UML 2.0 Components and Fractal: An Analysis

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Outline

- Motivations & objectives
- UML 2.0 components: a gentle overview
  - interfaces, ports, and connectors
  - subcomponents
- Fractal components with UML 2.0
  - evaluation and mapping
- Implementation
  - modeling tool plug-in
- Conclusion

Motivations & Objectives

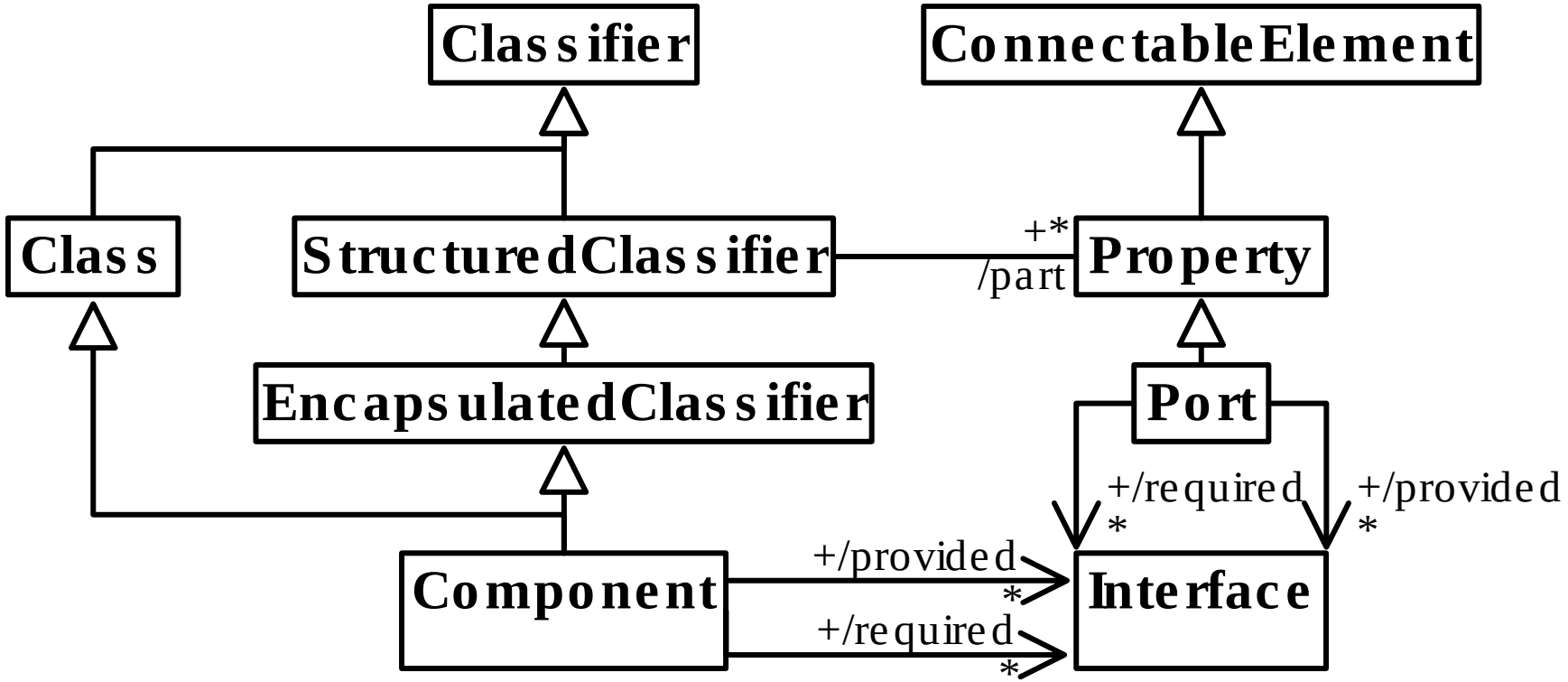
- Advanced component models exist
- UML 2.0 now has Components with
  - provided and required interfaces
  - hierarchy

  Note: UML 1.x Components were deployment/packaging units only
- Objectives
  - Analyze UML 2.0 — “does it fit the needs of advanced component models” ?
    - including “extra features” — collection interfaces, “collection subcomponents”....
  - Propose a mapping for Fractal

UML 2.0 Overview: Key Features

- Component: now “as we now it”
  - hierarchy / nested components
  - ***provided*** and ***required*** interfaces
- Key concepts:
  - StructuredClassifier
    - functionality decomposed into ***parts***
  - EncapsulatedClassifier
    - communication through Ports
  - Port
    - has provided and required Interfaces
    - has multiplicity (=> collection interfaces)
  - Component
    - combines these features

