CATALYSIS

Systematic Components and Frameworks with UML

Desmond D’Souza

dsouzad@acm.org

Kinetium

About the Speaker

Desmond D’Souza is founder of Kinetium. He is co-author and developer of the *CATALYSIS* method (Addison Wesley 1998), and is a respected authority and speaker at companies and conferences internationally. He was previously senior vice president of component-based development at Platinum Technology and at Computer Associates, working on methods, tools, and architectures for component-based development. He founded ICON Computing, an object and component technology methods and services company that was acquired by Platinum in 1998. Mr. D’Souza has worked with object and component technology since 1985.

Kinetium provides solutions for component-based development, modeling, and architecture. To learn more about the strategies, methods, modeling, architecture, and technology of component-based development and e-Business, you can contact Desmond at **dsouzad@acm.org**

Outline

Introduction

What problem are we setting out to address?

Components

What they are, how they interact, how to describe them

Architecture

What it is, why it is essential, how to describe it

Frameworks

The basic idea

Reuse

What it is (and is not), reuse at all levels

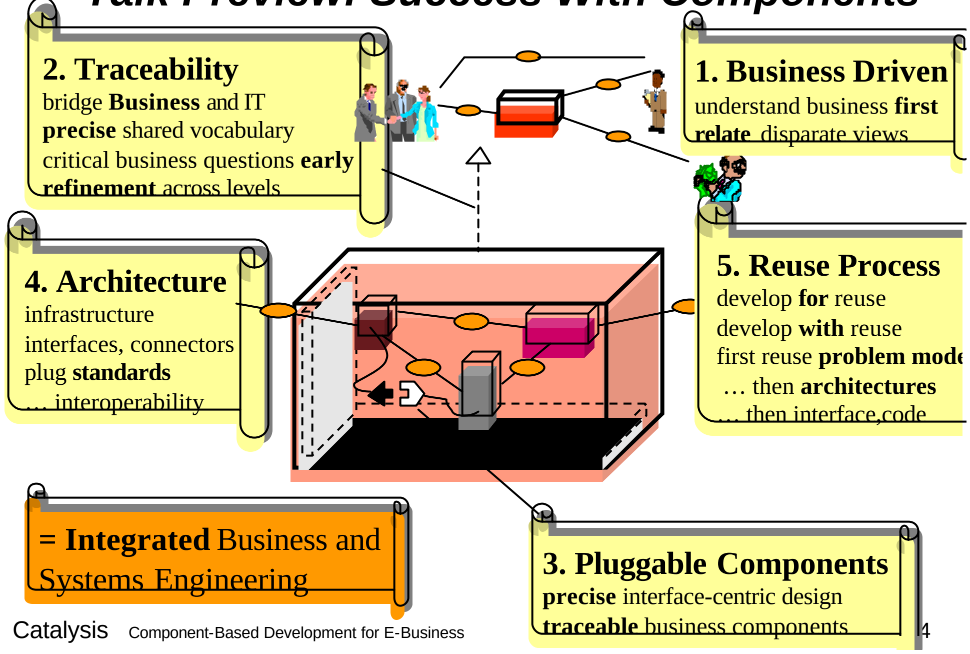
Systematic Reuse with Frameworks

Making models, designs, code reusable

Summary

Catalysis in Perspective

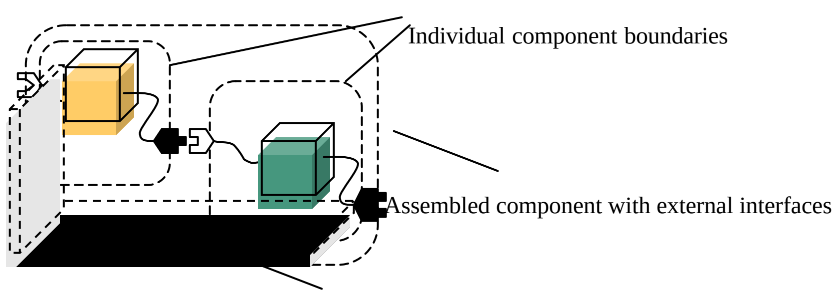
Talk Preview: Success With Components



Outline

What is a Component?

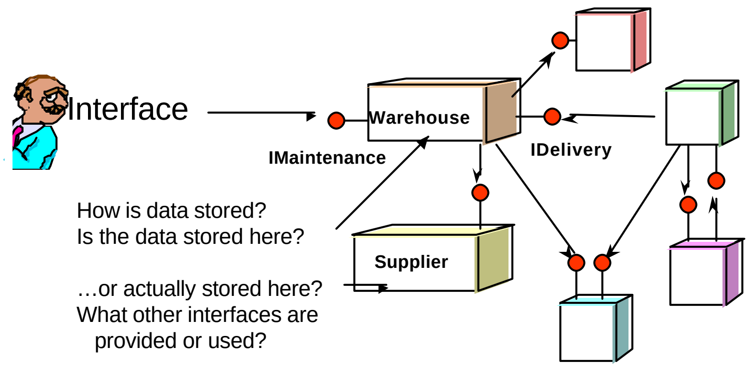
- A package of software that can be independently replaced. It both provides and requires services based on specified interfaces. It conforms to architectural standards to interoperate with others.



- Totally separate interface from implementation
- Component package can include installable, interface, specs, models, tests, docs, …
- Granularity from 1-class JavaBean to multi-tiered business component with UI, DB

How do Components Interact?

