**Date:** Month yyyy

Precise Semantics of UML Composite Structures

*Version (e.g., Alpha 1, Beta 1, 1.0)*

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Preface

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**Helvetica/Arial - 10 pt. Bold:** OMG Interface Definition Language (OMG IDL) and syntax elements.

**Courier - 10 pt. Bold:** Programming language elements.

Helvetica/Arial - 10 pt: Exceptions

NOTE: Terms that appear in italics are defined in the glossary. Italic text also represents the name of a document, specification, or other publication.

# Scope

The Scope clause shall appear at the beginning of each specification and define, without ambiguity, the subject of the specification and the aspect(s) covered. It indicates the limits of applicability of the specification or particular parts of it. It shall not contain requirements.

The scope shall be succinct so that it can be used as a summary for bibliographic purposes.

It shall be worded as a series of statements of fact.

# Conformance

The Conformance clause identifies which clauses of the specification are mandatory (or conditionally mandatory) and which are optional in order for an implementation to claim conformance to the specification.

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# Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

List of normative references.

# Terms and Definitions

For the purposes of this specification, the following terms and definitions apply.

Term

Definition

Term

Definition

Term

Definition

# Symbols

List of symbols/abbreviations.

# Additional Information

## Changes to Adopted OMG Specifications [optional]

TBD.

## Acknowledgements

TBD

# Abstract Syntax

TBD.

## Overview

TBD.

### Abstract Syntax



Figure 1. Composite Structures



Figure 2. Interface Realization



Figure 3. Communication

### Class Descriptions

### CallOperationAction

#### Generalizations

 fUML::Syntax::Actions::BasicActions::CallOperationAction

#### Properties

 onPort : Port [0..1]

### Class

#### Generalizations

 fUML::Syntax::Classes::Kernel::Class

#### Properties

 interfaceRealization : InterfaceRealization [0..\*]

 ownedConnector : Connector [0..\*]

 ownedPort : Port [0..\*]

### ConnectableElement

#### Generalizations

 fUML::Syntax::Classes::Kernel::TypedElement

### Connector

#### Generalizations

#### Properties

 end : ConnectorEnd [2..\*]

 kind : ConnectorKind [1]

 type : Association [0..1]

### ConnectorEnd

#### Generalizations

 fUML::Syntax::Classes::Kernel::MultiplicityElement

#### Properties

 partWithPort : Property [0..1]

 role : Property [1]

### Interface

#### Generalizations

 fUML::Syntax::Classes::Kernel::Classifier

#### Properties

 ownedAttribute : Property [0..\*]

 ownedOperation : Operation [0..\*]

 ownedReception : Reception [0..\*]

### InterfaceRealization

#### Generalizations

#### Properties

 contract : Interface [1]

### Port

#### Generalizations

 fUML::Syntax::Classes::Kernel::Property

#### Properties

 isBehavior : Boolean [1]

 isConjugated : Boolean [1]

 providedInterface : Interface [0..\*]

 requiredInterface : Interface [0..\*]

### SendSignalAction

#### Generalizations

 fUML::Syntax::Actions::BasicActions::SendSignalAction

#### Properties

 onPort : Port [0..1]

### Trigger

#### Generalizations

 fUML::Syntax::CommonBehaviors::Communications::Trigger

#### Properties

 port : Port [0..\*]

# Execution Model

Note from the Reston meeting:

We need to introduce the following classes in the ExecutionModel:

* **PortObject** : A particular kind of Object, which should embed a behavior describing request propagations across ports (which may be a propagation following attached connector instances, or insertion of the corresponding signal instance in the event pool of the Object owning this PortObject). This class probably needs to maintain a list of delegation connector instances and a list of assembly connector instances, in order to be able to determine paths for propagation.
	+ **=> Maybe, not necessary to have port objects**.
* **ConnectorInstance (extends fuml::StructuredValue)** : In the case where a Connector is typed by an association, fUML::Link is probably sufficient (ends of the connector instance can be determined using featureValue). However, in the case where the connector is not typed, we cannot use Link, because it extends ExtensionalValue, and because we need something else that FeatureValues to identify ends.
	+ **=> Unclassified links may be introduced in a revision of fUML**

**Alternative?**

 **. 1. Dynamically create an association to type this connector**

 **. 2. Through a transformation, generate the association typing the connector => The execution model can be written with the hypothesis that the connector is typed by an association.**

We need to extend the following classes from the fUML execution model:

