Part III
Chapter 3
Interaction

3.1 Introduction

In object models it is assumed that the only signs of activity are the **interactions** taking place between objects. Activity within objects remains hidden. Evidence of **interaction** is provided by the symbols conveyed on each of the connections. It is assumed that interactions are **determined** cooperatively by the participating objects. Occasionally a system will be defined where a **conflict** arises and the exercise of physical power rather than cooperative action determines what happens. Sometimes cooperating objects will offer a range of possible interactions and the outcome is **indetermined**[†].

It is often useful to treat interactions as though they consisted of separate but linked parts. A composition of interactions is referred to as a **composite interaction**. It is possible to compose an interaction in different ways from its constituent parts. A **multiple interaction** consists of several parts taken from identical alphabets. An **indefinite interaction** is a multiple interaction which consists of an indefinite number of parts: from the specification it is not possible to say how many parts there are to the composite interaction. In information processing systems it is often assumed that, once a system becomes operational, its components will continue to interact indefinitely.

The parts of a composite interaction sometimes have a temporal order imposed on them. Such interactions are called **composite sequenced interactions**. A composite sequenced interaction is a composite interaction that has been constrained by the introduction of the temporal ordering. Composite sequenced interactions can be composed in different ways from their constituent parts. The **multiple sequenced interaction** and the **indefinite sequenced interaction** are the sequenced counterparts of multiple and indefinite interactions respectively.

† We are aware that the terms determined and indetermined may be confusing, but we are equally aware that alternatives also lead to confusion.

3.2 Reference section

The manual pages that follow contain the descriptions of the concepts interaction, determined interaction, indetermined interaction, conflic composite interaction, multiple interaction, indefinite interaction, composi sequenced interaction, multiple sequenced interaction, and indefini sequenced interaction.

NAME

Interaction

PURPOSE

To enable cooperative action between objects.

SYNOPSIS

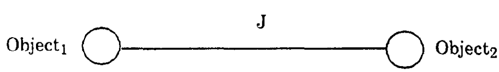
An interaction is determined by the objects that are interacting together with the connection between them. Each object places constraints on what can occur and the particular interaction that takes place is determined by the combined constraints of the objects.

The specification of an object will associate the name of the object with the constraints that it places on possible interactions. Not all interactions, allowable by the connection, need be permitted by the objects but it is expected that the objects denoted in object diagrams will not be able to engage in interactions outside of those indicated by the alphabet of interactions associated with the connection.

CANONICAL FORM

An interaction involves two objects with a connection between them as shown in figure 3.1. A particular interaction is subject to the constraints imposed by the two objects. In Figure 3.1 the potential interactions are explicitly indicated by the alphabet. The constraints imposed by the objects are described in their specification. The object specification and the object are linked through the label attached to the object.

Figure 3.1 An interaction between two objects



SPECIFICATION

Assume a connection between two objects conveys symbols from the alphabet, J. A particular but unknown interaction is represented by a lower case letter j, where

$j \in J$

Each object places a constraint on the symbols of the alphabet th can be conveyed across their interfaces. If the interfaces a properly matched to the connection then the constraint imposed l the object will limit the possible interactions, or symbols, to a subs of the interactions, or symbols, allowed by the connection. Objec might impose constraint J_1 and $Object_2$ might impose constraint J If the objects are matched then

$J_1 \subseteq J$ and $J_2 \subseteq J$.

An interaction j is bounded by the three constraints J, J_1 and J That is

$j \in J \cap J_1 \cap J_2$

this expression simplifies to

$j \in J_1 \cap J_2$

Thus $J_1 \cap J_2$ is the set of possible interactions.

REALIZABILITY ISSUES

In some cases the physical realization of the connection constrai the interaction beyond the constraints imposed by the interactir objects. If the specification is to be valid, interacting objects mε however not be constrained by the connection that connects the interfaces. This is what is meant by phrase "the connection properly matched to the interfaces". If this assumption unreasonable, then an object must be included in the model su that any additional constraints are made explicit.

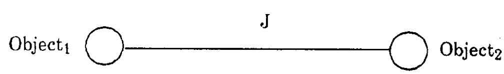
NAME
Determined interaction

PURPOSE
To provide determined cooperative action by objects

SYNOPSIS
Interactions can be fully determined from the specification, when the constraints imposed by the objects lead to a single possible interaction.

CANONICAL FORM
A determined interaction involves two objects with a connection between them as shown in figure 3.2. Knowledge of the specifications of the connected objects is required to discover whether an interaction will be determined or not.