Components interact via clearly specified interfaces

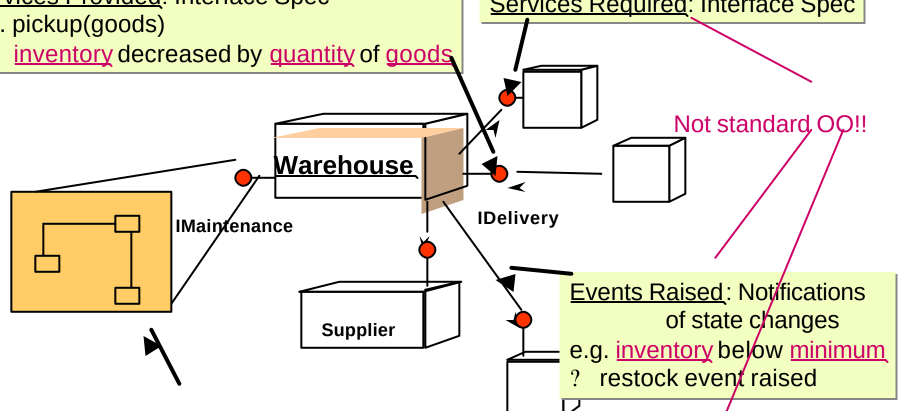


Focus on behavior; stored data, implemented procedures, other interfaces remain completely hidden from clients

Specifying a Component for its Client(s)

Services Provided: Interface Spec
e.g. pickup(goods)
? inventory decreased by quantity of goods

Services Required: Interface Spec



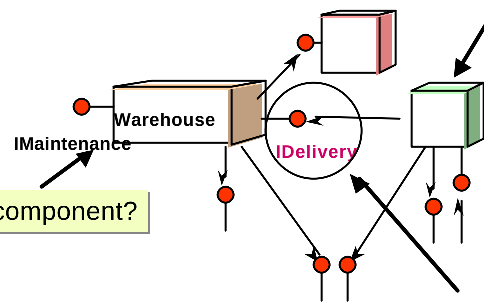
Events Raised: Notifications of state changes
e.g. inventory below minimum
? restock event raised

Logical model of component state: state attributes for each interface
The interface operations and events are specified based on this
e.g. inventory and minimum attributes used to specify restock event

Result: Precise model of information exchanged, assumptions, guarantees

Client 1: Interface Client

What does the <u>implementor</u> of <u>this</u> component need to know ...



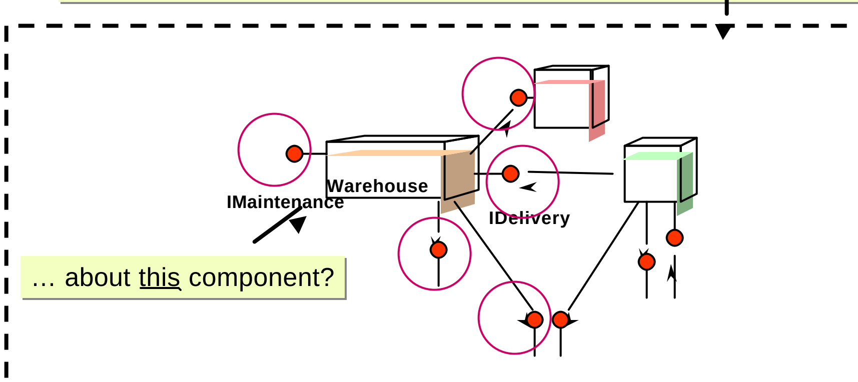
… about <u>this</u> component?

Just <u>this</u>!

A client only knows about the relevant **interface** specification
- operations, events, logical state through that interface
- each interface has its own ops, events, logical model of state
    - warehouse inventory, staffing, storage maintenance: different views

Client 2: Component Assembler

What does the <u>creator</u> of this component <u>assembly</u> need to know ...

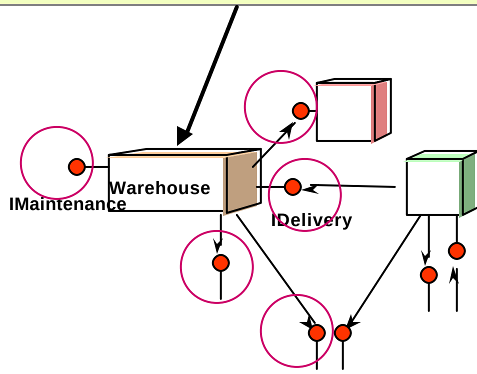


… about <u>this</u> component?

Assembler needs to know full **component specifications**
- **all** interfaces provided and required
- how the logical state models (and events, operations) are related
    e.g. storage out for maintenance ? less space available for delivery

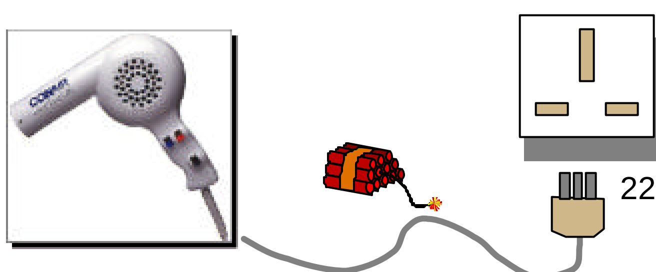
Client 3: Component Implementor

What does the implementor of this component need to know?



