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# ISSUES ENCOUNTERED BETWEEN MODEL VIEWS

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ABSTRACT: The implementation of an intelligent manufacturing system requires a comprehensive understanding of the system and its environment. Modeling and simulation are critical to this understanding. Models are typically developed from one of five perspectives or views. A review of the literature describing different views is presented and a comparison of the views identified is presented. These five views are: business rule, activity, business process, resource, and organization views. The primary concern in this research is the identification of the issues of multiple views of an enterprise or system. Most project managers do not consider the issues pertaining to a multiple view model of a system. These managers develop and even maintain multiple types of models for different purposes. These multiple types of models are generally developed on an ad hoc basis. By understanding the issues relating to maintaining multiple views of an enterprise, the benefits of multiple views can be realized while minimizing its difficulties. Three approaches to multiple views are explained and their relative shortcomings are discussed. Issues related to the inconsistencies encountered in modeling these views will be presented.

## INTRODUCTION

A model is generally regarded as a representation of reality. Details that are unnecessary are not included. The typical uses of modeling are[1, 2, 3, 4]:

- To analyze and design the enterprise and its processes prior to implementation
- To help reduce complexity
- To communicate a common understanding of the system
- To gain stakeholder buy-in

- To act as a documentation tool for ISO 9000, TQM, Concurrent Engineering, and other efforts.

Models are created for different purposes. An enterprise may be represented in many different manners to describe a specific aspect of the enterprise. This is analogous to mechanical design. A computer model of a part is typically represented in several different models in order to represent a different aspect of the part. For instance, a mechanical design most likely has orthographic views describing the physical nature of the part, an numerical control program view for machining of the part, and a finite element view for part analysis. All of these views are useful in the design, analysis and production of the part. Similarly, an enterprise model contains different views to aid in the design, analysis, and implementation of the enterprise. A primary thrust of this research is to understand the relationship between various views. This paper seeks to identify the various issues in relating these views to each other.

## TYPES OF MODELS

Models are either static or dynamic. A model cannot combine the two types into a single model. Each type has its own advantages and disadvantages. In this section, we discuss the two types of models: static and dynamic models.

### Static

Static models attempt to provide a static representation of dynamic systems. Static models generally portray the possible flow paths of objects through a system. This information is very helpful in determining what items participate in the process and the functions performed by the system. Although static representations can indicate the allowable system behaviors, they cannot depict the range of time-variant behavior generated as a result of resource availability or the number of items flowing through the process. To adequately predict the performance characteristics of dynamic systems, the time-variant behaviors of the system must be defined and represented.

### Dynamic

Dynamic representations of systems attempt to capture and describe the behavior of the system over time under different operating conditions. For the purposes of this paper, we are referring to discrete-event simulation as the dynamic system model. Although the static system representations are capable of providing the vast majority of the information needed to construct a dynamic systems model, they do not possess the mechanisms needed to enact the process behavior constraints defined in their representations. Discrete-event simulation tools, in contrast, are capable of executing sets of system behavior roles and tracking the system’s transition through a series of states. In this manner, a dynamic model can provide information about the state of the system at a given instance in time or can generate performance measures of the system over a given period of time. Dynamic models can be used iteratively to study system behavior under different operating conditions. Subtle changes in resource availability or system loading can have dramatic effects on the performance of the system. This range of potential behaviors is very difficult to represent with a static system model. Dynamic models are typically used to aid analyst in a predictive manner. These models are frequently used to provide answers to "what-if" scenarios.

## VIEWS

Any improvement effort must understand the enterprise from multiple perspectives or views. These perspectives are required due to the various questions and viewpoints of the end customers of the improvement effort. Previous research defines a number of different views. The Computer Integrated Manufacturing Open Systems Architecture (CIMOSA) work promotes four views: Function, Information, Resource, and Organization[5]. The Zachman Framework of 1987[6] was extended by Sowa in 1992[7] and describes the planner (model scope), owner (enterprise model), designer (system model), builder (technology model), and subcontractor (components) as the dimensions that must be described. Curtis[8] defines his four views as functional (what process elements are being performed, and what flows of information entities are relevant to these process elements), behavior (when process elements are performed (sequencing)), organizational or resource (where and by whom processes are performed, physical communications mechanisms, storage media and locations), and informational (what information entities produced or manipulated by the process). This includes data, artifacts, products, and objects. ARIS (Architecture of Integrated Information Systems) also has four views. The three main views used are data, function, and organization. Depending on context (information or business system) the fourth view is either called the resource or control view. Previous work in the development of architectures by the Automation & Robotics Research Institute[9] describes a five-view approach:

- Business Rule (or Information) View defines the entities managed by the enterprise and the rules governing their relationships and interactions,
- Activity View defines the functions performed by the enterprise (*what* is done),
- Business Process View defines a time-sequenced set of processes (*how* it is done),
- Resource View defines the resources and capabilities managed by the enterprise,
- Organization View describes how the enterprise is organized which includes the set of constraints and rules governing how it manages itself and its processes.

This does not, however, mean that all these views must be present in all models. A model is an abstract representation of reality which should exclude details of the world which are not of interest to the modeler or the ultimate users of the model. Models are developed to answer specific questions about the enterprise. This research focuses specifically on the need for analysis of resource constraints and process flows. Most of these authors and others have commented on the difficulty in relating the views to each other and the problem of consistency. This paper attempts to identify some issues of maintaining multiple views and provides some examples.

## APPROACH

Petrie in the Introduction to *Enterprise Integration Modeling* describes three approaches to model integration[10]. These approaches are called, Master Model, Unified Models, and Federated Models. These approaches have been modified and applied to a specific form of model integration, that of view synthesization. The three approaches are identified in this research as the master view approach, the driving view approach, and the federated (or late binding) approach. This section describes what is meant in this research by these three approaches.

### Master View

Historically, most attempts to synthesize or integrate the different views have taken what we call the master view approach. This approach attempts to define all the required information in a single view and then feed the other views from this view. A key component of this approach is the concept that any changes may be made in the master view and then the other views are regenerated from this view. An attempt at this approach is described in previous research[11]. The previous research attempted to drive a simulation model (resource view) from a static model (activity or process view). An example of this approach can be found in figure 1. This figure demonstrates the requirement of additional annotation to the IDEF (Integrated DEFinition) method. Even with this additional annotation, the authors found that for a complete resource view several entities must be

