An AsmL Semantics for Dynamic Structures in UML-RT

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Motivation

$\longrightarrow$ Dynamic reconfigurations are inherent to many applications.
$\longrightarrow$ Capturing them at design time is not easy.

- the UML-RT profile supports dynamic structures:
  - runtime creation of capsules $\rightsquigarrow$ optional capsules
  - multiple containment $\rightsquigarrow$ plugin capsules
  - dynamic connections $\rightsquigarrow$ unwired ports
- a precise semantics of such concepts is needed for the formal analysis of UML-RT models

We use the AsmL specification framework to give an executable semantics to dynamic structures in UML-RT.

Abstract State Machines (ASM) and AsmL

Abstract State Machines (ASM) used for the semantics

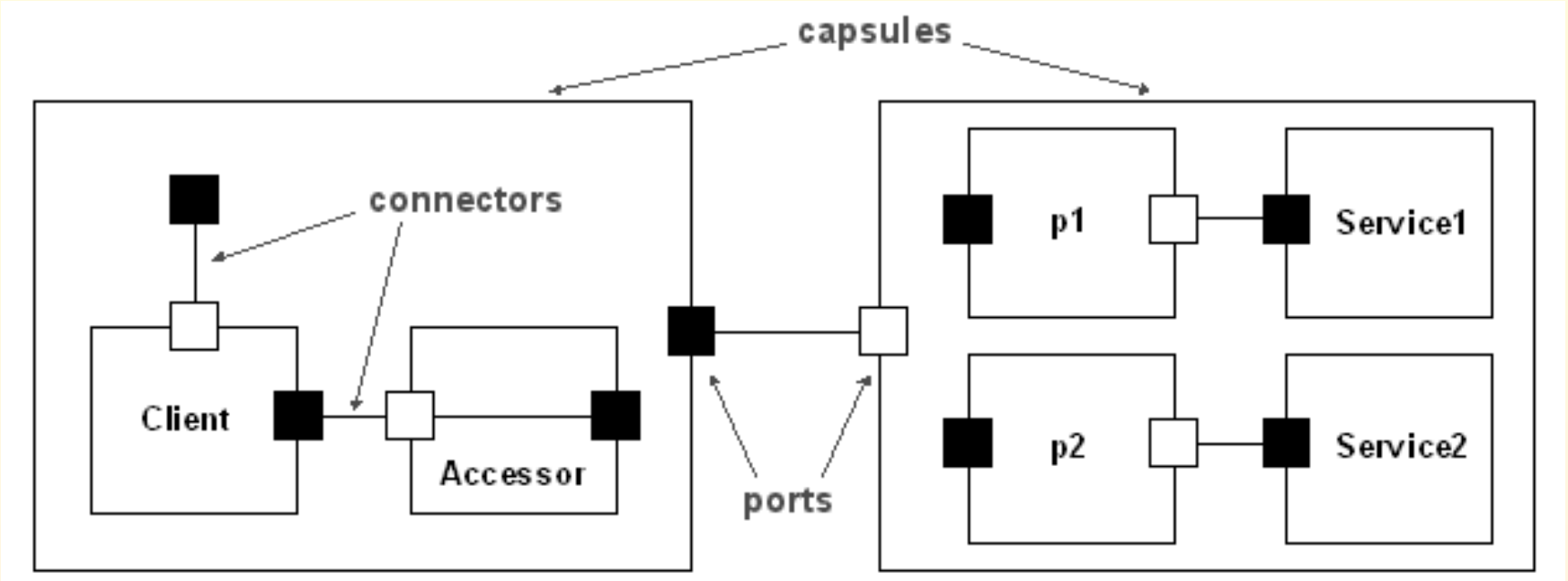
- ASMs are transitions systems with
  - → states described by sets with relations and functions
  - → transitions described by update rules
- AsmL is a specific implementation for ASMs
  - → object-oriented concepts, strong type system, tool support

