	Goal	Artifacts	Context
1.				
2.				
3.				

Figure 1: A blank activity list

Context: No activity occurs in isolation; there are always key contextual factors that influence the success of an activity, or the reasons why it is performed, or the incentives for performing it a certain way. This is intended to be an open-ended entry for tracking contextual factors that respondents identify as important. The ability to keep track of semi-structured information is an important part of this approach, since many kinds of contextual details would be impossible to capture in a formal representation of manageable size.

Developing the activity list

Interviews are the best starting point for developing an activity list. The best interview strategy will be relatively unstructured, so that the interviewee can describe what he or she does in a fairly open ended manner (Weinberg, 1988). To initiate this process, the interviewer can use what Spradley (1979) calls a "grand tour" question: "Tell me what you do in your job?" Depending on the setting, the interviewer might also ask for an actual tour of the facility, to see each part of the physical setting where activities take place. The objective at first is to keep the discussion quite open-ended, so that the interviewee does not inadvertently focus in too quickly on one part of a process and leave out another. During the interview, the interviewer adds activities to the list employing the language and labels used by the respondent, in the order that the respondent mentions them.

As the interview progresses, it will be helpful to start directing the conversation towards particular activities. The list immediately prompts questions about each activity if the interviewer cannot capture appropriate content from the respondent's narrative. Example questions might include:

Questions about processes (from the general to the specific):

- Can you tell me what activities you engage in?
- Can you tell me what activities make up this process?
- What deadlines do you have to meet?
- What paperwork do you encounter in your daily work?

Questions about activities (once these have been surfaced):

- Who performs in this activity (e.g., actors)?
- What are the goals of this activity? What are you trying to accomplish?
- What are the goals of the various departments or individuals engaged in this activity?
- What forms, reports, or other paperwork must you complete or have available to complete this activity?
- What forms or reports does this activity produce?
- What else (e.g., product prototypes) does the activity produce?
- What contextual factors are of critical importance to completing this activity (this includes issues, problems, exceptions, key performance measures, incentives, or interdependencies).

The objective during the activity representation stage is initially to collect as many activity names and/or activity attributes as possible, forming a rudimentary understanding of how the activities aggregate together into a defined process. Little initial effort focuses on the potentially nested nature of activities: the goal here is rather to populate the activity list with as many activity labels and explanations as possible.

The following examples refer to a study of import coordination in the athletic footwear industry undertaken by the authors. After an interview with the import manager of a running shoe company, the activity list might look like Figure 2.

Activity lists add structure to field notes by collecting activities and actors while associating contextual elements (such as performance parameters or industry trends) noted by the respondent. The lists also provide a mechanism for obtaining verification from the respondent. An activity list immediately provides discussion points for developing shared, verified descriptions of activities and their attributes: in this sense an activity list can function as a table of contents for the shared understanding developed through semi-structured interviews.

Activity hierarchies

Once completed, an activity list becomes a tool for assembling activities into hierarchies. An activity hierarchy begins to add the notions of decomposition and specialization to the descriptions surfaced by list. Decomposition simply means breaking an activity down into subactivities. One can elicit an activity decomposition during an interview by asking, "What are the steps in this process?" Often, one finds that there is more than one way of breaking an activity down into its component parts, or that the components differ depending on what kind of order is being processed, or what kind of customer is being served, etc. These alternative ways of accomplishing the same activity are called "alternative specializations." A general activity (such as order entry) may be accomplished in several different ways, each of which is specialized for a particular purpose. One can elicit alternative specializations during an interview by asking, "Are there different ways that you accomplish this activity?"

Activity	Actor	Goal	Artifacts	Context
Ordering	Manufacturing department	Place orders for shoes	Purchase order	Lead-time depends on supplier lead-times
Manufacturing	Far East factory	Manufacture shoes within contract parameters	Letter of credit; Manufacturing contract	Many shoe companies building on separate lines in the same plants
Consolidation	Consolidator	Move product from factory to U.S. port with minimum cost and delay	Bill of lading	Apparent improvement in efficiency from using third-party consolidators as scale increases.
Customs	Customs broker; Customs agent	Assure that inbound product is as specified and approved	Customs clearance form	Pre-approval important to minimizing delays. Asymmetrical distribution of shoe expertise among ports.
Warehousing	Logistics department	Break down and transship loads at minimum time and costs	Shipping manifest	Trend appears to be away from warehousing, at least for large accounts.
Drop-shipment	Transportation department; Third-party transportation	Deliver directly to customer within weekly time window	Invoice	Requires upstream activity (e.g., pig tailing) at consolidator or plant. Key unit is container load.