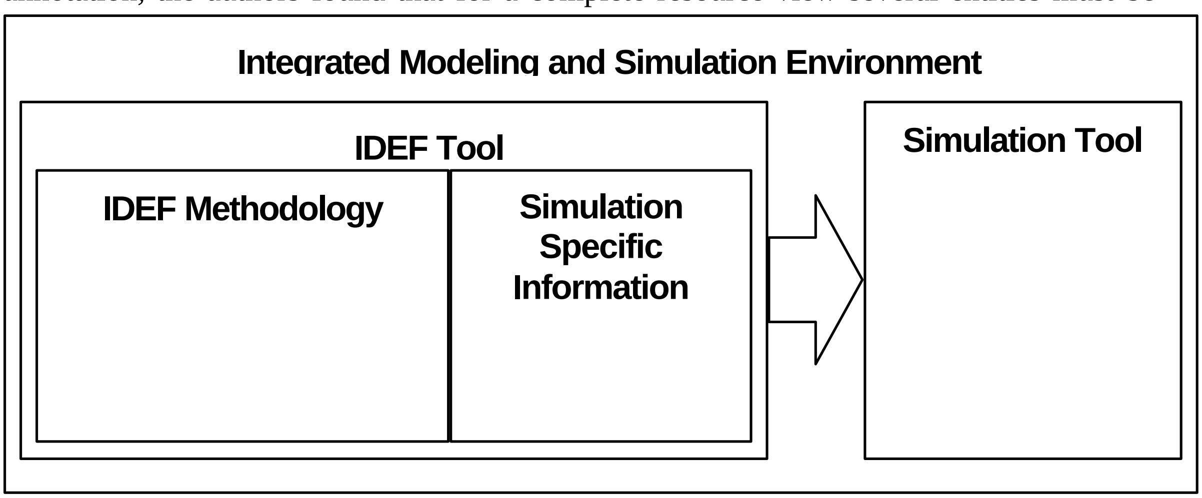


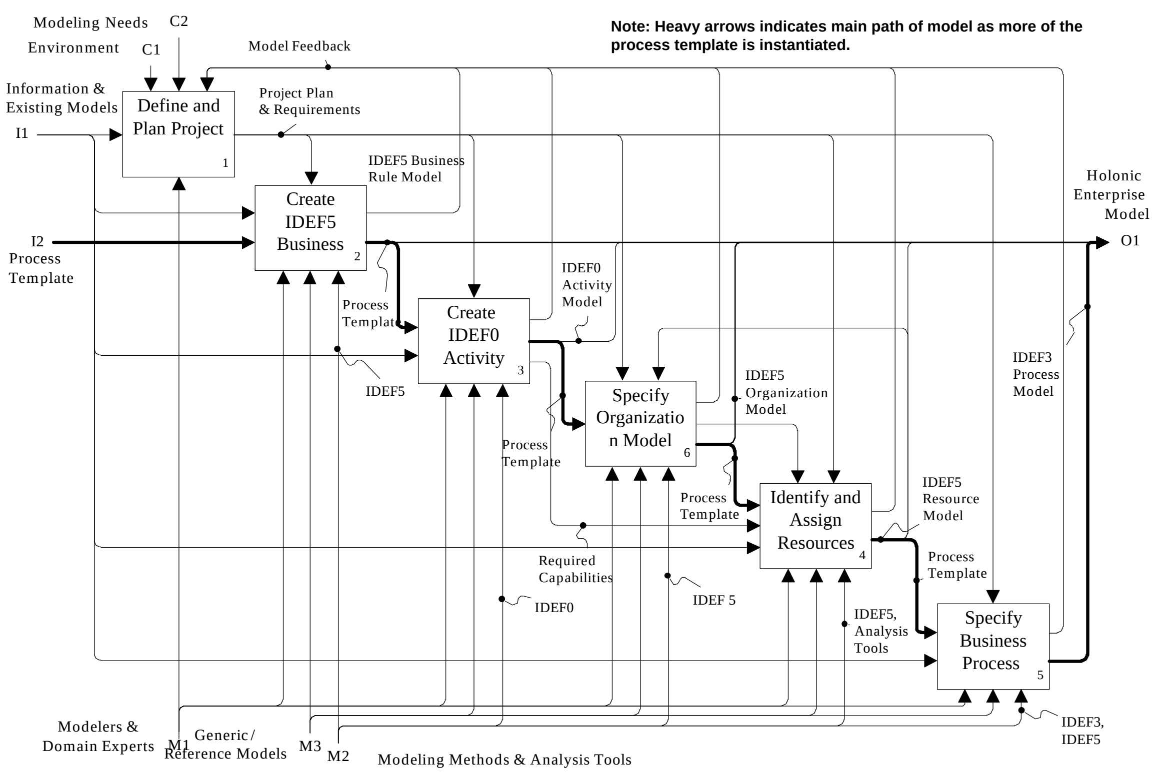

Figure 1. Master View Approach Example

entered in the resource view. This is primarily a limitation of the tools used rather than the actual method used. However, the concept of additional annotation demonstrates that the method is really changed from its original intent to support a single view. The authors are unaware of any successful attempt to synthesize views in this manner. Any changes made to the master view must be translated to the receiving view and then additional annotations must occur in the receiving view.

## Driving approach

Several have recognized the difficulty (if not impossibility) of including all relevant information in a single view. Therefore, what we refer to as the driving approach has also been used. This approach is similar to the master view approach except that the driving approach does not expect a single view to contain all relevant information about an enterprise. The driving approach chooses the largest content view, populates it, and then attempts to populate the other views from that information. Research described by Presley[12] and Kim[13] provides two examples of this approach.

Presley provides an IDEF0 model describing his methodology. He integrates the views through the IDEF5 Ontology Capture Method. This methodology is shown in figure 2. The IDEF5 model serves as the business rule view. The necessary relationships are extracted from the IDEF5 model and are used to specify the organization and resource views. Activity information from the IDEF5 model is used to generate an IDEF0 activity view and IDEF3 business process view models.