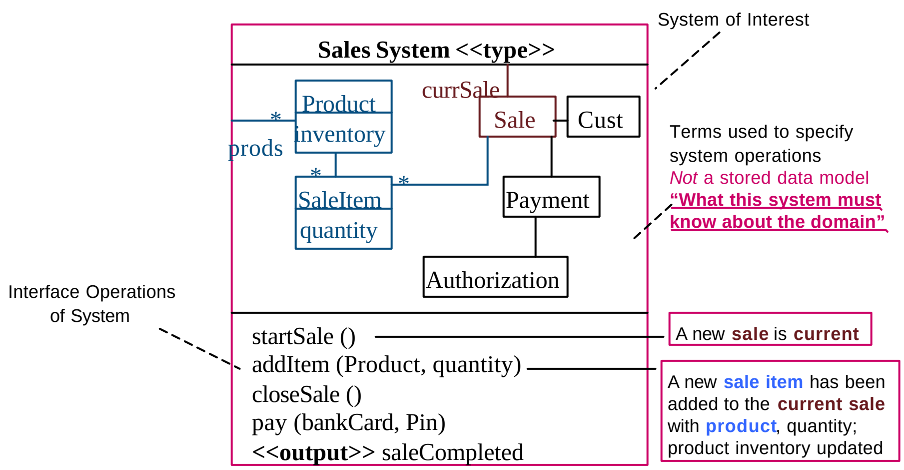
- implements all provided interfaces, assuming all required interfaces
- chooses physical state representation (or recursive assembly)
    - has additional implementation component dependencies (controversial)
- exhibits specified behavior and logical state view for each interface
- conforms to specified architecture common for these components

"Plug" together - Symmetry and Caution



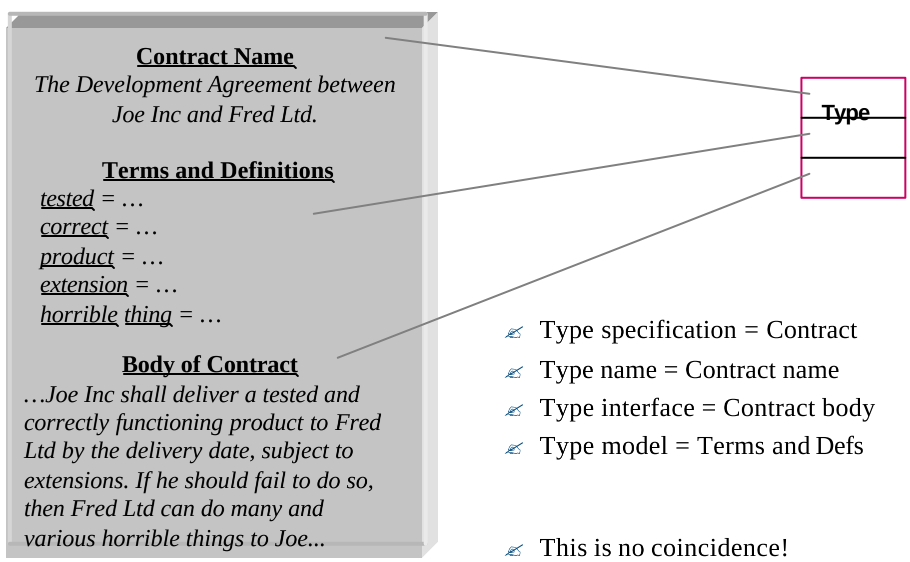
- "Plugging-in" parts will only work if the two ends are compatible
    - Client must specify *required* behavior
    - Implementor must specify *provided* behavior
- Needs a *symmetrical, precise, black-box* view of every component
    - We want to "plug" together even dynamically, in cyberspace !
- Need some *shared standards* for connecting plugs to sockets

Type = *Precision in Interface Specs*



Note: Behavior Specs can be made precise using UML/Object Constraint Language (OCL)

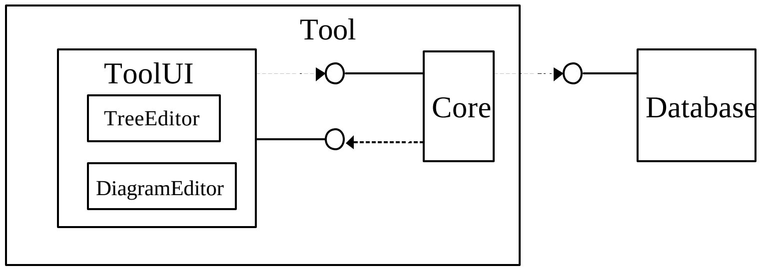
Software Interface as Contract



- Type specification = Contract
- Type name = Contract name
- Type interface = Contract body
- Type model = Terms and Defs