Figure 2: Example of a partial activity list for the athletic footwear supply chain

Activity hierarchies can be represented as outlines or as graphical hierarchies. To represent the hierarchy as an outline, simply indent the outline when there is a sub-activity. An activity decomposition hierarchy for the footwear import study is shown expressed as an outline in Figure 3.

- Order product
- Manufacture product
- Ship product
  - Consolidate shipment
  - Transport by container ship
  - Clear Customs
  - Transport to Warehouse [or] Transport to Customer

Figure 3: Activity hierarchy for shoe imports, outline format

Using the outline format, it is relatively easy to develop specialization hierarchies from process decompositions: in a mechanical sense, a specialization represents an alternative set of subactivities for accomplishing some activity in the outline. If it is possible to identify two or more sets of activities for decomposing Activity A, for example, then those alternative decompositions should be investigated as alternative specializations. In Figure 3, for example, the decomposition of Ship Product can be specialized to include either Transport to Warehouse or Transport to Customer.

When representing specialization and decomposition in the same hierarchy, a graphical view of the hierarchy may sometimes provide a clearer picture of what is going on. For example, consider the comparison of the ship product activity for domestic vs. overseas manufacturing depicted in Figure 4. For a footwear manufacturer that manufactures only in the United States, the Ship Product activity would comprise trucking product from a manufacturing plant to a distribution center. For a footwear manufacturer that uses manufacturing plants located in the Far East, the Ship Product activity includes consolidation, ocean shipping, and customs clearance as well as domestic transport. Depending on the contextual circumstances, the two Ship Product decompositions represent different ways of accomplishing the shipping activity - in other words, they represent alternative specializations of the overall process.

Activity lists and activity hierarchies combine to provide a series of steps to follow in building activity representations from field data. The activity list provides a set of activities and selected attributes. The activity hierarchy combines the activities from the list, using attributes and relationships derived from the list to identify activity decompositions and