Figure 3.2 An interaction between two objects



SPECIFICATION
Suppose a connection between two objects can convey symbols from the alphabet J and that $Object_1$ imposes constraint J_1 and $Object_2$ imposes constraint J_2.

If an interaction $j \in J$ is to be fully determined then application of all the constraints on an alphabet from objects and connections must result in a set of possible interactions that includes only one member.

This requirement can be written as

$\#(J_1 \cap J_2) = 1$

For example, if J could be represented the set of symbols $\{j_1, j_2, j_3, j_4, j_5, j_6\}$, then the constraint J_1, represented by the set $\{j_1, j_3, j_5\}$, satisfies the condition $J_1 \subseteq J$ and the constraint J_2, represented by the set $\{j_1, j_2, j_4\}$, satisfies the condition $J_2 \subseteq J$. Then the interaction j is given by

$j \in J_1 \cap J_2$

and

$J_1 \cap J_2 = \{j_1, j_3, j_5\} \cap \{j_1, j_2, j_4\} = \{j_1\}$

Then

$\#(J_1 \cap J_2) = 1$

which means that j is totally determined. The symbol j_1 will conveyed on the connection.

REALIZABILITY ISSUES

SEE ALSO

INTERACTION

NAME

Indetermined interaction

PURPOSE

To describe cooperative action by objects that cannot be precisely determined from knowledge of the object specifications.

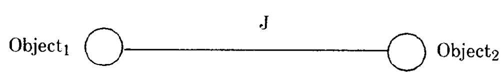
SYNOPSIS

Interactions are said to be indetermined, where a specification allows a number of valid possible interactions. There is a choice of symbols, but there is no way of finding out from the description of the system, which symbol will be chosen.

CANONICAL FORM

An indetermined interaction involves two objects with a connection between them as shown in figure 3.3. The specification of the connected objects is required to reveal that an interaction is indetermined.

Figure 3.3 An interaction between two objects



SPECIFICATION

Each object places a constraint on the symbols of the alphabet that can be conveyed across their interfaces. Suppose $Object_1$ imposes constraint J_1 and $Object_2$ imposes constraint J_2 and

$J_1 \subseteq J$ and $J_2 \subseteq J$.

An indetermined interaction has been specified if

$\#(J_1 \cap J_2) > 1$

If an interaction is indetermined then application of all the constraints will yield a number of possible interactions that could take place.

For example, if J could be represented by the set of symbols $\{j_1, j_2, j_3, j_4, j_5, j_6\}$, the constraint J_1 is represented by the set $\{j_1, j_3, j_4\}$ and the constraint J_2 is represented by the set $\{j_1, j_2, j_4\}$, then the interaction j is given by

$j \in J_1 \cap J_2$

and

$J_1 \cap J_2 = \{j_1, j_3, j_4\} \cap \{j_1, j_2, j_4\} = \{j_1, j_4\}$

which means that it cannot be determined whether the interaction j will be represented by j_1 or j_4. Either will satisfy the description of the interaction given by the specification of the objects and their connection.

REALIZABILITY ISSUES

The symbolic model gives a set of possible interactions. Only one of the possibilities will occur. Which possibility will occur will depend on factors in the real system that have not been included in the model of the system.

SEE ALSO

INTERACTION

NAME

Conflict

PURPOSE

To denote that cooperative action between objects cannot take place.

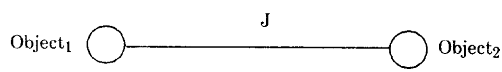
SYNOPSIS

Conflict occurs where objects over constrain potential interactions so that no interaction can satisfy the constraints. The symbolic model cannot help predict what will happen. Isomorphism between the symbolic and physical models is no longer maintained and predictions about the interactions that will occur require a more detailed model that can demonstrate how the competing constraints will be resolved.

CANONICAL FORM

An over constrained interaction involves two objects with a connection between them as shown in figure 3.4. Conflict can be detected through examination of the object specifications.

Figure 3.4 An interaction between two objects



SPECIFICATION

Suppose $Object_1$ imposes constraint J_1 and $Object_2$ imposes constraint J_2. J_1 and J_2 are subsets of the alphabet J carried on the connection.

$J_1 \subseteq J$ and $J_2 \subseteq J$.

Conflict occurs when the constraints imposed by a pair of objects and a connection result in there being no possibility of a valid interaction. Conflict occurs when

$\#(J_1 \cap J_2) = 0$.