* Structural feature actions: **Extend ClearStructuralFeatureValueActionActivation and RemoveStrucutralFeatureValueActionActivation** to account for the fact that when the corresponding actions are invoked for a structural feature which is a port, their execution may result in removing ConnectorInstances (i.e., not only links)
	+ => If we make link, this is already covered by fuml
* Link actions: NOTE: I was about to write something on create and destroy link actions for addressing the case of ConnectorInstances described above (i.e. creating / destroying links which are not typed by associations), but it seems that writeLinkActions requires LinkEndDatas, which as far as I understand it prevents from creating a link which is not instance of an association.
* **Locus: overload *instantiate*** in order to enable instantiations resulting in “non-empty” objects (i.e., exploit the kind of structural configuration described by the composite structure)
	+ Fig 9.27 => Issue of constructors. Note: We need a mechanism to manage stereotypes in fUML. Could we do that with some kinds of profile APIs? (e.g., for SysML, *applyBlock(Class), isBlock(Class)* )
* **Extend InvocationActionActivation (and SendSignalActionActivation and CallOperationActionActivation)** to account for the fact that the invocation targets a particular PortObject
	+ Problem in UML:
		- An InvocationAction has a 1..1 target input pin (which is typed by the classifier of the target object), and references an operation (which should be an operation of the target object classifier). In the case of the port, the operation should be an operation of the required interface. => The onPort must be a port of the opposite, not a port of the context classifier.
		- Hope it will be fixed in UML 2.5
* **Extend SignalInstance** so that it can carry the information that it occurred on a specific PortObject. It may also be necessary to have an information capturing the last link crossed by the SignalInstance during the propagation process, so that it is possible for a PortObject to determine if it must propagate through delegation or assembly links (e.g., in the case where the PortObject represents a Port providing and requiring a same given Interface).
* **Extend AcceptEventActionEventAccepter** so that matching takes into account the port on which the SignalInstance occured

## Overview

TBD.

## Abstract syntax



Figure 4. Composite Objects



Figure 5. Signal



Figure 6. Actions



Figure 7. Strategies

## Class Descriptions

### AcceptEventActionActivation

The behavior of fUML CallOperationActionActivation::match() is overriden, in order to account for the fact that a given signal instance may need to be matched with triggers where a list of ports is given. (NOTE: Addresses requirement R9 "Specifying one or more ports for an event implies that the event triggers the execution of an associated behavior only if the event was received via one of the specified ports.")

#### Generalizations

 fUML::Semantics::Actions::CompleteActions::AcceptEventActionActivation

#### Operations

[1] public match (in signalInstance : SignalInstance) : Boolean {

 // Return true if the given signal instance matches a trigger of the accept

 // action of this activation.

 // Matching implies that the type of the signalInstance matches the Signal

 // of one of the triggers.

 // When the type matches with the Signal, and if the trigger specifies a

 // list of ports,

 // the signalInstance matches the trigger only if it occured on a port

 // identified in the list.

 AcceptEventAction action = (AcceptEventAction)(this.node) ;

 TriggerList triggers = action.trigger ;

 Signal signal = signalInstance.type ;

 Boolean matches = false;

 Integer i = 1;

 while (!matches & i <= triggers.size()) {

 Trigger t = triggers.getValue(i-1) ;

 matches = ((SignalEvent)t.event).signal == signal ;

 if (matches && (t instanceof Composites::Syntax::Trigger)) {

 if (! (signalInstance instanceof SignalInstanceWithPort)) {

 matches = false ;

 }

 else {

 PortList portsOfTrigger = ((Composites::Syntax::Trigger)t).port ;

 Port onPort =

 ((SignalInstanceWithPort)signalInstance).interactionPoint

 .definingPort ;

 Boolean portMatches = false ;

 Integer j = 1 ;

 while (! portMatches & j <= portsOfTrigger.size() ) {

 portMatches = onPort == portsOfTrigger.getValue(j-1) ;

 j = j + 1 ;

 }

 matches = portMatches ;

 }

 }

 i = i + 1;

 }

 return matches;

}

### AddStructuralFeatureValueActionActivation

The behavior of fUML AddStructuralFeatureActionActivation::doAction() is overriden. In the case where the targeted structural feature is a port and the value to be added is a Reference, an InteractionPoint is created on the basis of the given Reference. It then behaves like in fUML, except that the execution continues using the created InteractionPoint instead of the given Reference.

#### Generalizations

 fUML::Semantics::Actions::IntermediateActions::AddStructuralFeatureValueActionActivation

#### Operations

[1] public doAction () {

 // If the feature is a port and the input value to be added is a Reference,

 // Replaces this Reference by an InteractionPoint, and then behaves

 // as usual.

 // If the feature is not a port, behaves as usual

 AddStructuralFeatureValueAction action =

 (AddStructuralFeatureValueAction)(this.node);

 StructuralFeature feature = action.structuralFeature;

 if (! (feature instanceof Port)) {

 // Behaves as usual

 super.doAction() ;

 }

 else {

 ValueList inputValues = this.takeTokens(action.value);

 // NOTE: Multiplicity of the value input pin is required to be 1..1.