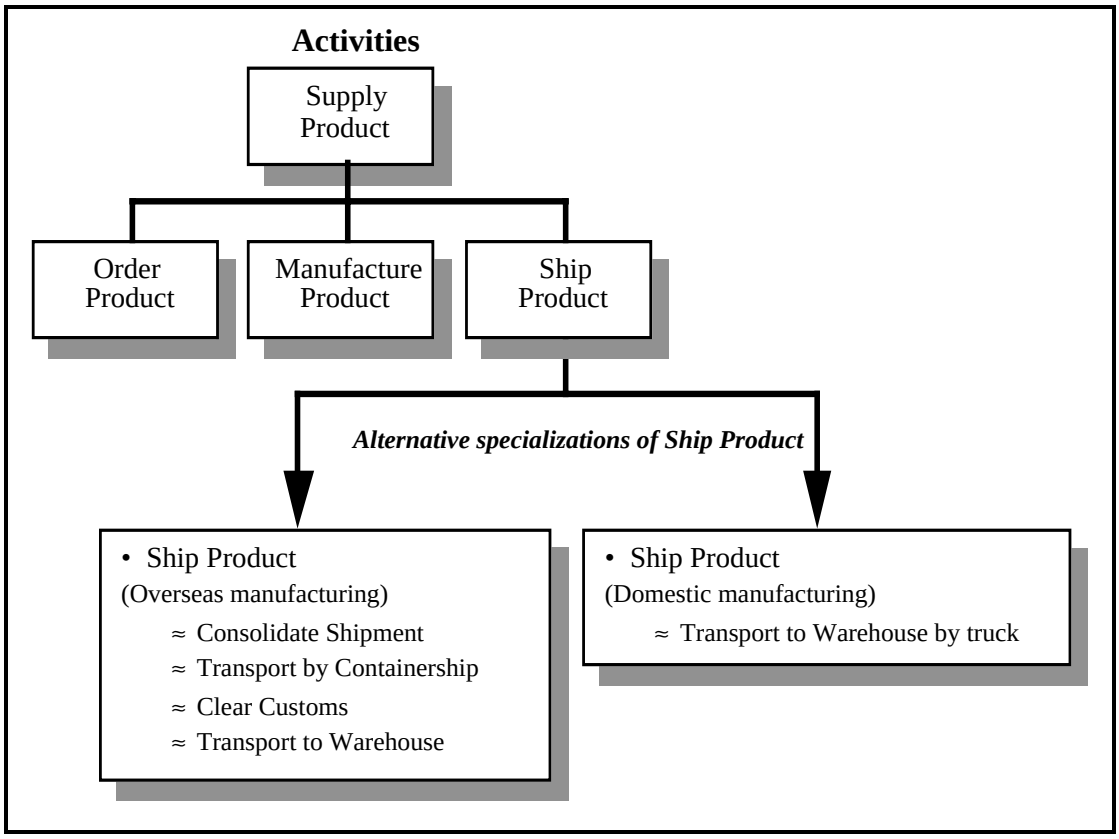

Figure 4: Activity hierarchy with alternative specializations, graphical format

specializations. The resulting activity hierarchy then serves as a candidate hierarchy for dependency analysis.

Top-down vs. bottom-up approaches to representation and analysis

It is important to understand activity representation and dependency analysis from both a top-down and a bottom-up perspective. The top-down perspective proceeds from a common vocabulary, which may represent a fairly high level of abstraction. In the Process Handbook, common vocabulary is expressed in the form of existing entries in the process taxonomy. In the examples above, activities such as Order Product, Manufacture Product, and Ship Product can be understood at such a level. At high levels of abstraction, process models take the perspectives employed by management teams, strategic planners, and many process consultants. The bottom-up perspective proceeds from local vocabulary, which typically involves a lower level of abstraction, and includes specific artifacts through which the product is executed. Activities derived from the examples above such as Transmit Letter of Credit, Load Shoes into Shipping Container, Verify Customs Clearance, and Sign Shipping Manifest represent such low-level activities. At the lowest levels of abstraction, process models use the vocabulary of the participants who execute the process. As mentioned above, this will often create a need to expand the range of vocabulary in the Handbook.

One strength of the activity hierarchy approach is that it forces users to reconcile top-down and bottom-up process views. To represent activities adequately in the Handbook, it is necessary to proceed from both a top-down and a bottom-up perspective, noting where the two approaches do or do not generate consistent activity linkages. To this end, the activities from the activity list need to be assembled into decomposition and specialization hierarchies using both top-down and bottom-up analysis.

Bottom-up activity analysis begins with activity artifacts: the physical products, physical or electronic forms and reports, and specific low-level transactions that take place to execute the process. Activity artifacts can often be identified by following the production and paper trail left by a process. Collecting the records used to document a set of process activities often provides such a paper trail. The Artifacts column on the activity list is included expressly for this purpose.

Top-down activity analysis begins with the activity decomposition hierarchy and examples of specializations as

reflected in an existing Process Handbook entry. Analyzing activities downwards from higher levels of abstraction takes place in two steps. First, the analysis examines the highest-level activities on the activity decomposition developed so far and extrapolates more generalized activities from them (e.g., Order Product might be extrapolated from Order Footwear). Second, the analysis considers the other activities to see which represent "steps in" these more general activities (indicating decomposition) or "ways to" accomplish the more general activity (indicating specialization).

DEPENDENCY ANALYSIS

The activity representation provides a first cut at understanding process components and the decomposition/specialization relationships between them. Developing Handbook entries requires analyzing observed processes in sufficient detail to represent both activities and dependencies between activities. The next part of this discussion describes dependency analysis.

Production versus Coordination

This methodology makes a distinction between two broad kinds of activities: production, or "core", activities, and coordination activities. This distinction, which is drawn from coordination theory (Malone and Crowston, 1991; 1994), is critical to the analysis of dependencies in processes. The basic idea is very simple: whenever there is a dependency between two production activities (for example, one activity uses the output of another), coordination is required. Given the continuing decrease in the cost of technologies that support coordination (e.g., computers and telecommunications), it is often possible to make considerable improvements in the design of a process simply by focusing attention on the dependencies between activities and the coordination processes used to manage them.

There are two key criteria that can be used to distinguish production or core activities:

(1) Transformation. If the activity produces a direct physical change on the product, there is a strong argument that it is a production activity. More generally, if the outputs from the activity differ significantly from the inputs in a manner that suggests that the inputs have been transformed, that activity is typically a production activity. The stitching step in the shoe manufacturing process is an example that satisfies transformation criteria. Soles and uppers are inputs to the process; assembled shoes are an output. Consider, for example, the stitching process which combines a padded nylon bag with three molded plastic parts to produce a high-performance running shoe.