An executable AsmL specification for UML-RT models:

- semantics of UML-RT specified in AsmL
- translation of a given UML-RT model into AsmL
- analysis of the AsmL specification using the SpecExplorer tool (simulation, model-checking, testing)

UML-RT and Rational Rose Real-Time

ROOM (1994) & UML (1997) $\rightsquigarrow$ UML-RT (1998)
supported by Rational Rose Real-Time



In UML 2.0
Structured Classes that may have ports and internal structure
(depicted by Composite Structures diagrams)

Ports and connectors

class Port

name as String
protocol as Protocol
isRelay as Boolean
isWired as Boolean
isPublic as Boolean
peerPort as Port or Null

class ConnectorEnd

capsuleRole as CapsuleRole or Null
port as Port

class Connector

end1 as ConnectorEnd
end2 as ConnectorEnd

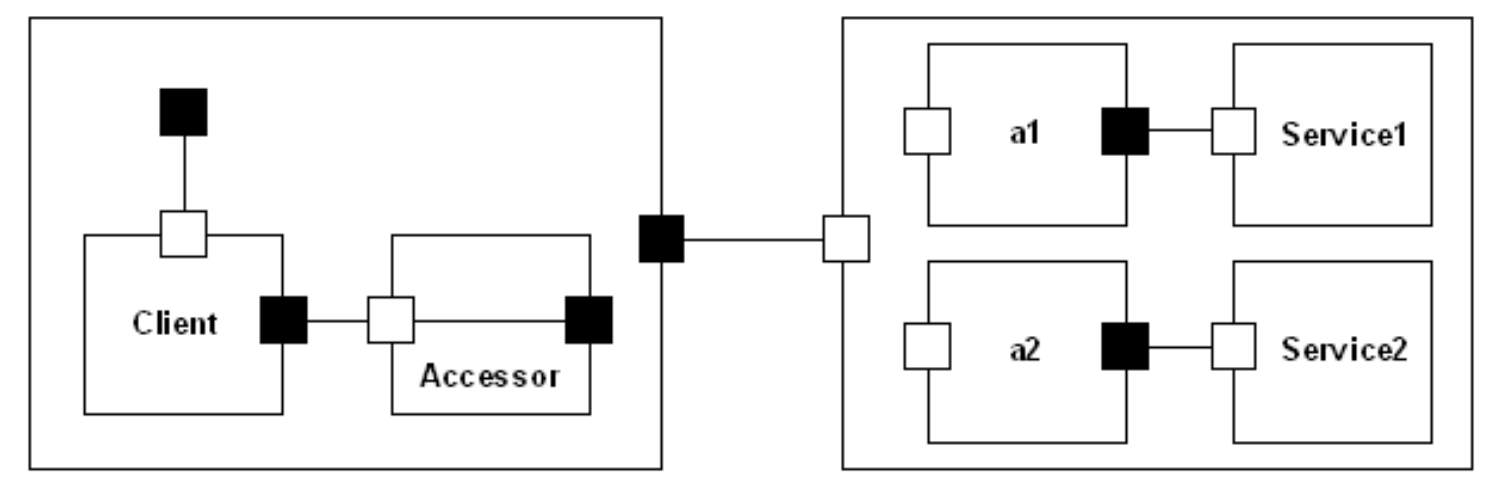
Only ports with compatible protocols can be connected.

Rose RealTime supports dynamic connections of unwired ports.

In UML 2.0

Ports and connectors were newly introduced in UML 2.0, but with a slightly more general semantics than in UML-RT.