 Value inputValue = inputValues.getValue(0);

 if (inputValue instanceof Reference) {

 // First constructs an InteractionPoint from the inputValue

 Reference reference = (Reference)inputValue ;

 InteractionPoint interactionPoint = new InteractionPoint() ;

 interactionPoint.referent = reference.referent ;

 interactionPoint.definingPort = (Port)feature ;

 // The value on action.object is necessarily instanceof

 // ReferenceToCompositeStructure (otherwise, the feature cannot

 // be a port)

 ReferenceToCompositeStructure owner =

 (ReferenceToCompositeStructure)this

 .takeTokens(action.object).getValue(0);

 interactionPoint.owner = owner ;

 // Then replaces the Reference by an InteractionPoint

 // in the inputValues

 inputValues.remove(0) ;

 inputValues.addValue(0,interactionPoint) ;

 // Finally concludes with usual fUML behavior of

 // AddStructuralFeatureValueAction (i.e., the usual behavior when

 // the value on action.object pin is a StructuredValue)

 Integer insertAt = 0;

 if (action.insertAt != null) {

 insertAt = ((UnlimitedNaturalValue)this

 .takeTokens(action.insertAt).getValue(0))

 .value.naturalValue;

 }

 if (action.isReplaceAll) {

 owner.setFeatureValue(feature, inputValues, 0);

 } else {

 FeatureValue featureValue = owner.getFeatureValue(feature);

 if (featureValue.values.size() > 0 & insertAt == 0 ) {

 // If there is no insertAt pin, then the structural feature must

 // be unordered, and the insertion position is immaterial.

 insertAt = ((ChoiceStrategy)this.getExecutionLocus()

 .factory.getStrategy("choice"))

 .choose(featureValue.values.size());

 }

 if (feature.multiplicityElement.'isUnique') {

 // Remove any existing value that duplicates the input value

 Integer j = position(inputValue, featureValue.values, 1);

 if (j > 0) {

 featureValue.values.remove(j-1);

 if (insertAt > 0 & j < insertAt) {

 insertAt = insertAt - 1;

 }

 }

 }

 if (insertAt <= 0) {

 // Note: insertAt = -1 indicates an unlimited value of "\*"

 featureValue.values.addValue(inputValue);

 } else {

 featureValue.values.addValue(insertAt - 1, inputValue);

 }

 }

 }

 else {

 // behaves as usual

 super.doAction();

 }

 }

}

### CallOperationActionActivation

Extends fUML CallOperationActionActivation::getCallExecution(). If onPort is specified, instead of dispatching directly to target reference by calling operation dispatch, dispatchOut (cf. ReferenceToCompositeStructure) is called, so that the operation call will be finally dispatched to the environment (from where the execution will be taken). (Note: Adresses requirement R2 "Invocation actions may also be sent to a target via a given port, either on the sending object or on another object.")

#### Generalizations

 fUML::Semantics::Actions::BasicActions::CallOperationActionActivation

#### Operations

[1] public getCallExecution() : Execution {

 // If onPort is not specified, behaves like in fUML

 // If onPort is specified, and if the value on the target input pin is a

 // reference, dispatch the operation

 // to it and return the resulting execution object.

 // As compared to fUML, instead of dispatching directly to target reference

 // by calling operation dispatch,

 // dispatchOut is called, so that the operation call will be finally

 // dispatched to the environment (from where the execution will be taken).

 CallOperationAction action = (CallOperationAction)(this.node);

 Execution execution = null ;

 if (action.onPort == null ) {

 execution = super.getCallExecution() ;

 }

 else {

 Value target = this.takeTokens(action.target).getValue(0);

 if (target instanceof ReferenceToCompositeStructure) {

 execution = ((ReferenceToCompositeStructure)target)

 .dispatchOut(action.operation, action.onPort);

 }

 }

 return execution;

}

### CompositeObject

CompositeObject extends fUML Object with specific operations for managing propagations of requests through ports, from the environment to the internals of this object, or from the objet to its environment. NOTE, this class addresses the following requirements: - R4: If connectors are attached to both the port when used on a property within the internal structure of a classifier and the port on the container of an internal structure, the instance of the owning classifier will forward any requests arriving at this port along the link specified by those connectors. - R5: If there is a connector attached to only one side of a port, any requests arriving at this port will terminante at this port [Non-behavior port] - R6: For a behavior port, the instance of the owning classifier will handle requests arriving at this port (as specified in the behavior of the classifier), if this classifier has any behavior. - R7: If there is no behavior defined for this classifier, any communication arriving at a behavior port is lost. - R8: If several connectors are attached on one side of a port, then any request arriving at this port on a link derived from a connector on the other side of the port will be fowarded on links corresponding to these connectors. It is a semantic variation point whether these requests will be forwarded on all links, or on only one of those links.