(2) Essentialism. This answers the question, "For any given activity, can you imagine any possible way to accomplish the overall process without it?" If not, then it is fair to say that the activity in question is essential for the completion of the process. Generally speaking, production activities have this quality.

The distinction between production and coordination raises questions regarding tangibility and questions about boundaries. Tangibility questions relate to how easily an observer can define the "product:" if the product is an easily-identified physical object or a service that can be readily quantified, then analyzing production and coordination activities becomes a relatively straightforward process. An automobile, for example, is a tangibly different object when it rolls off the assembly line than it was when its parts entered the factory. An airline flight is a more tangible quantity when on-time performance becomes a governing, measurable criteria. Distinguishing between production and coordination from an activity-based perspective becomes easier to the degree that output differs measurably from input across a range of process activities.

Any comparison between activity types furthermore depends in part on the boundary set for the analysis - e.g., on the level of abstraction chosen for viewing the process. Activities that look like production to members of a work group, for example, may look like coordination activities to their departmental managers. The expediter who is trying to accelerate delivery on a stack of purchase orders probably considers the pile of successfully-closed POs in his outbox at the end of the day as production. To the line manager waiting for the products, the expediting is a coordination function. If AT&T hires Federal Express to distribute spare parts among its computer installations, AT&T managers might consider "Fedexing" as coordinating parts delivery. To the Federal Express driver, however, getting the right package to the right loading dock at the right time is a major production step.

These examples suggest that where an activity crosses boundaries within or between levels in a process activity hierarchy, it is likely to be considered a production step by actors at that level in the organization. To actors at higher levels (whose organizational boundaries are implicitly *not* being crossed by the activity), the activity might be viewed as coordination.

This distinction extends rather than contradicts the contrasts drawn here between "core" or "production" activities and "coordination" activities. Indeed, the question of boundaries strengthens the definitions because it recognizes that analyzing activities is contingent upon organizational context. An analysis scheme that can convert between production and coordination views at appropriate levels of the activity hierarchy offers powerful integrating features that other process analysis methods lack. Indeed, one of the strengths of this method derives from understanding how activities can be perceived differently at successive organizational levels.

Dependency	Components	Description
Flow		One activity produces an output that another activity requires as an input
	Prerequisite	A product or service must be produced as output before the input can be made available
	Usability	The consumed product or service must reach some level of performance or usefulness before it can be employed as an input.
	Accessibility	The consumed product or service must be moved or stored before it can be used.
Sharing		More than one activity requires the use of the same (finite) resource.
Fit		More than one activity contributes to production of the same output.

Figure 5: Kinds of Dependencies

Major Kinds of Dependencies

There are several kinds of dependencies that exist between production activities (see Malone et al, 1999, for a more complete discussion). These dependencies are summarized in Figure 5.

Flow. This is the most intuitive kind of dependency. It has three aspects that can be separated for analytical purposes. First, there is the notion of prerequisite: one activity must be completed before another can start. Second, there is the notion of usability: the output of one activity must be appropriate for the input of the next. Finally, the output of one activity must be physically available for the next. Taken together, these three aspects summarize what we call the flow dependency.

Sharing. Another common kind of dependency has to do with activities that share common resources, such as personnel, equipment, budget, or managerial attention. When shared resources exist, there is typically a need to schedule, budget, or otherwise allocate them among activities.

Fit. This is similar to the sharing dependency, except that in this case multiple activities share in the production of a common output (rather than sharing in the consumption of a common input). A shared customer is a common example, where many different departments in one organization may all produce products used by a common customer. Another example is a task/subtask relationship where the results of subactivities must be combined into a coherent whole.

There are at least two ways to approach identifying an appropriate set of dependencies within any activity representation. The first perspective is a top-down approach that postulates dependencies, then looks for activities that coordinate them. The second perspective is a bottom-up approach that starts with postulated activities, then searches for dependencies that they manage or participate in. In both cases, the activity hierarchy developed during activity representation provides the process space within which to consider dependencies.