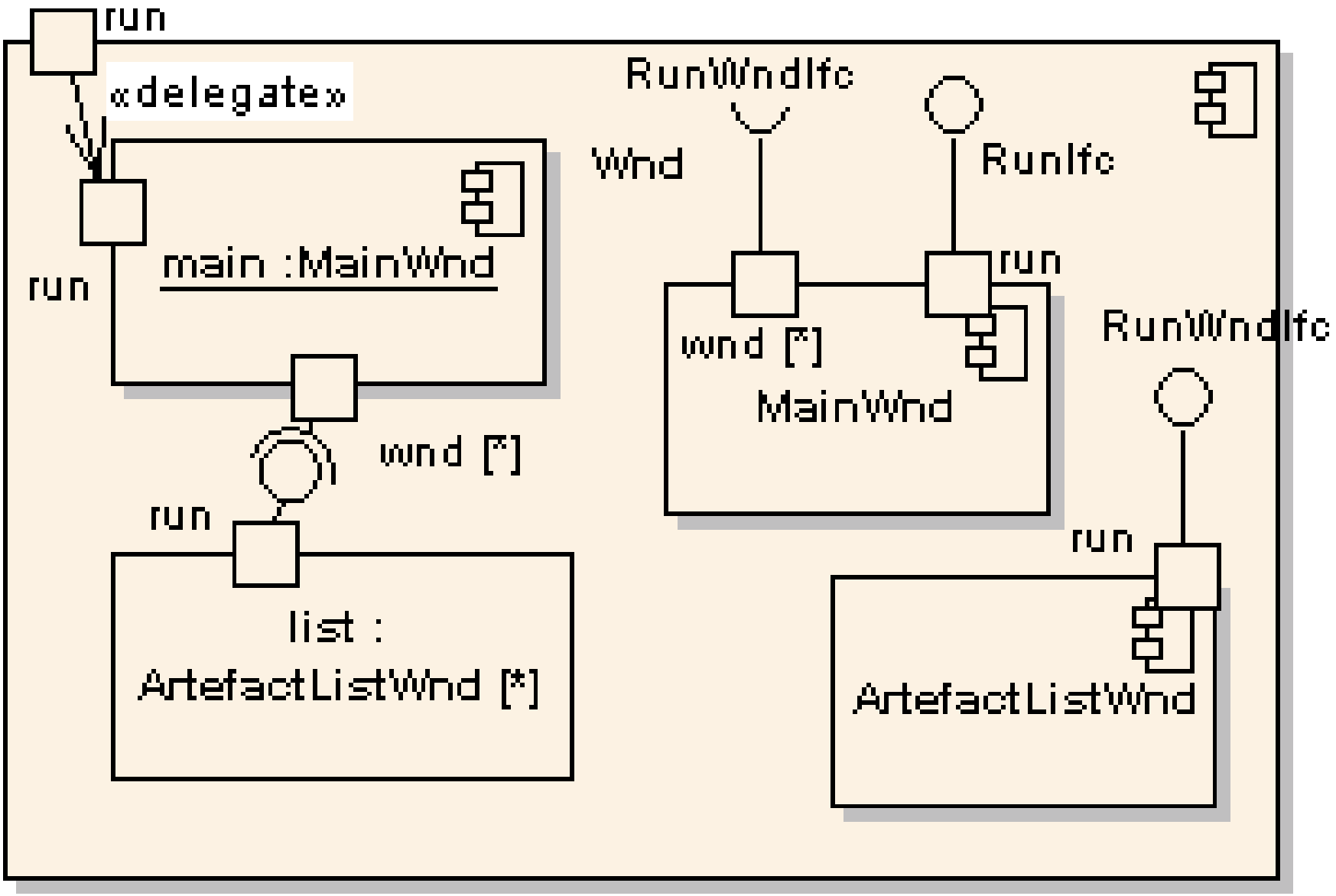
UML 2.0: Metamodel — relevant parts



Subcomponents

- Two ways to model subcomponents:
- *Containment*
  - ***Component*** is a ***NameSpace***
  - may own a ***Component***, ***InstanceSpecification***, ***Class***, ***Interface***
  - owned Component is a type definition only
    => must be accompanied with an ***InstanceSpecification***
  - ... no multiplicities
- *As* ***parts***
  - ***Component*** is a ***StructuredClassifier***
    - may own parts
      - part: has type, multiplicity

Figure: Subcomponents, Connectors ...



Connectors

Connectors ~ bindings in Fractal —

- connect provisions and requirements
  - precisely: a ConnectableElement
  - Port and Property are a ConnectableElement, Interface is not!
    - raised in UML2.0 FTF issues 7247-7251 ... postponed
- link to part (subComponent) via ***partWithPort***

- Technical problems: connector can't be linked to:
  - Interfaces
  - InstanceSpecification (nor the Ports/Interfaces of the subcomponent it represents)
- Two types of connectors
  - delegate — "vertical")
  - assembly — "horizontal"
  - can be mapped to Fractal bindings and SOFA (3 kinds)

Components: Attributes & Methods

- ***Component*** is a specialization of ***Class***

- may have attributes and methods
  - attributes — configuration parameters ("attributes, properties") of components
  - methods declarations:
    - operations directly provided in Component
    - concept used in Corba CCM