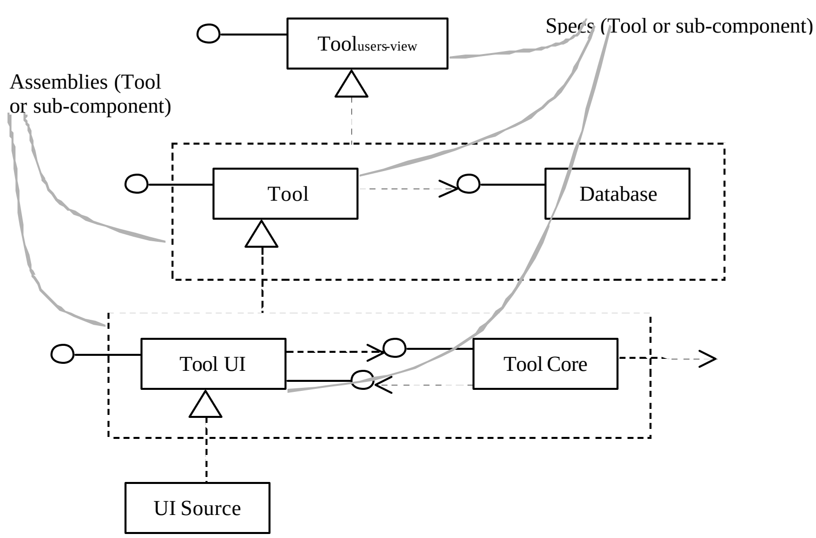
- This is no coincidence!

Different Aspects of a Component - I

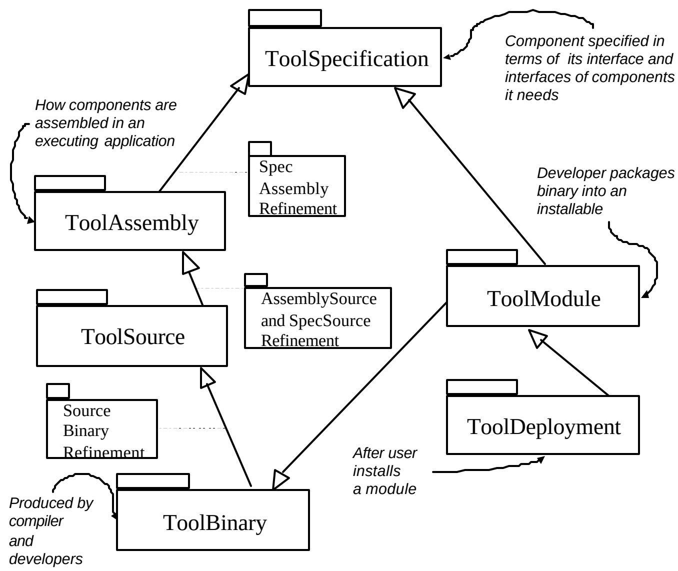


- From Catalysis-based component standard with Microsoft / MDC
  - www.mdcinfo.com

Different Aspects of a Component - II



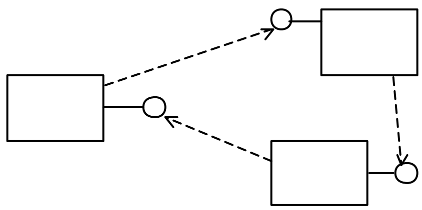
Different Aspects of a Component - III



Different Aspects of a Component - IV

- **Component** - full-lifecycle includes black-box spec, assembly of sub-components, source, binary, installable module, deployment
  - Component Specification - a component specified as a collection of ports. This style of specification is suitable for assembling the component with other components to produce a larger component
  - Component Assembly - a static configuration of components, whose ports are wired together with connectors
  - Component Source - defines the lowest level manually created “source” code for a component that will be related to its compiled form
  - Component Binary - the installable, executable binary for a component (e.g., class file bytecodes for a JavaBeans component). Binaries
  - Component Module - packaged installable collection of binaries and other needed parts
  - Component Deployment - deployed, registered, and ready for discover and instantiation
  - Component Architecture - rules and constructs applicable at each of these levels

Summary - Components



- Interface centric, collaboration patterns
- Symmetrical, precise, black box views
- Refinement - separate interface from implementation
- Full-lifecycle component model - specification, design/assembly, module, deployment

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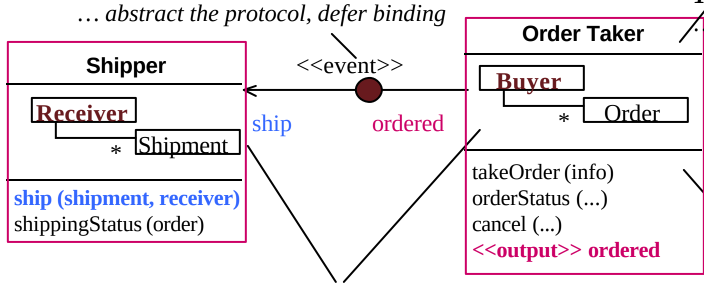
Catalysis in Perspective

Modeling Business Components

- Assembling many configurations from kit of parts demands
  - abstract parts, abstract connections, multiple views and “plug” precision

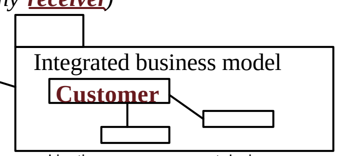
2. Higher-level late-bound connectors and properties
… abstract the protocol, defer binding

1. Higher-level parts
… abstract the objects

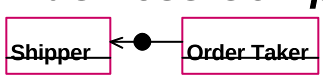


4. Precise interfaces for 3rd party assembly

3. Separate views of ***customer*** *for flexibility (can ship to any* ***receiver****)*
- *must integrate in conceptual models*
- *must integrate data in implementation*
  - *shared objects with multiple interfaces*
  - *federated data + cross-component links*