Capsules



class CapsuleClass

name as String
super as CapsuleClass
subcapsuleRoles as Set of CapsuleRole
ports as Set of Port
connectors as Set of Connector
behaviour as StateMachine or Null

class CapsuleRole

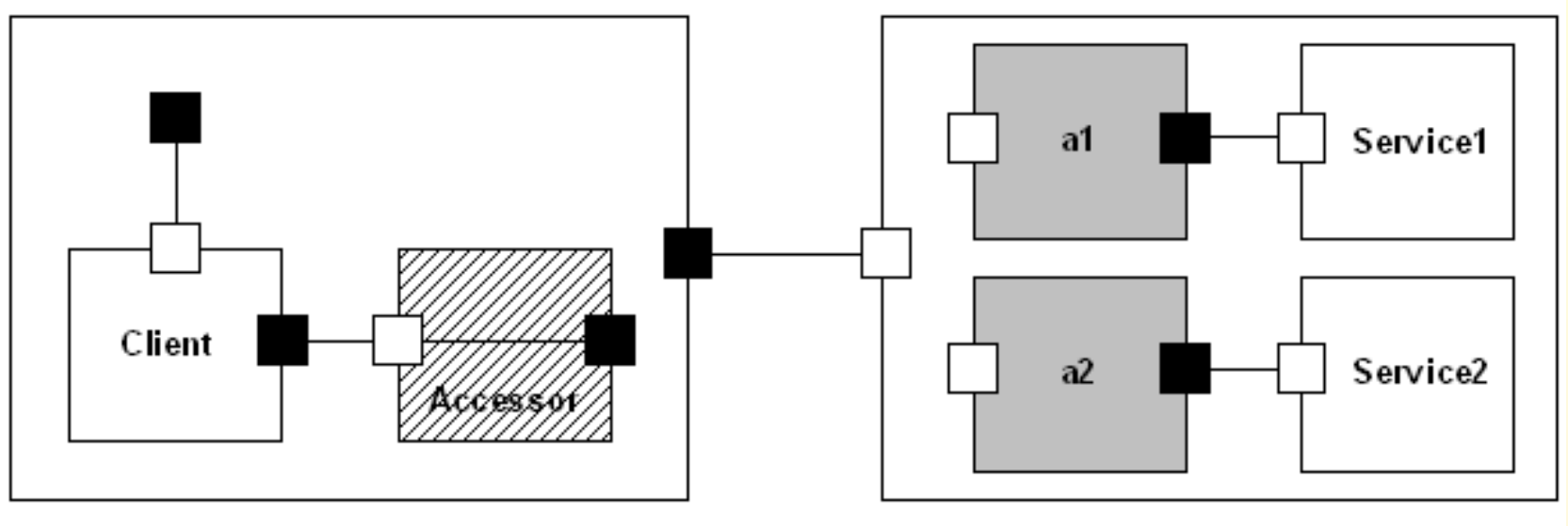
name as String
capsuleClass as CapsuleClass
parent as CapsuleRole or Null
kind as CapsuleRoleKind
isSubstitutable as Boolean
inst as CapsuleInstance or Null

class CapsuleInstance

name as String
capsuleClass as CapsuleClass
subcapsules as Set of CapsuleRole
ports as Set of Port
importedIn as Set of CapsuleRole
state as State