#### Generalizations

 fUML::Semantics::Classes::Kernel::Object

#### Properties

 ownedConnectorInstances : ConnectorInstance [0..\*]. The collection of ConnectorInstance owned by this CompositeObject. For each ConnectorInstance, definingConnector is a Connector belonging to one of the Class typing this CompositeObject

#### Operations

[1] public dispatchFromPort (in operation : Operation,

 in interactionPoint : InteractionPoint)

 : Execution {

 // If the interaction is a behavior port, does nothing [for the moment... ?],

 // since the only kind of event supported in fUML is SignalEvent

 // If this is not a behavior port, select appropriate delegation links

 // from interactionPoint, and propagates the operation call through

 // these links

 Execution execution = null ;

 if (interactionPoint.definingPort.isBehavior) {

 // Do nothing

 }

 else {

 ReferenceList targets =

 this.selectTargetsForDispatching(operation, interactionPoint) ;

 // If targets is empty, no delegation target have been found,

 // and the operation call will be lost

 if (! (targets.size()==0)) {

 // Choose one target non-deterministically

 Integer index =

 ((ChoiceStrategy)this.locus.factory.getStrategy("choice"))

 .choose(targets.size()) ;

 Reference target = targets.getValue(index - 1) ;

 execution = target.dispatch(operation) ;

 }

 }

 return execution ;

}

[2] public dispatchOut (in operation : Operation, in onPort : Port) : Execution {

 // TODO:

 // Propagate the operation call through interaction points corresponding

 // to onPorts, following appropriate links,

 // This will result in calling dispatch(operation) on oppositeEnd found

 // from the links

 return null ;

}

[3] public selectConnectorsForDispatching(in operation : Operation,

 in port : Port)

 : Connector [\*] {

 // From the given signal and port, retrieves potential connectors through

 // which request can be delegated. These connectors are delegation

 // connectors attached to Port interactionPoint.definingPort, and whose

 // target provides the requested operation

 ConnectorList connectors = new ConnectorList() ;

 Integer i = 1 ;

 // Iterates on types of this CompositeObject

 while (i <= this.types.size()) {

 Type t =this.types.getValue(i-1) ;

 if (t instanceof Class\_) {

 Class\_ class\_ = (Class\_) t ;

 Integer j = 1 ;

 // Iterates on Connectors of the current type

 while (j <= class\_.ownedConnector.size()) {

 Connector cddConnector = class\_.ownedConnector.getValue(j-1) ;

 if (cddConnector.kind == ConnectorKind.delegation) {

 Integer k = 1 ;

 Boolean matches = false ;

 // Iterates on ConnectorEnds of the current Connector

 while (k <= cddConnector.end.size() && !matches) {

 ConnectorEnd cddEnd = cddConnector.end.getValue(k-1) ;

 if (!(cddEnd.role == port && cddEnd.partWithPort == null)) {

 if (cddEnd.role instanceof Port) {

 if (operation.owner instanceof Interface) {

 // We have to look in provided interfaces of the port if

 // they define directly or indirectly the Operation

 Integer l = 1 ;

 // Iterates on provided interfaces of the current end

 InterfaceList providedInterfaces =

 ((Port)cddEnd.role).providedInterface ;

 while (l <= providedInterfaces.size() && !matches) {

 Interface interface\_ = ((Port)cddEnd.role)

 .providedInterface

 .getValue(l-1) ;

 // Iterates on members of the current Interface

 Integer m = 1 ;

 while (m <= interface\_.member.size() && !matches) {

 NamedElement cddOperation =

 interface\_.member

 .getValue(m-1) ;

 if (cddOperation instanceof Operation) {

 DispatchWithAccountForInterfacesStrategy strategy =

 new DispatchWithAccountForInterfacesStrategy() ;

 matches =

 strategy.operationsMatch(

 (Operation)cddOperation,

 operation) ;

 if (matches) {

 connectors.addValue(cddConnector) ;

 }

 }

 m = m + 1 ;

 }

 l = l + 1 ;

 }

 }

 }

 else {

 // The connector does not target a Port.