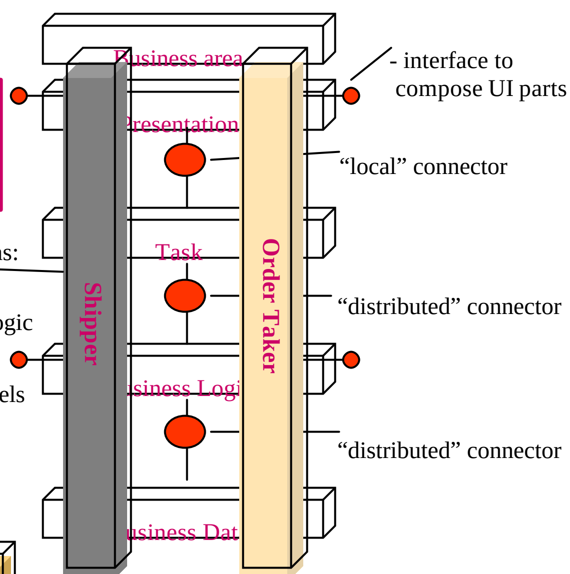


Business Components - Tiered Architecture

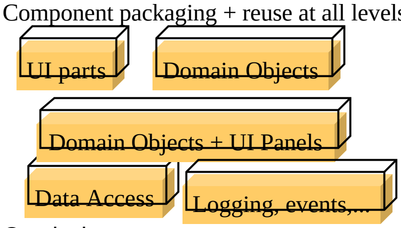


Zoom in to architectural tiers and corresponding interfaces, or **zoom out** to model abstract business components and connectors

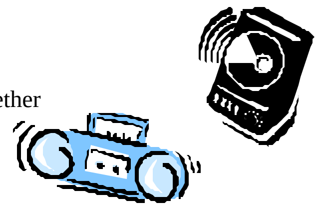
Can package application components as:
- vertical slice
- interfaces to connect Business Logic



Component packaging + reuse at all levels



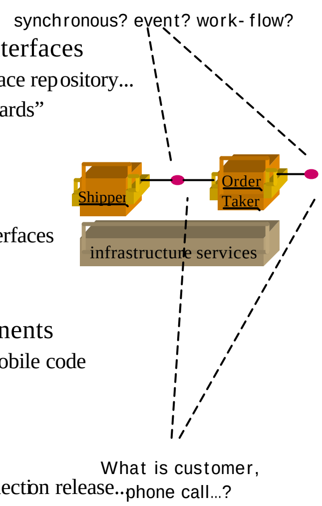
Component "Kits"



- Components are never stand-alone
  - Only meaningful in collections that work well together
    - A component "Kit"
- But the parts must work together in many assemblies
  - Can only happen if they interoperate at the appropriate levels
- And each part must be itself flexibly and adaptable
  - … often by configuring its smaller-grained "components"
- **So, a component kit is a (potentially open-ended) set of parts built on a coherent architecture**

Components without Architecture = Failure!

- For separately built components to work together they **must** share…
- Standard "horizontal" infrastructure services and interfaces
  - transactions, security, directory, request broker, interface repository...
  - OMG, Microsoft rapidly defining many global "standards"
- Standard "vertical" models of domain concepts
  - What is a "Customer", "Phone Call", "Order", etc.
    - components must use same "domain language" at interfaces
  - OMG defines "Vertical" architectures standards as well
- Standard "connector" mechanisms between components
  - Synchronous / asynchronous message, event, workflow, mobile code
  - Location transparency: CORBA, DCOM
- Other architecture standards
  - Architectural tiers, implicit context passing, lock and connection release..



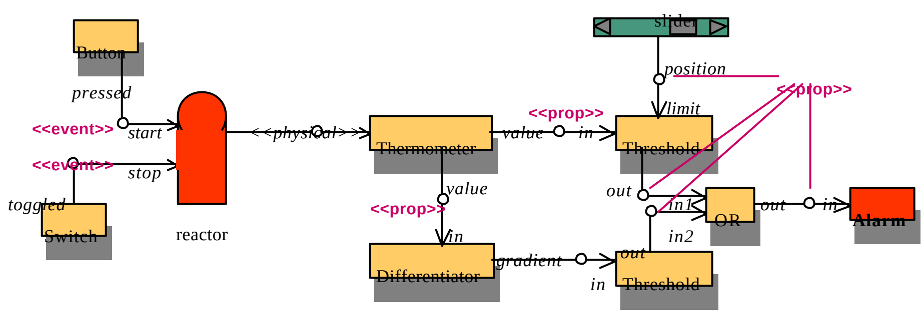
What is Architecture?

The set of principles and decisions, rules, or patterns about **any** system that keep its designers from exercising **needless creativity**