For example, if J can be represented by the set of symbols $\{j_1, j_2, j_3, j_4, j_5, j_6\}$, the constraint J_1 is represented by the set $\{j_1, j_3, j_5\}$ and the constraint J_2 is represented by the set $\{j_2, j_4, j_6\}$, then the interaction j is given by

$j \in J_1 \cap J_2$

and

$J_1 \cap J_2 = \{j_1, j_3, j_5\} \cap \{j_2, j_4, j_6\} = \{\}$

Thus $\#(J_1 \cap J_2) = 0$.

It is impossible to say, from this result, what will physically represent j.

REALIZABILITY ISSUES

There is no means of determining which interaction will take place from the specification of the objects and the connection. The resolution of the conflict may be the result of the competitive application of physical power. In some cases this may lead to permanent changes thought of as damage.

SEE ALSO

INTERACTION

NAME

Composite interaction

PURPOSE

To allow the composition of an interaction from simpler parts.

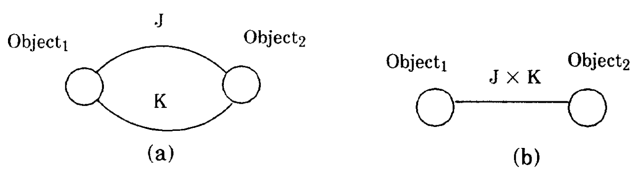
SYNOPSIS

Sometimes an alphabet associated with a connection can be shown as a composition of two, or more, other alphabets.

CANONICAL FORM

Figure 3.5(a) shows two objects interacting using several connections. A single connection carrying a larger alphabet can replace them. In Figure 3.5(b) the connection carries the composite alphabet composed of the symbols from the set J × K.

Figure 3.5 Several separate connections (a) composed into a single connection carrying a composite alphabet (b)



SPECIFICATION

Separate connections carry symbols from separate alphabets and connections do not impose constraints on one another. When viewed as a system of connections, any combination incorporating one valid symbol from each of the connections can be conveyed.

For a set of n connections between two objects there are n alphabets. Each connection will carry a symbol from its associated alphabet. Assume the set of alphabets is

$\{X_1, X_2, \ldots, X_n\}$

An interaction will include a member of each alphabet and can be written as a tuple

$(x_1, x_2, \ldots, x_n)$

where $x_m \in X_m$ for each m:1..n.

All of the possible interactions are taken from the set of tuples

$P = X_1 \times X_2 \times \ldots \times X_n$

which can be considered to be an alphabet of possibilities and can be written as

$\{(x_1, x_2, \ldots, x_n) \mid x_1 \in X_1 \wedge x_2 \in X_2 \wedge \ldots \wedge x_n \in X_n\}$

Suppose the two objects involved in the interactions impose constraints, P_1 and P_2. The interactions that do take place are therefore taken from the set

$P_1 \cap P_2$

Because the constraints are subsets of the alphabet allowed on the system of connections

$P_1 \subseteq P$ and $P_2 \subseteq P$

which implies that the constraints must be written as sets of tuples too.

REALIZABILITY ISSUES

Extensive alphabets can be carried either by multiple connections which each convey smaller alphabets or by repeated use of a single connection that conveys a small alphabet. The corresponding terms, used in the connection of physical components of computer systems, are parallel and serial connections.

SEE ALSO

COMPLEX OBJECTS

NAME

Multiple interaction

PURPOSE

To allow the composition of an interaction from multiple identical but simpler interactions

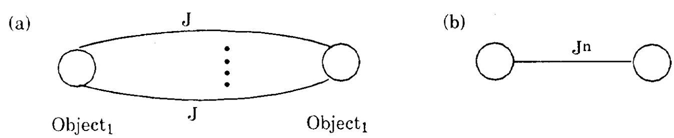
SYNOPSIS

It is sometimes possible to compose an interaction from several parts, each of which is taken from the same alphabet. Such an interaction is a multiple interaction. It is possible to gather several connections which can carry alphabets with the same carrier set into one connection and label that connection with the composition of the interaction alphabets. The multiple interaction is taken from this composite alphabet.

CANONICAL FORM

Figure 3.6 shows two objects connected with several connections each labelled with the alphabet J. The dots indicate that there are potentially many such connections. The objects can be drawn connected by one single connection and this connection must be labelled with the composite alphabet, as shown in the figure, where n is the number of parts of the composite alphabet.

Figure 3.6 Several connections between two objects (a) gathered into a single connection with multiple alphabet (b)



SPECIFICATION

A multiple interaction is a composite interaction, where the component interactions are all drawn from the same set; the set of interactions allowed on the connections.