 // We have to look if the Classifier typing this property

 // directly or indirectly provides a Reception for signal

 Integer l = 1 ;

 if (cddEnd.role.typedElement.type instanceof Class\_) {

 while (l <= ((Class\_)cddEnd.role.typedElement.type)

 .member.size()

 && !matches) {

 NamedElement cddOperation =

 ((Class\_)cddEnd.role.typedElement.type)

 .member.getValue(l-1) ;

 if (cddOperation instanceof Operation) {

 DispatchWithAccountForInterfacesStrategy strategy =

 new DispatchWithAccountForInterfacesStrategy() ;

 matches =

 strategy.operationsMatch(

 (Operation)cddOperation,

 operation) ;

 if (matches) {

 connectors.addValue(cddConnector) ;

 }

 }

 l = l + 1 ;

 }

 }

 }

 }

 k = k + 1 ;

 }

 }

 j = j + 1 ;

 }

 i = i + 1 ;

 }

 }

 return connectors ;

}

[4] public selectConnectorsForSending(in signal : Signal,

 in port : Port)

 : Connector [\*] {

 // From the given signal and port, retrieves potential connectors

 // through which request can be delegated

 // These connectors are delegation connectors attached to Port

 // interactionPoint.definingPort,

 // and whose target provide a reception for Signal signalInstance.type

 ConnectorList connectors = new ConnectorList() ;

 Integer i = 1 ;

 // Iterates on types of this CompositeObject

 while (i <= this.types.size()) {

 Type t =this.types.getValue(i-1) ;

 if (t instanceof Class\_) {

 Class\_ class\_ = (Class\_) t ;

 Integer j = 1 ;

 // Iterates on Connectors of the current type

 while (j <= class\_.ownedConnector.size()) {

 Connector cddConnector =

 class\_.ownedConnector.getValue(j-1) ;

 if (cddConnector.kind == ConnectorKind::delegation) {

 Integer k = 1 ;

 Boolean matches = false ;

 // Iterates on ConnectorEnds of the current Connector

 while (k <= cddConnector.end.size() && !matches) {

 ConnectorEnd cddEnd = cddConnector.end.getValue(k-1) ;

 if (!(cddEnd.role == port && cddEnd.partWithPort == null)) {

 if (cddEnd.role instanceof Port) {

 // We have to look in provided interfaces of the port

 // if there is a reception defined for signal

 Integer l = 1 ;

 // Iterates on provided interfaces of the current end

 InterfaceList providedInterfaces =

 ((Port)cddEnd.role).providedInterface ;

 while (l <= providedInterfaces.size() && !matches) {

 Interface interface\_ =

 ((Port)cddEnd.role).providedInterface.getValue(l-1) ;

 // Iterates on Receptions of the current interface

 Integer m = 1 ;

 while (m <= interface\_.ownedReception.size()

 && !matches) {

 if (interface\_.ownedReception.getValue(m-1).signal

 == signal) {

 matches = true ;

 connectors.addValue(cddConnector) ;

 }

 m = m + 1 ;

 }

 l = l + 1 ;

 }

 if (matches == false) {

 // No matching reception has been found in reception

 // directly owned by provided interfaces

 // Need to check in inherited members of these

 //provided interfaces.

 l = 1 ;

 // Iterates again on provided interfaces

 while (l <= providedInterfaces.size() && ! matches) {

 Interface interface\_ =

 providedInterfaces.getValue (l -1) ;

 // Iterates on inherited members of the current Interface

 Integer m = 1 ;

 while (m <= interface\_.inheritedMember.size()

 && !matches) {

 NamedElement cddReception =

 interface\_.inheritedMember.getValue(m-1) ;

 if ((cddReception instanceof Reception)

 &&

 (((Reception)cddReception).signal == signal)) {

 matches = true ;

 connectors.addValue(cddConnector) ;

 }

 m = m + 1 ;

 }

 l = l + 1 ;

 }

 }

 }

 else {

 // The connector does not target a Port.

 // We have to look if the Classifier typing this property

 // directly or indirectly provides a Reception for signal

 Integer l = 1 ;

 if (cddEnd.role.typedElement.type instanceof Classifier) {

 while (l <= ((Classifier)cddEnd.role

 .typedElement.type).member.size()

 && !matches) {

 NamedElement cddReception =

 ((Classifier)cddEnd.role.typedElement.type)

 .member.getValue(l-1) ;

 if ((cddReception instanceof Reception)

 &&

 (((Reception)cddReception).signal == signal)) {

 matches = true ;

 connectors.addValue(cddConnector) ;

 }

 l = l + 1 ;

 }

 }

 }

 }

 k = k + 1 ;

 }

 }

 j = j + 1 ;

 }

 i = i + 1 ;

 }

 }

 return connectors ;

}

[5] public selectTargetsForDispatching (in operation : Operation,

 in interactionPoint : InteractionPoint)

 : Reference [\*] {

 // From the given operation and interactionPoint, retrieves potential

 // connectors through which request can be delegated

 // These connectors are delegation connectors attached to Port

 // interactionPoint.definingPort,

 // and whose target provides or realize operation

 ConnectorList connectors =

 this.selectConnectorsForDispatching(operation,

 interactionPoint.definingPort) ;

 // Select links owned by the context object for which the

 // definingConnector is included in the list of matching connectors.