- Desmond D’Souza

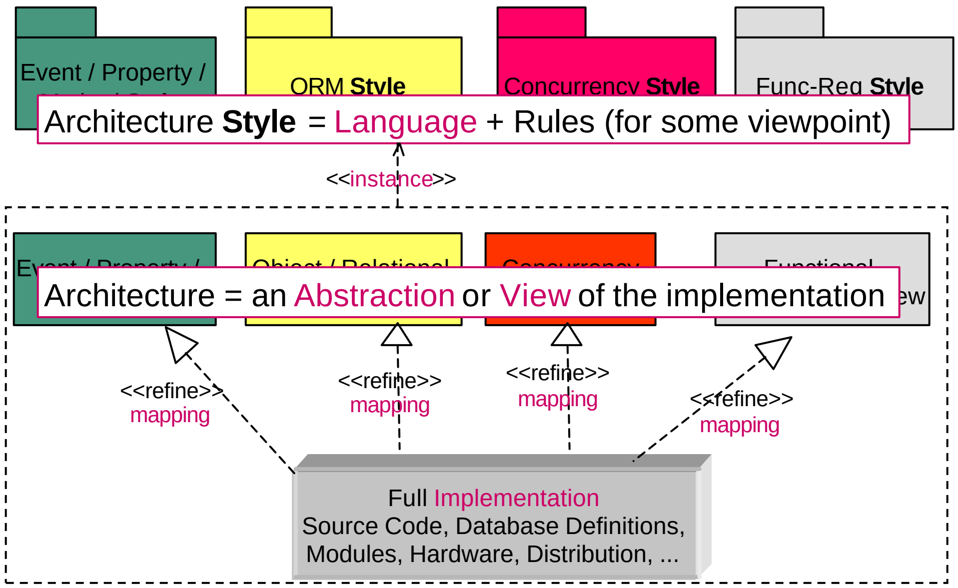
- It is not about any specific size, scale, domain, or infrastructure
- Can range from “*3-tier C/S*” to “*use Corba OTS*” to “*get/set method name rule*”
- Includes business architectures: *“all operations support are geographically centralized”* or *“record client company information at first client inquiry”*
- Based upon ***Frameworks***

Is This an “Architecture”?



- This is an abstract view of the implementation
  - It uses the language of properties, events, methods
    - … and of connectors between these “connection points”
  - It has a mapping to Java code patterns i.e. a refinement
- This design is an instance of the Java Beans style: design + code

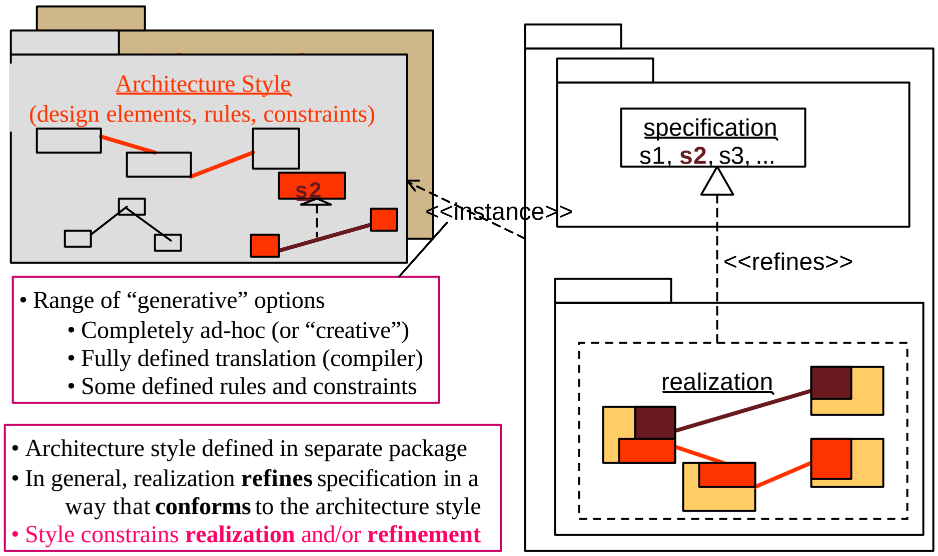
***Architecture as** View **based on** Style*



Varying Degree of Generative Style

- Architectural styles to keep 2 attributes in sync
  - Style 0: “The Cowboy” - do it any way you want
  - Style 1: “2 copies + update protocol” construct defined, use at will
  - Style 2: “1 copy in shared memory” construct defined, use at will
  - Style 3: both Style 1 and Style 2 available, choose at will
  - Style 4: *Whenever* you have a **requirement** to keep 2 attributes in sync with each other *across a distribution boundary with infrequent updates,* **use** the “2 copies + update protocol” **design**

Catalysis - Architecture Style in UML



- Range of "generative" options
  - Completely ad-hoc (or "creative")
  - Fully defined translation (compiler)
  - Some defined rules and constraints

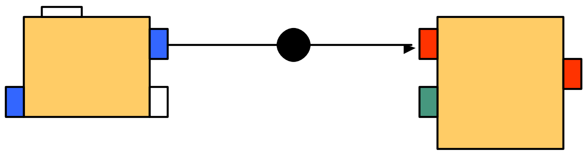
- Architecture style defined in separate package
- In general, realization **refines** specification in a way that **conforms** to the architecture style
- Style constrains **realization** and/or **refinement**

Summary - Architecture

- … it limits needless creativity
- Wide range:

  0% (cowboy)………………….. 100% (compiler)
- Architecture defines / uses specific constructs, language, patterns, rules
- Architecture definition sharable across projects

Summary - Component Architecture



- Connectors couple Ports (connection points) of Components
  - Connector abstracts interaction protocol and intermediaries
  - Port abstracts internal structure as connection point
  - Architecture style defines set of port / connector types
- Ports and connectors provide a thinking / design-time tool
  - Implementation is considerably more complex
- Dynamic run-time assembly requires objectified port / connector
  - Alternately, some form of reflective access to components
- Frameworks provide succinct application of all the above