The collection of particular interactions between Object$_1$ and Object$_2$ in Figure 3.6(a) is denoted by a tuple, which is taken from the set of tuples:

$\{J \times J \times J \times \ldots\ldots\ldots \times J \times J\}$

Each J in this expression is associated with one particular connection between $Object_1$ and $Object_2$. The order of the components of the Cartesian product is important since it may be used to identify the particular connection to which the alphabet is linked.

When composing a connection from several other connections the composite alphabet on the new connection must be capable of producing all the possible combinations of symbols on the previously separate connections. This is expressed by the Cartesian product of the constituent alphabets. A composed connection may be introduced, which is labelled with the original alphabet and an indication of the number of connections that are composed as follows:

$J^n = J \times J^{n-1}$

where $J^1 = J$

and $J^0 = \{\}$, which would indicate the absence of a connection.

J^n contains ordered tuples, each with n members. The order associates the members with the connections It follows that a particular interaction, taken from J^n, will consist of n ordered members and is expressed as:

$j^n \in J^n$

REALIZABILITY ISSUES

SEE ALSO

INTERACTION

NAME

Indefinite interaction

PURPOSE

To provide for continual and changing interaction.

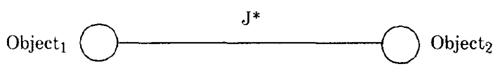
SYNOPSIS

Interactions between objects are often composed of indefinite sequences of symbols. An indefinite interaction is specified when it is not possible to determine exactly how many components there will be in a composite interaction. Sequences may be distributed in space and time.

CANONICAL FORM

Figure 3.7 shows two objects that can engage in interactions from the alphabet J*. The asterisk indicates that the alphabet consists of an indefinite composition of members of the alphabet J.

Figure 3.7 Two objects engaging in an indefinite interaction.



SPECIFICATION

The indefinite alphabet carried by the connection can be defined recursively:

$J^* = J \times J^*$ or

$J^* = \{ (j, j^*) \mid j \in J \wedge j^* \in J^* \}$

The result of this definition is that the carrier set of J* contains an indefinite number of symbols. Each symbol in J* is a tuple of indefinite length. The elements of the tuple are each members of J.

Take an alphabet $J = \{j_a, j_b\}$ then an indefinite interaction is taken from J* such that:

$(j_1, j_2, j_3, \ldots) \in J^*$

where $j_1 \in J, j_2 \in J, j_3 \in J \ldots$

The ordering implied by the sequence notation and the numbering of elements both specify the ordering of the symbols in the indefinite tuple.

The constraints that two interacting objects place on the symbols allowed by the connection determine what interaction will take place. These constraints have to be expressed in terms of the symbols that are allowed by the connection. In this case the constraints are expressed in terms of the symbols of J^*, that is in terms of indefinite tuples of elements taken from J. Suppose $Object_1$ places a constraint J_1 and $Object_2$ places constraint J_2, such that

$J_1 \subseteq J^*$ and $J_2 \subseteq J^*$

Provided the interfaces are a proper match for the connection an interaction j is taken from

$j \in J_1 \cap J_2$

where j is an indefinite tuple.

Each element or group of elements of an indefinite interaction can be determined, indetermined, or the subject of conflict. Just like their definite counterparts this depends on whether $J_1 \cap J_2$ yields one member, more than one member, or no members respectively.

REALIZABILITY ISSUES

A realizable object cannot embody an indefinite constraint. However, many indefinite constraints can be expressed in terms of the recursive application of a finite constraint. Only those constraints that can be represented in a finite form can be incorporated into a physical mechanism.

SEE ALSO

DETERMINED INTERACTION
INDETERMINED INTERACTION
CONFLICT
COMPOSITE INTERACTION

NAME

Composite sequenced interaction

PURPOSE

To allow the composition of an interaction from a sequence of simpler parts

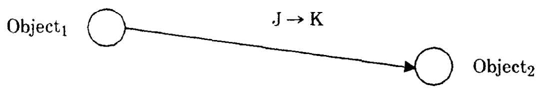
SYNOPSIS

Sometimes an alphabet associated with a connection can be shown as a sequence of two or more other alphabets. Each possible interaction is then composed of a sequence of symbols.

CANONICAL FORM

Figure 3.8 shows two objects interacting using an alphabet that is composed of a sequence of two other alphabets.

Figure 3.8 A connection labelled with a sequenced alphabet.



SPECIFICATION

The term $(j \rightarrow k)$ is used to describe a symbol that is a composition of the symbols j and k formed on a single physical connection with the symbol k following the symbol j. The arrow indicates an ordering. The ordered composition is a specialization of the general composition of j and k indicated by (j, k).