 Integer i = 1 ;

 ConnectorInstanceList connectorInstances =

 new ConnectorInstanceList() ;

 while (i <= connectors.size()) {

 Integer j = 1 ;

 Connector connector = connectors.getValue(i-1) ;

 while (j <= this.ownedConnectorInstances.size()) {

 ConnectorInstance connectorInstance =

 this.ownedConnectorInstances.getValue(j-1) ;

 if (connectorInstance.definingConnector == connector) {

 connectorInstances.addValue(connectorInstance) ;

 }

 j=j+1 ;

 }

 i = i+1 ;

 }

 // For each matching link, retrieves the end value opposite

 // to interactionPoint.

 // If this value is a reference (which means that it is possible to dispatch

 // operation to it), it is added in the list of potential targets.

 ReferenceList targets = new ReferenceList() ;

 i = 1 ;

 while (i <= connectorInstances.size()) {

 ConnectorInstance link = connectorInstances.getValue(i-1) ;

 Association association = link.type ;

 Property oppositeEnd = association.memberEnd.getValue(0);

 if (oppositeEnd == interactionPoint.definingPort) {

 oppositeEnd = association.memberEnd.getValue(1);

 }

 Value value = link.getFeatureValue(oppositeEnd).values.getValue(0) ;

 if (value instanceof Reference) {

 targets.addValue((Reference)value) ;

 }

 i = i + 1;

 }

 // if targets is empty, no matching targets have been found,

 // and the operation call will be lost

 return targets ;

}

[6] public selectTargetsForSending (in signalInstance : SignalInstance,

 in interactionPoint : InteractionPoint)

 : Reference[\*] {

 // From the given signalInstance and interactionPoint,

 // retrieves potential connectors through which request can be delegated

 // These connectors are delegation connectors attached to

 // Port interactionPoint.definingPort, and whose target provide a

 // reception for Signal signalInstance.type

 ConnectorList connectors =

 this.selectConnectorsForSending(signalInstance.type,

 interactionPoint.definingPort) ;

 // Select links owned by the context object for which the

 // definingConnector is included in the list of matching connectors.

 Integer i = 1 ;

 ConnectorInstanceList connectorInstances =

 new ConnectorInstanceList() ;

 while (i <= connectors.size()) {

 Integer j = 1 ;

 Connector connector = connectors.getValue(i-1) ;

 while (j <= this.ownedConnectorInstances.size()) {

 ConnectorInstance connectorInstance =

 this.ownedConnectorInstances.getValue(j-1) ;

 if (connectorInstance.definingConnector == connector) {

 connectorInstances.addValue(connectorInstance) ;

 }

 j=j+1 ;

 }

 i = i+1 ;

 }

 // For each matching link, retrieves the end value opposite

 // to interactionPoint.

 // If this value is a reference (which means that it is possible to send it

 // a signal), it is added in the list of potential targets.

 ReferenceList targets = new ReferenceList() ;

 i = 1 ;

 while (i <= connectorInstances.size()) {

 ConnectorInstance link = connectorInstances.getValue(i-1) ;

 Association association = link.type ;

 Property oppositeEnd = association.memberEnd.getValue(0);

 if (oppositeEnd == interactionPoint.definingPort) {

 oppositeEnd = association.memberEnd.getValue(1);

 }

 Value value = link.getFeatureValue(oppositeEnd).values.getValue(0) ;

 if (value instanceof Reference) {

 targets.addValue((Reference)value) ;

 }

 i = i + 1;

 }

 // if targets is empty, no matching targets have been found,

 // and the signal instance will be lost

 return targets ;

}

[7] public sendFromPort (in signalInstance : SignalInstance,

 in interactionPoint : InteractionPoint) {

 // If the interaction is a behavior port,

 // creates a SignalInstanceWithPort from the signal instance,

 // and sends it as usual using operation send

 // If this is not a behavior port,

 // select appropriate delegation targets from interactionPoint,

 // and propagates the signal to these targets

 if (interactionPoint.definingPort.isBehavior) {

 SignalInstanceWithPort newSignalInstance =

 new SignalInstanceWithPort() ;

 SignalInstance copy = (SignalInstance)signalInstance.copy() ;

 newSignalInstance.featureValues = copy.featureValues ;

 newSignalInstance.type = copy.type ;

 newSignalInstance.interactionPoint = interactionPoint ;

 this.send(newSignalInstance) ;

 }

 else {

 ReferenceList targets =

 this.selectTargetsForSending(signalInstance,

 interactionPoint) ;

 // If targets is empty, no delegation target have been found,

 // and the signal is lost

 Integer i = 1 ;

 // Do the following concurrently

 while (i <= targets.size()) {

 Reference target = targets.getValue(i-1) ;

 target.send(signalInstance) ;

 i = i + 1 ;

 }

 }

}

[8] public sendOut(in signalInstance : SignalInstance, in onPort : Port) {

 // TODO:

 // Propagate the signal instance through interaction points

 // corresponding to onPorts, following appropriate links.