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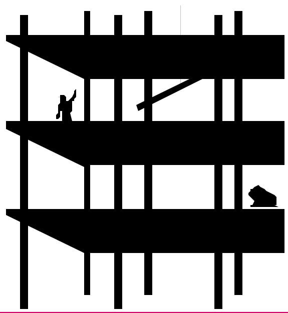
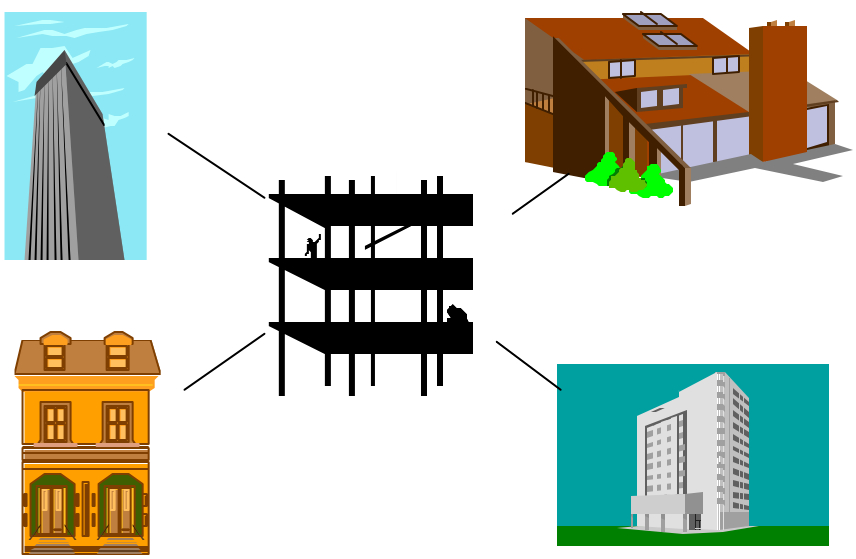
A Framework is a Skeletal Solution

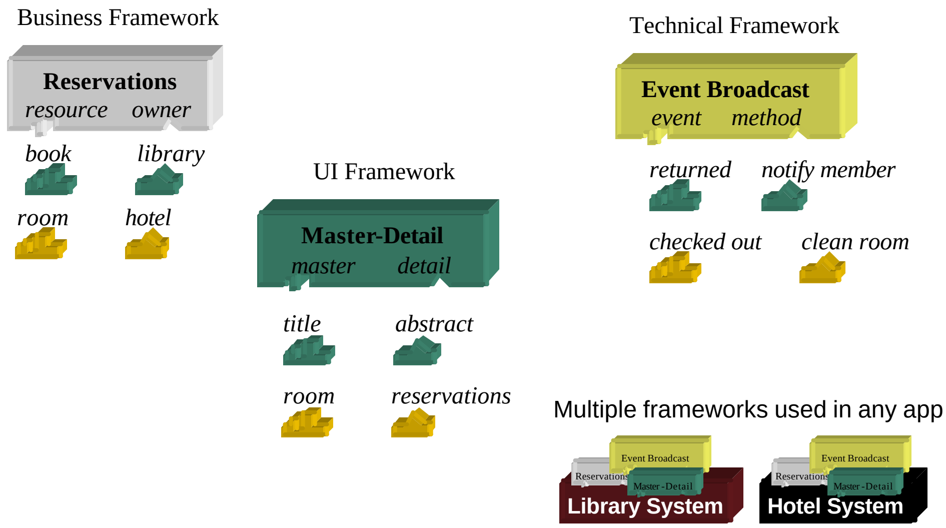


- Framework defines overall structure of parts and relationships
    - trusses, beams, floor, how can they fit together, rules
  - but some specifics are deferred
    - number of floors, layout, wall placement, windows, doors
- You "plug-in" the specifics when "instantiating" the framework
  - subject to constraints the framework imposes on the bits you plug in
- A framework helps define and enforce some aspect of architecture

Many Variants by Framework "Plug-In"s



Framework Concept at All Levels



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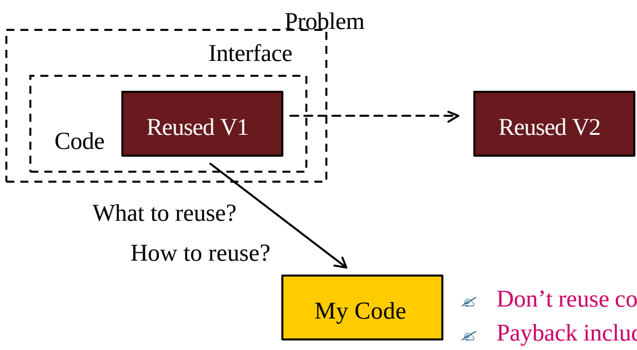
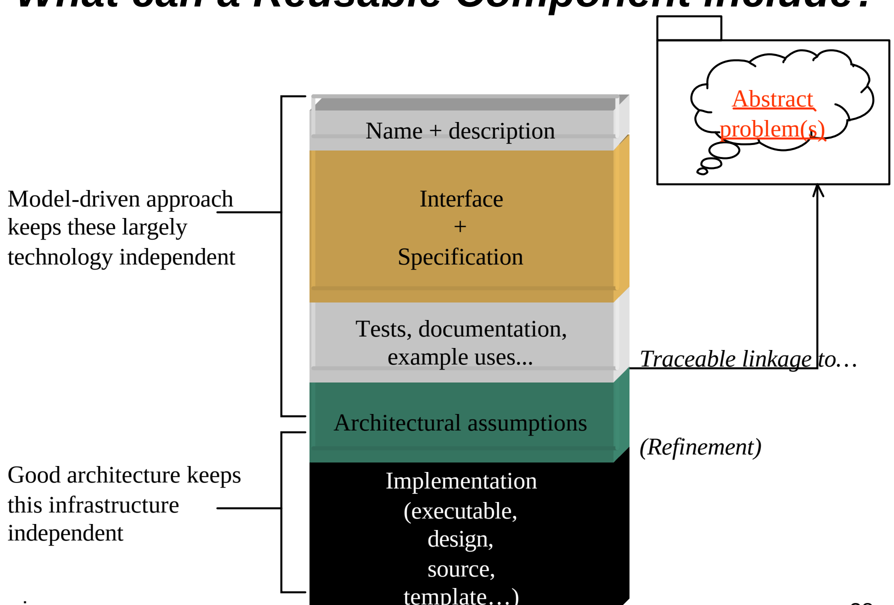
What is Reuse?