Components: Realization, Inheritance

Realization:
"*How the component type will be implemented*"

- implement directly (owned methods)
- realizing classifier
  - point to an implementing class

- a Component may inherit
  - from another Component
    - Component (type) inheritance
  - from a Class, Interface
    - exact meaning not given
    - method and attribute declarations — as if specified for the Component
    - method implementations — implicit realization

Summary

- abstractions match the needs of Fractal
  - component types
  - interfaces
  - subcomponents
  - bindings
  - attributes
  - component implementation

  - It is possibly to have a Fractal mapping ...
    ... but it is necessary to propose one!
  - Goal: cover all Fractal ADL constructs

Fractal Mapping

- Stereotype <<FractalComponent>>
  - identify components designed for Fractal
  - store tagged values
- Mapping specifics
  - we consider Java implementations of Fractal
  - and assume interface signatures and content descriptors are FQ Java class names

Fractal Mapping: Interfaces

- Interfaces: both options considered.
  - Direct Interfaces:
    - Automatically assigned unique names.
    - Mandatory interface with single cardinality.
  - Interfaces via Ports:
    - Only one interface per port.
    - Position of interface client/server.
    - Port multiplicity determines cardinality+contingency.
  - The UML Interface determining the type is mapped to a Java interface.

Fractal Mapping: Subcomponents

- Fractal specific feature: embedded subcomponent definition
  - Nested UML Component definition similar
    - but defines only component type
  - Only with InstanceSpecification has the desired meaning
    - **Mapping:** pair Component+InstanceSpecification
- Subcomponent (<component definition="...")
  - either as part or InstanceSpecification
- InstanceSpecification with path expression => shared component
- Connectors: both assembly and delegate map to bindings

Fractal Mapping (cont.)

- Attributes => component attributes
  - AttributeController interface generated as a part of mapping
    - type restrictions:
      UML must use primitive types only.
- Generalization =>
  - component inheritance
  - content class inherits from a base class + a number of interfaces
- Realization => content class selected, otherwise generated

Fractal Mapping: Behavior Specifications

- Initial simple approach:
  - tagged value BehaviorProtocol
- A ***Component*** may *own* a ***Behavior***
- Suitable metaclass ***OpaqueBehavior***
  - Attributes ***body*** and ***language*** can be mapped to new Fractal ADL **`Behavior`** element
  - Can accommodate recent as well as earlier behavior specification mechanisms for Fractal

Fractal Mapping: Implementation

- Mapping implemented as a plug-in for Enterprise Architect
  - Generates Fractal ADL + Java source code
    - Java Interfaces, Attribute Controller, skeleton of content class.
  - Possible future extension:
    - Reverse engineer Fractal ADL ...and possibly also runtime Fractal representation
    - Additional Generator for Fractlet (Fractal implementation based on Java 1.5 annotations)
    - Generate initialization code instead of ADL

Evaluation: UML vs. Fractal

- Fractal covered
  - Fractal ADL can be modeled in UML
  - partly due to flexibility of UML
  - only missing piece: component arguments
- UML not covered
  - Not everything syntactically correct in UML
    - has a meaning in Fractal
    - is legal in Fractal
    - makes sense to map
  - Part of our mapping: a number of constraints for UML models to be compliant with the mapping
    - details in Polak M.: UML 2.0 Components, Master's Thesis, Charles Univ., advisor: Vladimir Mencl, Sep 2005.
- Decisions need to be made in mappings
  - e.g., Corba CM Profile

Other Component Models: SOFA

- Two levels of component specification
  - frame, architecture

  => two stereotypes
    - <<SOFAFrame>>, <<SOFAArchitecture>>
  - architecture linked to frame via a <<realize>> dependency
  - only an architecture may contain subcomponents, and their type must be a frame
- Other minor differences
  - SOFA allows constant definitions in frames
    - mapped as readOnly attributes with an initialization value
  - Multiplicities on Ports mapped as arrays of Interfaces
  - Behavior: Only Behavior Protocols supported in SOFA

Conclusion

- UML 2.0: a lot is underspecified or unspecified
- Some flexibility intentional
  - Left up to profile or tool developers.
    - e.g., meaning of “A Component inherits from a Class”.
- Some issues not handled — metamodel does not permit some needed constructs.
  - e.g., link a ***Connector*** to ports of a subcomponent specified as an ***InstanceSpecification***
  - Tools use proprietary metamodel modifications.

    “Hacks” => Negative impact on model interchangeability
- UML very rich, a selection of constructs mapped.

Future work:

- Implementation
  - Various extensions possible.
- Propose fixes for UML
  - new model element ***ComponentInstance***
- Look at additional component models.

- References
  - Polak, M.: *UML 2.0 Components*, Master's Thesis, Charles Univ., advisor: Vladimir Mencl, Sep 2005.
  - http://nenya.ms.mff.cuni.cz/~mencl/projects/uml20components-thesis.html