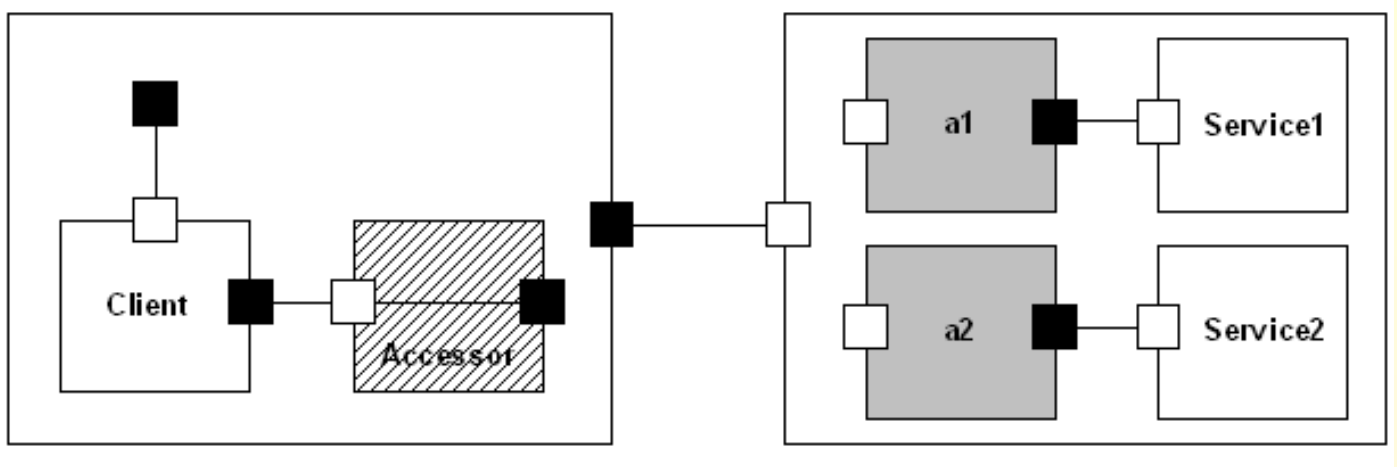
with CapsuleRoleKind $= \{$fixed_capsule, optional_capsule, plugin_capsule$\}$

Dynamic structures in UML-RT



- fixed capsule role – incarnated at initialization time of parent
  - → In **UML 2.0**: composition (*isComposite*=true)
    Graphically: nested box with solid outline
- optional capsule role – incarnated/destroyed at runtime
  - → In **UML 2.0**: composition with variable multiplicity for parts
- plugin capsule role – filled in at runtime
  - → In **UML 2.0**: aggregation (*isComposite*=false)
    Graphically: nested box with dashed outline

Capsule incarnation



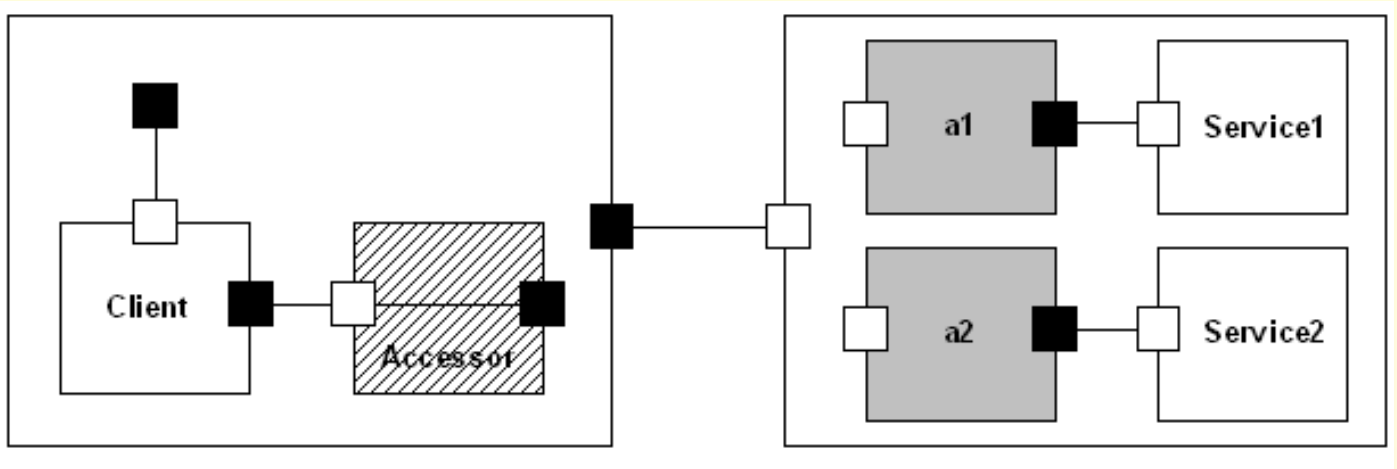
incarnate(capsuleRole as CapsuleRole)

`require` capsuleRole.inst = null

instance := `new` CapsuleInstance(...)
createSubcapsuleRoles(instance)
createPorts(instance)
incarnateAllFixedRoles(instance)
connectPorts(instance)
capsuleRole.inst = instance
`if` capsuleRole.kind = optional connectPorts(capsuleRole.parent,capsuleRole)

In Rose RealTime, optional capsules can be incarnated on different execution threads.