Kim developed the FIDO (Function, Information, Dynamic, Organization) model which is based on object oriented principles throughout the entire suite. FIDO bases its model on

Figure 2. View Synthesization Methodology (taken from [12])

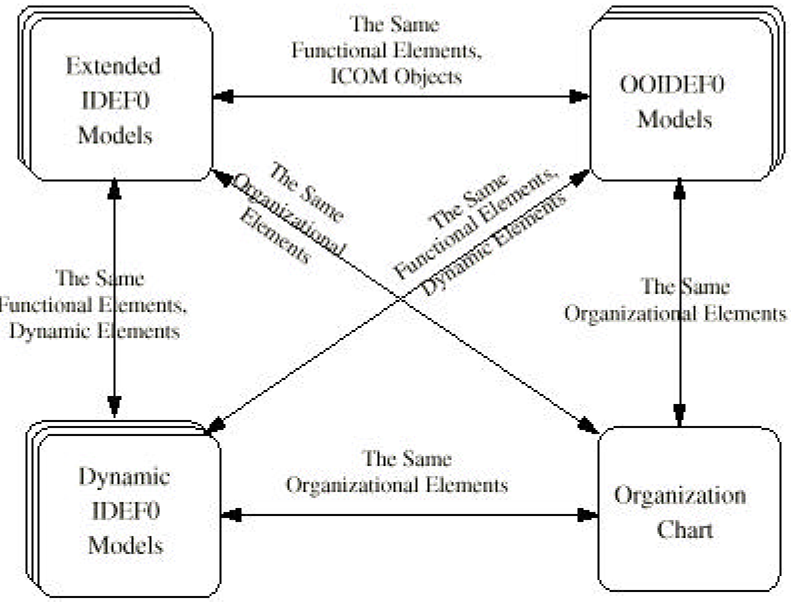



Figure 3. Consistencies between different views (taken from [13] )

an extended IDEF0 functional model and expands this using object-oriented analysis and design. FIDO views complement each other by utilizing the same elements as shown in figure 3. FIDO1 (Extended IDEF0 modeling) is an extension of the IDEF0 activity model. This view is the basis for all the other views in the FIDO methodology. FIDO maps the model to a SLAMII simulation model which is accomplished by adding time, cost, quality, resource type, resource capacity, and branching parameters.

## Federated approach

Federated means that information is gathered in its native format and then placed in other formats. The federated approach is similar to the driving approach except that it allows the iterative population of each view while maintaining consistency between views. The driving approach assumes that one view contains the driving knowledge and then additional knowledge is added in the other views. This requires all information to be added to the master view. The federated approach allows the user to populate each view as information becomes available in that view. The advantage of this approach is that it allows the addition of knowledge in the view most conducive to the form of knowledge captured. For example, if process knowledge is captured then knowledge can be placed in a process view and then populated in the other views. This makes the approach ensure the consistency between views rather than requiring the user to determine how to enter information in the master view. This method is highly tool dependant. The rigor of the tool capability in ensuring the proper mapping between views is critical to the success of this method.

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## ISSUES BETWEEN VIEWS

We list four key issues in the synthesis between views. These four issues are: 1) gaps in the view, 2) differences in methodology structure, 3) artificial wrappers (decomposition versus aggregation), and 4) model ambiguities.

### Gaps in the view

A model is defined as a representation of reality. Details that are important to the question answered by the model are included. Other details are not included. Therefore, some information that is pertinent in one view may not be relevant in another view, which is the advantage of using multiple views. Figure 4 shows conceptually that there is significant overlap between the activity, process, and organization views. However, there are also significant portions of each view that are not described in the other views. This a key issue for both the master view and the driving view approaches. All information about a given system or enterprise can not be represented in a single view.