 // This will result in calling send(signalInstance) on

 // oppositeEnd found from the links

}

### ConnectorInstance

ConnectorInstance extends Link with the ability to specify that this association instance plays a particular Connector. NOTE: The execution model described in this specification makes the hypothesis that connectors are necessarily typed by an Association.

#### Generalizations

 fUML::Semantics::Classes::Kernel::Link

#### Properties

 definingConnector : Connector [1]. The Connector played by this ConnectorInstance

### DispatchWithAccountForInterfacesStrategy

Extends fUML RedefinitionBasedDispatchStrategy to account for the fact that the invoked operation may belong to an interface, and not to one of the classifiers of the target object (NOTE: Not mandatory to have it defined as an extension. Could be defined as direct specialization of DispatchStrategy)

#### Generalizations

 fUML::Semantics::Classes::Kernel::RedefinitionBasedDispatchStrategy

#### Operations

[1] public getMethod (in object : Object,

 in operation : Operation )

 : Behavior {

 // Override getMethod so that it accounts for the fact that the Operation

 // may belong to an Interface (realized by one of the classifier of object),

 // and not directly to one of the classifier of object.

 return null ;

}

[2] public operationsMatch (in ownedOperation : Operation ,

 in baseOperation : Operation )

 : Boolean {

 // Override operationsMatch, in the case where baseOperation belongs

 // to an Interface

 return false ;

}

### InteractionPoint

An InteractionPoint represents the runtime manifestation of a Reference to an Object playing the role of a Port. More specifically, it overrides operation dispatching and signal receptions in order to capture the specific propagation semantics of requests targeting a port. NOTE: This class is related to the following requirements: - R1. The target value of an invocation action may also be a port. In this case, the invocation request is sent to the object owning this port as identified by the port identity, and is, upon arrival, handled as described in "Port" clause

#### Generalizations

 fUML::Semantics::Classes::Kernel::Reference

#### Properties

 definingPort : Port [1]. The Port for which this InteractionPoint is a runtime manifestation

 owner : ReferenceToCompositeStructure [1]. Represents the Reference to the CompositeObject owning this InteractionPort. NOTE: This is introduced to address requirement R3 (It represents the "link from that instance to the instance of the owning classifier [...] through which communication is forwarded to the instance of the owning classifier or through which the owning classifier communicates)

#### Operations

[1] public dispatch (in operation : Operation ) : Execution {

 // Delegates dispatching to the owning object

 return this.owner.dispatchFromPort(operation, this) ;

}

[2] public send (in signalInstance : SignalInstance ) {

 // Delegates sending to the owning object

 this.owner.sendFromPort(signalInstance, this) ;

}

[3] public startBehavior (in classifier : Class [0..1],

 in inputs : ParameterValue [\*]) {

 // Overriden to do nothing

}

### ReferenceToCompositeStructure

This class extends fuml Reference with specific operations for managing request propagation through ports, from the environment to the internals of the referent object, or from the referent objet to its environment. (NOTE: Addresses requirement R1 "The target value of an invocation action may also be a port. In this case, the invocation request is sent to the object owning this port as identified by the port identity, and is, upon arrival, handled as described in "Port" clause", and R2 "Invocation actions may also be sent to a target via a given port, either on the sending object or on another object.")

#### Generalizations

 fUML::Semantics::Classes::Kernel::Reference

#### Properties

 compositeReferent : CompositeObject [1]. The composite object referenced by this ReferenceToCompositeStructure. This property subsets Reference::referent.

#### Operations

[1] public dispatchFromPort (in operation : Operation,

 in interactionPoint : InteractionPoint)

 : Execution {

 //Delegates dispatching to composite referent

 return this.compositeReferent.dispatchFromPort(operation, interactionPoint) ;

}

[2] public dispatchOut (in operation : Operation, in onPort : Port) : Execution {

 // Delegates dispatching (through the port, to the environment)

 // to compositeReferent

 return this.compositeReferent.dispatchOut(operation, onPort) ;

}

[3] public sendFromPort (in signalInstance : SignalInstance,

 in interactionPoint : InteractionPoint) {

 // delegates sending to composite referent

 this.compositeReferent.sendFromPort(signalInstance, interactionPoint) ;

}

[4] public sendOut(in signalInstance : SignalInstance, in onPort : Port) {

 // Delegates sending (through the port, to the environment)

 // to compositeReferent

 this.compositeReferent.sendOut(signalInstance, onPort) ;

}

### SendSignalActionActivation

Extends behavior of fUML SendSignalActionActivation::doAction(). If onPort is specified, instead of sending directly to target reference by calling operation send, sendOut (cf. ReferenceToCompositeStructure) is called, so that the constructed signal instance will be finally sent to the environment. (Note: Addresses requirement R2 "Invocation actions may also be sent to a target via a given port, either on the sending object or on another object.")