Capsule importation



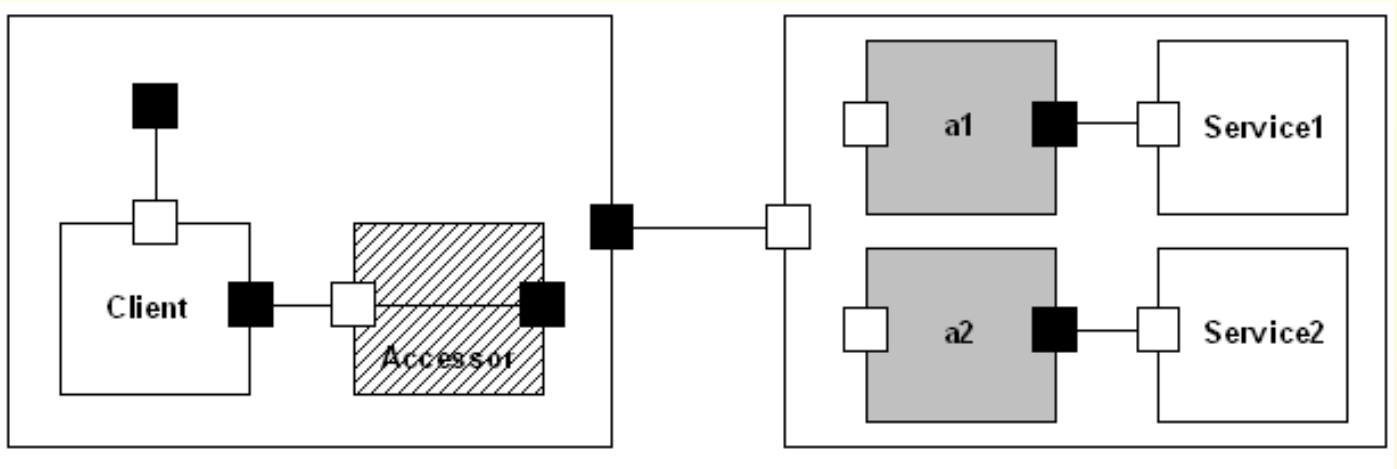
import(instance as CapsuleInstance, pluginRole as CapsuleRole)

```
require pluginRole.instance = null
require instance <> null
require compatibleCapsuleRoles(pluginRole, instance.capsuleClass)

connectPorts(pluginRole.parent, pluginRole, instance)
pluginRole.inst := instance
add pluginRole to instance.importedIn
```

Constraint: A port of the imported capsule instance cannot be simultaneously connected in two different plugin roles.

Capsule deportation and destruction



- Basically, 'undo' of importation and incarnation
- Deportation of capsule instance CI from capsule role CR:
  - → remove all connectors to CI from CR.parent
  - → remove CR from the set CI.importedIn
- Destruction of a capsule role CR:
  - → destroy connections to and in CR
  - → recursively destroy all owned fixed and optional capsules roles
  - → Semantic variation point: Destroy or keep the owned subcapsule instances that are imported in another capsule role

Next steps

- integrate the semantics of state machines and communication services (as supported by Rational Rose Realtime tool)
- analysis of generated AsmL code using SpecExplorer (simulation, testing, model checking)
- semantics for the UML 2.0 composite structures

Thank you for attention!