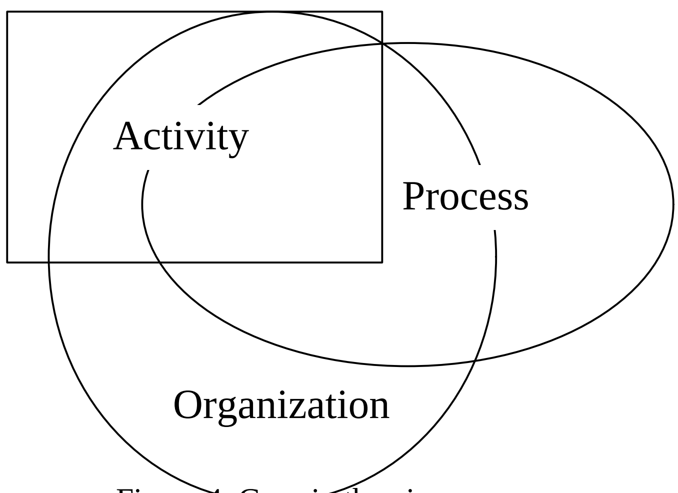


Figure 4. Gaps in the view

### Differences in Structure

The structure of the various views are not necessarily conducive to mapping between views. For example, activity and process views facilitate a hierarchical representation, whereas, the data view does not. A high level activity view may contain “documents” as a data element, and a lower level activity view contains “purchase orders.” The data view would contain only the element “purchase orders” with the subsequent data required on the fields of the form. A mapping technique might be to only map the leaf level of the hierarchical method, but this approach loses the advantages of a hierarchical model in reducing the complexity of the system and increasing the understanding of the system.

## Artificial Wrappers

Hierarchical modeling provides a useful tool for understanding an enterprise or system. Typically, models are utilizing a subordinate principle of abstraction called decomposition[14], which is the breaking down of each activity into more detail in a continuous manner until the greatest level of detail is achieved[1]. An example of this top down modeling as in the IDEF0 method as shown in figure 5.

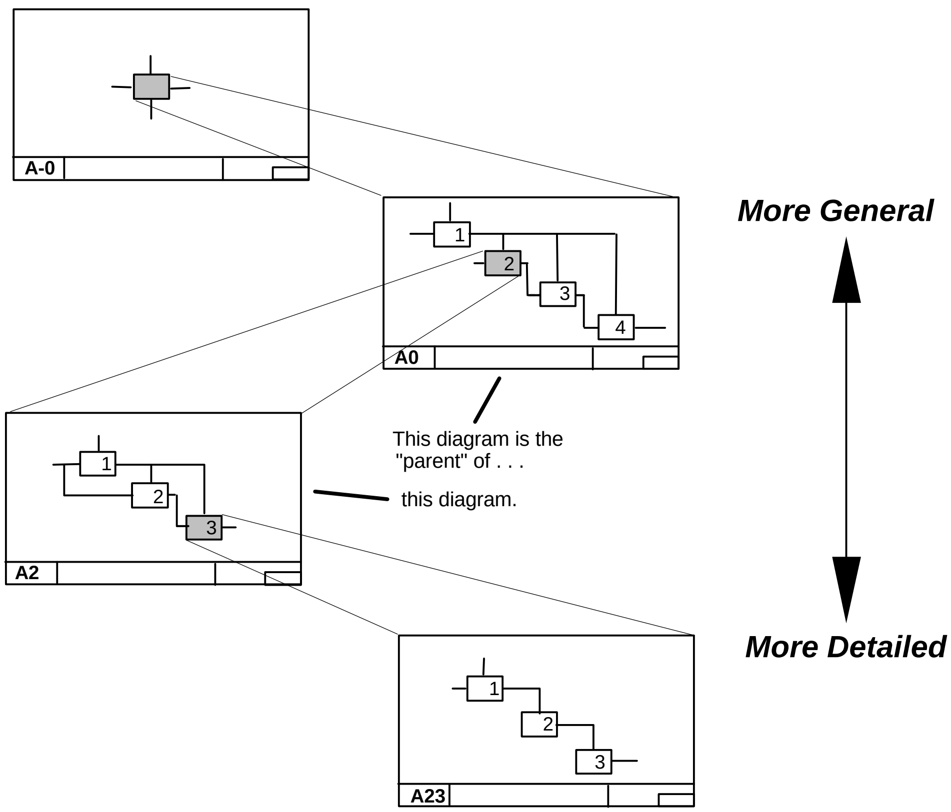


Figure 5. Functional Decomposition

However, many times this forces an “artificial wrapper” on the middle levels of the hierarchy. This may be confusing to the reviewers. Most of the reviewers of models are familiar with either the top levels of the system or with the bottom levels of the system. There are generally familiar “labels” for these levels that provide a frame of reference for these reviewers. In the previous figure, the A-0 and A0 level would likely use similar terms for the activities identified at these levels. Also, the A23 level would also use familiar terms for the activities at lower levels. However, the middle level activities, such as those in A2, might not be recognized by anyone familiar with the system. Therefore, in order to properly decompose these activities, an “artificial wrapper” is placed on groupings to aggregate the lower level activities to match these with the higher level activities. Most

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systems are well defined at the high levels and at the low levels, but are not explicitly defined at the middle levels. In the authors experience, this has confused many model reviewers.