A sequenced interaction is sometimes called a trace.

Alphabets of sequenced symbols can be formed from pairs of alphabets. The composition of alphabets into a sequenced alphabet is indicated by an arrow:

$$J \rightarrow K = \{ (j \rightarrow k) \mid j \in J \wedge k \in K \}$$

The composition of alphabets to form a sequenced alphabet is a specialization of the general composition of alphabets indicated by

$$J \times K$$

Where J × K appears on a connection it can be replaced by the more restrictive form J → K. The reverse substitution cannot be applied.

REALIZABILITY ISSUES

The form J → K explicitly states that the composition is ordered. The form J × K does not impose this restriction and allows composition in space or in time. Only when the laws of physics are taken into account does it become necessary to interpret the ordered interaction as a sequenced interaction.

SEE ALSO

INTERACTION
OBJECT WITH A DIRECTED INTERFACE
CAUSAL OBJECT

NAME

Multiple sequenced interaction

PURPOSE

To allow the composition of an interaction from multiple identical and sequenced, but simpler interactions

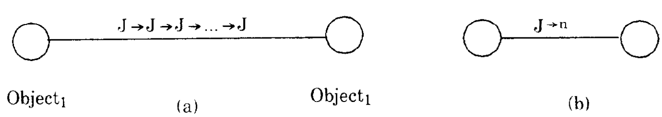
SYNOPSIS

It is sometimes possible to compose an interaction from several parts, each of which are identical in that they are each taken from the same alphabet. These parts may also be sequenced. It is possible to gather a sequence of alphabets with the same carrier set into one interaction alphabet. The multiple sequenced interaction is taken from this composite alphabet.

CANONICAL FORM

Figure 3.9(a) shows two connected objects that interact using a sequenced interaction alphabet, of which each part in the sequence is the set of symbols J. The dots indicate that there are potentially many parts to the sequence. The objects can be drawn connected by a connection that is labelled with the composite alphabet, as shown in Figure 3.9(b), where n is the number of parts that constitute the composite alphabet.

Figure 3.9 A multiple sequenced alphabet



SPECIFICATION

The connection between the objects in the figure carries a sequence of similar alphabets. The only difference between the alphabets is the order in which the symbols appear. An alphabet may be introduced, which is labelled as the original alphabet with indication of the number of parts in the sequence as follows:

$$J^{\rightarrow n} = J \rightarrow J^{\rightarrow n-1}$$

where $J^{\rightarrow 1} = J$

and $J^{\rightarrow 0} = \{\}$, which would indicate the absence of a connection.

$J^{\rightarrow n}$ contains ordered tuples with n members. It follows that a particular interaction, taken from $J^{\rightarrow n}$ will consist of n ordered members and is expressed as:

$j^{\rightarrow n} \in J^{\rightarrow n}$

REALIZABILITY ISSUES

The ordering of a multiple sequenced interaction can be interpreted as a sequence in time. The form $J^{\rightarrow n}$ explicitly states that the composition is ordered. The form J^n does not impose this restriction and allows the composition to be either spatial or temporal.

SEE ALSO

INTERACTION
OBJECT WITH A DIRECTED INTERFACE
CAUSAL OBJECT

NAME

Indefinite sequenced interaction

PURPOSE

To provide for continual changing interaction composed of an indefinite sequence of similar interactions

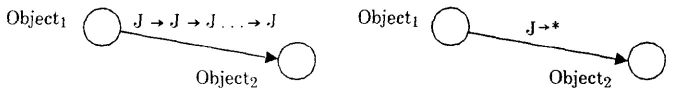
SYNOPSIS

The indefinite sequenced interaction takes the concept of the indefinite interaction and limits its interpretation to an indefinite sequence distributed in time.

CANONICAL FORM

Figure 3.10 illustrates two forms that represent two objects interacting using an indefinite sequenced alphabet.

Figure 3.10 An indefinite sequence from $Object_1$ to $Object_2$



SPECIFICATION

An indefinite sequenced interaction is a specialization of the indefinite interaction.

$J^{\rightarrow *} = J \rightarrow J^{\rightarrow *}$

$J^{\rightarrow *} = \{ (j, j^{\rightarrow *}) \mid j \in J \wedge j^{\rightarrow *} \in J^{\rightarrow *} \}$

An interaction j is an indefinite tuple on which an order has been imposed.

REALIZABILITY ISSUES

The indefinite sequence must be defined by recursive application of a finite constraint.

3.3 Examples

Editorial: examples are to be supplied.