#### Generalizations

 fUML::Semantics::Actions::BasicActions::SendSignalActionActivation

#### Operations

[1] public doAction () {

 // If onPort is not specified, behaves like in fUML

 // If onPort is specified,

 // Get the value from the target pin. If the value is not a reference,

 // then do nothing.

 // Otherwise, construct a signal using the values from the argument pins

 // As compared to fUML, instead of sending directly to target reference

 // by calling operation send,

 // sendOut is called, so that the constructed signal will be finally sent

 // to the environment.

 SendSignalAction action = (SendSignalAction)(this.node);

 if (action.onPort == null) {

 super.doAction() ;

 }

 else {

 Value target = this.takeTokens(action.target).getValue(0) ;

 if (target instanceof ReferenceToCompositeStructure) {

 Signal signal = action.signal;

 SignalInstance signalInstance = new SignalInstance();

 signalInstance.type = signal;

 PropertyList attributes = signal.ownedAttribute;

 InputPinList argumentPins = action.argument;

 Integer i = 0 ;

 while ( i < attributes.size()) {

 Property attribute = attributes.getValue(i);

 InputPin argumentPin = argumentPins.getValue(i);

 ValueList values = this.takeTokens(argumentPin);

 signalInstance.setFeatureValue(attribute, values, 0);

 }

 ReferenceToCompositeStructure targetReference =

 (ReferenceToCompositeStructure)target ;

 Port onPort = action.onPort ;

 targetReference.sendOut(signalInstance, onPort) ;

 }

 }

}

### SignalInstanceWithPort

SignalInstanceWithPort extends fUML SignalInstance with the ability to reference the specific InteractionPoint on which it occured. This is introduced to address the requirement R9 ("Specifying one or more ports for an event implies that the event triggers the execution of an associated behavior only if the event was received via one of the specified ports.").

#### Generalizations

 fUML::Semantics::CommonBehaviors::Communications::SignalInstance

#### Properties

 interactionPoint : InteractionPoint [1]. The InteractionPoint on which this signal instance occured.

#### Operations

[1] public copy () : Value {

 // Create a new signal instance with the same type, interaction point and

 // feature values as this signal instance.

 SignalInstanceWithPort newValue = (SignalInstanceWithPort) super.copy();

 newValue.type = this.type ;

 newValue.interactionPoint = this.interactionPoint ;

 return newValue;

}

# Test Suite

TBD.

**Annex A: Title**

(normative)

A.1  Clause heading

Text

**Normative annexes** are integral parts of the standard. Their presence is optional. An annex’s normative status (as opposed to informative) shall be made clear by the way in which it is referred to in the text and under the heading of the annex.

**Informative annexes** give additional information intended to assist the understanding or use of the standard and shall not contain provisions to which it is necessary to conform in order to be able to claim compliance with the standard. Their presence is optional. An annex’s informative status (as opposed to normative) shall be made clear by the way in which it is referred to in the text and under the heading of the annex.

A.2  Clause heading

Text

**Annex B: Title**

(normative)

B.1 Sample IDL

#pragma prefix “http\_//example.com"

**module stockquote\_wsdl {**

 interface StockQuotePortType {

 typedef sequence<float> ArrayOfFloat;

 typedef struct TimePeriod {

 wstring startTime;

 wstring endTime;

 };

 ArrayOfFloat GetTradePrices(

 in wstring tickerSymbol,

 in TimePeriod timePeriod,

 out float frequency);

 };

};

B.2 Sample Code

<?xml version="1.0"?>

<definitions name="StockQuote"

 targetNamespace="http://example.com/stockquote.wsdl"

 xmlns:tns="http://example.com/stockquote.wsdl"

 xmlns:xsd="http://www.w3.org/2001/XMLSchema"

 xmlns:xsd1="http://example.com/stockquote/schema"

 xmlns="http://schemas.xmlsoap.org/wsdl/">

 <types>

 <schema targetNamespace="http://example.com/stockquote/schema"

 xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"

 xmlns="http://www.w3.org/2001/XMLSchema">

 <complexType name="TimePeriod">

 <all>

 <element name="startTime" type="xsd:string"/>

 <element name="endTime" type="xsd:string"/>

 </all>

 </complexType>

 <complexType name="ArrayOfFloat">

 <complexContent>

 <restriction base="soapenc:Array">