Top-down: Dependencies to activities

Top-down dependency analysis considers the activities observed in the activity representation from the perspective of the dependencies described in Figure 5. The analysis builds arguments for candidate dependencies at high levels of the activity hierarchy. For each candidate dependency, arguments are then constructed around activities that manage its components (e.g., potential sub-dependencies). If such activities also surface from bottom-up dependency analysis (see below) a stronger case for that dependency structure emerges. This dependency structure becomes part of a candidate dependency list that respondents can then verify.

In the footwear importing process, for example, a proposed flow dependency exists between far eastern manufacturing plants and a U.S. footwear company's domestic distribution system. Activities associated with importing can be identified that manage prerequisite, usability, and accessibility dependencies. These include ordering and planning processes to manage prerequisite dependencies between materials (e.g., leathers), production, capacity planning and quality control processes to manage usability, and traffic functions to handle accessibility.

In many cases, existing organizational structures and practices highlight dependencies that are of key importance. In many industries, for example, special practices and structures, developed over decades, serve to manage key dependencies. In the footwear study, each of the activities noted above is to some degree contracted to a third-party provider who has specialized expertise, including the manufacturing plant, the consolidator, and the customs

broker. There appear to be scale-related differences in coordination practices across the footwear industry, moreover, leading to differential reliance on overseas plants and specialized consolidators. In this manner, organizational context provides data points against which to map the top-down structure of an emerging dependency hierarchy.

Bottom-up: Activities to Dependencies

The bottom-up approach is focused on the perspective that some subset of the activities in the activity representation are core activities without which the process could not fulfill its functions, while other activities represent efforts to coordinate the core activities.

The bottom-up approach develops an understanding of dependencies by examining activities identified in the activity representation, determining whether they are production (core) activities or coordination activities, and then asking a series of questions about each one in order to surface candidate dependencies.

For production activities, these questions are intended to identify dependency relationships with other activities and might include the following:

- What does this activity produce (or consume)?
- What resources does it share?
- Is this activity part of a larger activity, or does it have subactivities?
- Is there some output that this activity produces in concert with some other activity?

For coordination activities the focal question becomes:

- What dependency does this activity manage?

In this way, lower-level coordination activities can serve to flag the presence of higher-level dependencies.

An example of bottom-up dependency analysis is the rapid-fire exchange of fax messages generated between the import department of one large athletic footwear manufacturer and the company's Hong Kong consolidator during the Midwest floods of 1993. The footwear manufacturer, located in New England, was trying to discover the mix of container loads currently in shipment across the Pacific so it could modify cross-country delivery schedules to avoid flood-related delays. Bottom-up analysis would identify this activity (which was highlighted by company managers), relate it to activities higher in the activity hierarchy, and consider candidate dependencies that it surfaced (at higher levels in the activity hierarchy) or managed (at lower levels in the hierarchy). In this example, the fax exchanges, understood in organizational context, demonstrate from a bottom-up perspective one way in which the organization is attempting to manage the elements of the flow dependency proposed by the top-down analysis as existing between the footwear company's domestic distribution system and its far eastern manufacturing plants.

An Integrated Approach: Verification

The above perspectives on identifying and analyzing dependencies are intended to be used in combination; as with top-down and bottom-up approaches to activity representation, they are intended to help reconcile the tension between using a common vocabulary and incorporating new terminology. Arguments that identify activities as coordination gain strength insofar as they can be corroborated by more than one approach.

This multiple-analysis view of dependency description can be seen as leading to two-stage verification of an emerging process model. The first stage of verification - internal, or partial verification - is complete when the research team has considered the dependency and activity characteristics of its process description and is satisfied that it meets all of the activity representation and dependency analysis criteria illustrated above. The second stage of verification - external, or corroborated verification - is complete when the respondent(s) who contributed to the model agree that the model is a satisfactory representation of reality and practice as they know it.

CONCLUSION

The methodology described here provides a way to collect useful, semi-formal representations of business processes. The difficulties in collecting process data, and the tendency towards over-analysis suggest a need for an intermediate level of representation of the kind described here. By relying on ethnographic interviews and observation for process information, the method encourages a moderate but meaningful level of granularity in the process description. By encouraging both top down analysis (starting from an established, common vocabulary) and bottom-up analysis (starting from informants' local vocabulary), this approach strikes a balance between the need for comparability and the need for meaningful local details. Semi-formal representation is a critical aspect of this approach, because formal representations cannot adequately capture important contextual issues. Finally, by expressing dependencies between activities, this method provides a window onto the critical coordination problems (and coordination opportunities) that constrain and enable every business process.

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