## Model Ambiguities

Information that is pertinent in one view is frequently not included in another view. This reduction of information is useful for a clearer understanding of the system. However, this also leads to ambiguities in the model. Some concepts are easy to represent in one view of the model, but in the complementary view, additional information is required to remove

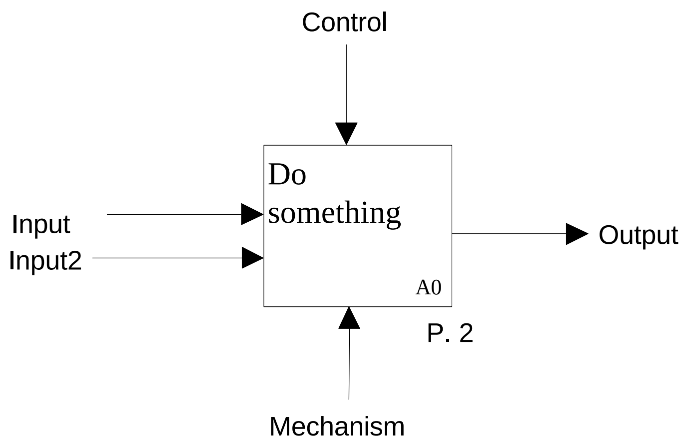


Figure 6. Example of ambiguity

ambiguities. In order to clarify this point, the following example is presented. In figure 6, an activity is shown with two inputs. This is a correct representation of the process, but it is ambiguous. The two inputs represent one of three conditions: an assemble, a match, or a selection. An assemble means the two inputs could represent two items needed for the activity together. An example could be a motherboard and a cpu. Any one motherboard may be assembled with any cpu (assuming this is a line with only one cpu and one type of motherboard). A match means that a specific instance of input must be matched with

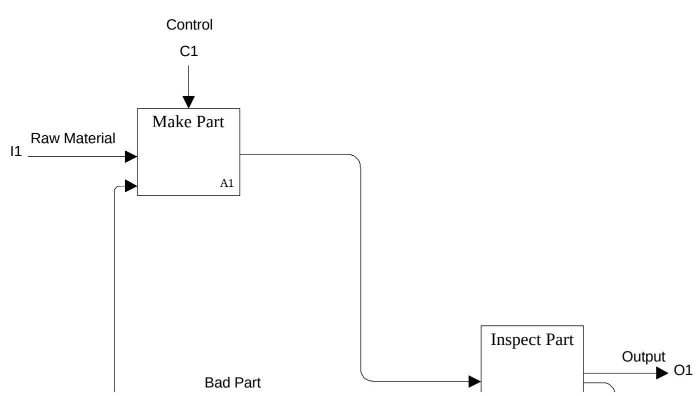


Figure 7. A Selection Activity

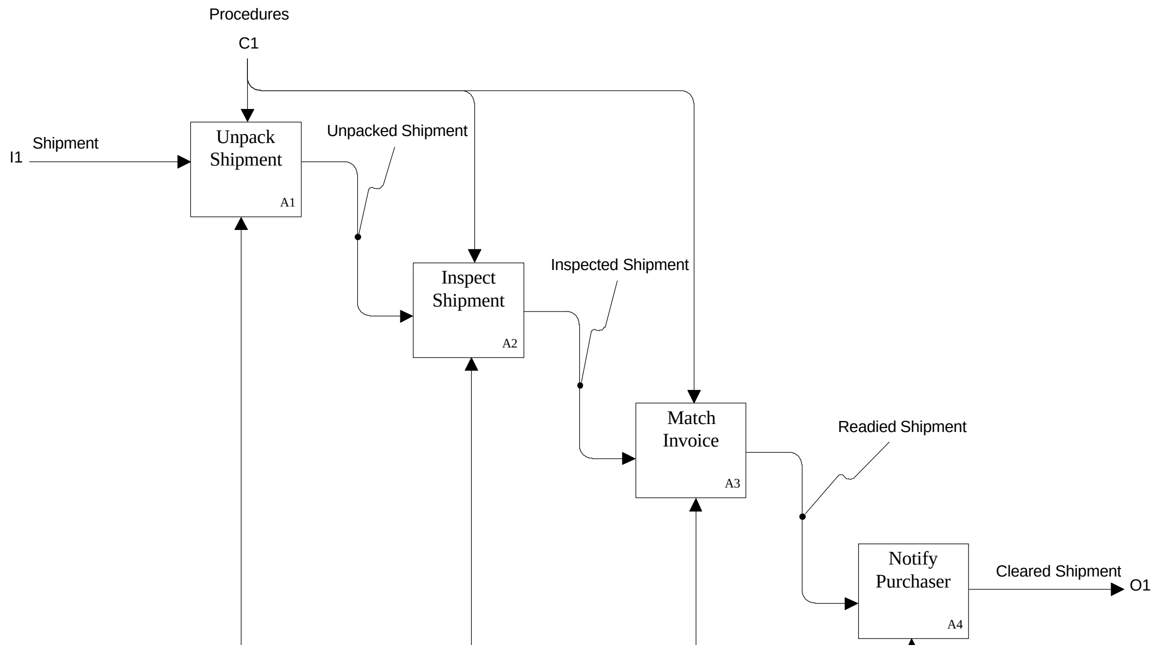


Figure 8. IDEF0 Ambiguous Diagram

input2 for the activity to occur. An example could be a part to be machined and its part program. A selection means that only one of the two inputs are needed for the activity to occur. An example of this can be seen in figure 7, which shows where the part is being manufactured and if not correct cycles back to the manufacturing process. Therefore, either type of input is required for the activity to occur. Another example can be seen by the IDEF0 model shown in figure 8. The IDEF0 model appears to explicitly describe the order of the activities (the method itself states that IDEF0 does not define temporal sequence). It is implied that first the employee information must be captured, then the physical must be performed, and then the employee benefits determined. This is not the intent of the system. The IDEF3 model shown in figure 9 does describe the partial sequence and seems to imply that the order of the last two processes is unimportant, yet both must be accomplished. By using the asynchronous *AND* junction, the actual intent of the system is clearly described.

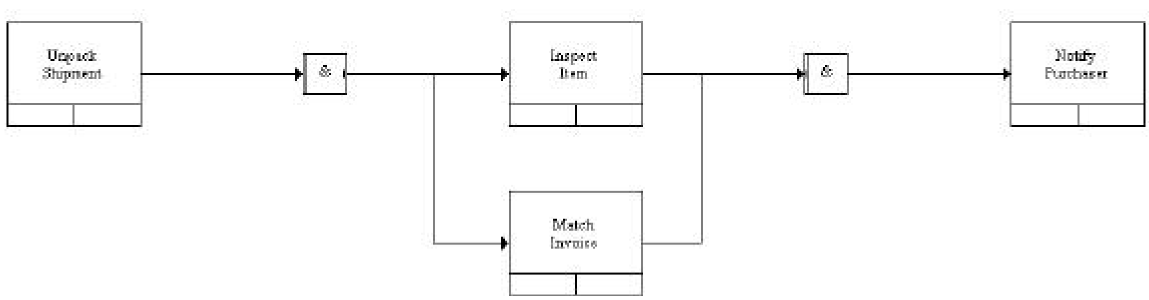


Figure 9. IDEF3 Process Sequence

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## CONCLUSION/FUTURE RESEARCH

A comprehensive understanding of the need and issues related to multiple views of an enterprise can aid in the implementation of intelligent manufacturing systems. This paper discussed the five perspectives typically used in most modeling efforts. Most analysis efforts develop and even maintain multiple types of models for different purposes. This paper discussed the three approaches to synthesizing multiple view models. Resolution to the issues identified in this research related to the inconsistencies encountered in modeling are critical to improving the design and analysis of any system. By understanding the issues relating to maintaining multiple views of an enterprise, the benefits of multiple views can be realized while minimizing the difficulties of multiple views. Some methods reduce complexity to aid in achieving understanding. However, this is not without cost. The reduction of complexity is achieved by the reduction of details. These details are critical for certain purposes (such as temporality). Multiple views enable the reduction of complexity in one view and allow the vital details to be described in another view. Future research will identify mechanisms for minimizing the effect of these issues discussed in this paper utilizing the federated approach to synthesizing multiple views of models.

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