- Don't reuse code without spec
- Payback includes specs, architecture, … code

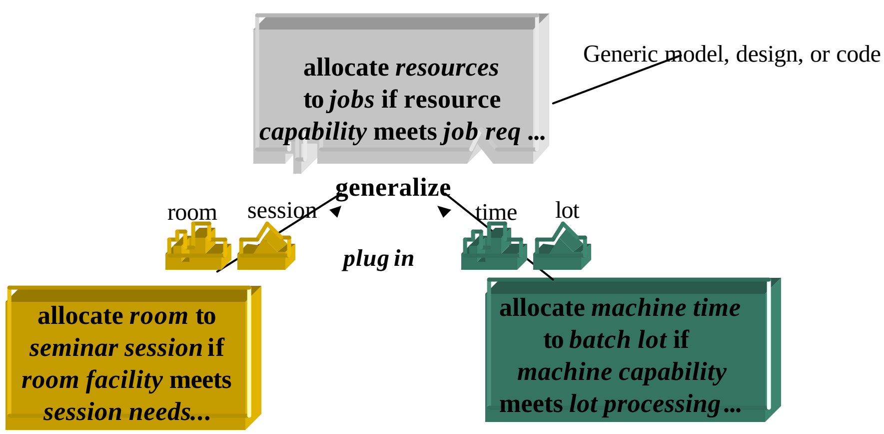
- What to reuse:
  - Code
  - Interfaces
  - Designs
  - Problem Domain Models
- How to reuse:
  - Cut and paste
  - White-box inheritance
  - Black-box composition
  - Code-generation

What can a Reusable Component include?



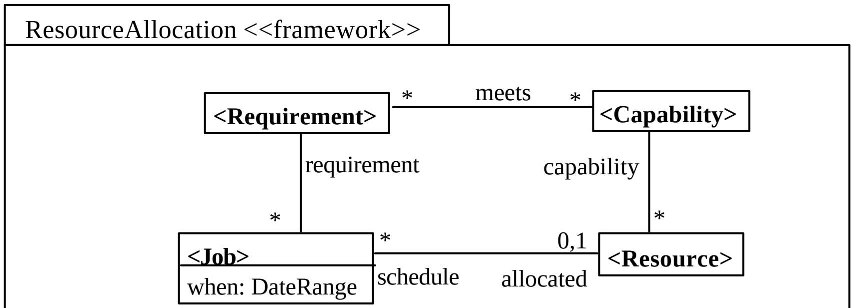
Outline

Model Frameworks - Generic Models



- A generic model / design / implementation component whose
  - Defines the broad generic structure and behavior
  - Provides *plug-points* for adaptation
- **Reuse starts with commonality in problems themselves!**

Resource Allocation Framework



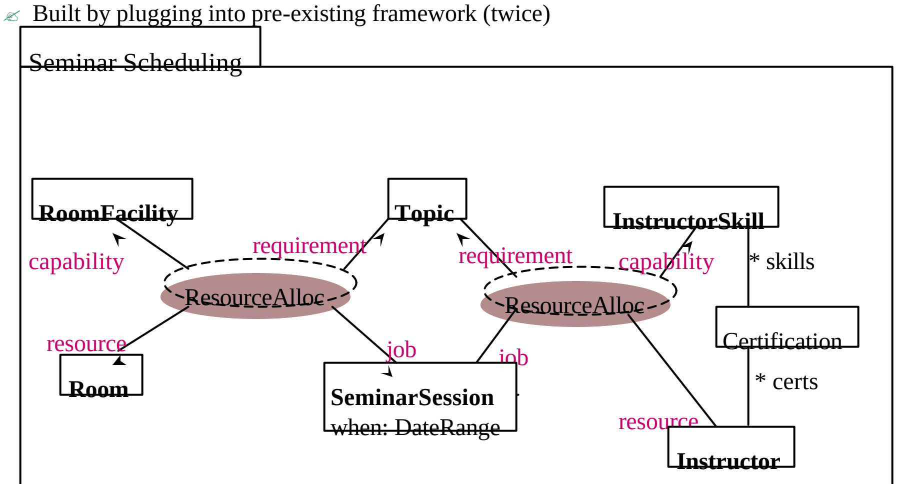
invariants

Job:: //only allocate resource whose capability matches requirements
allocated <> nil **implies** allocated.capability.meets **->includes** (self.requirement)

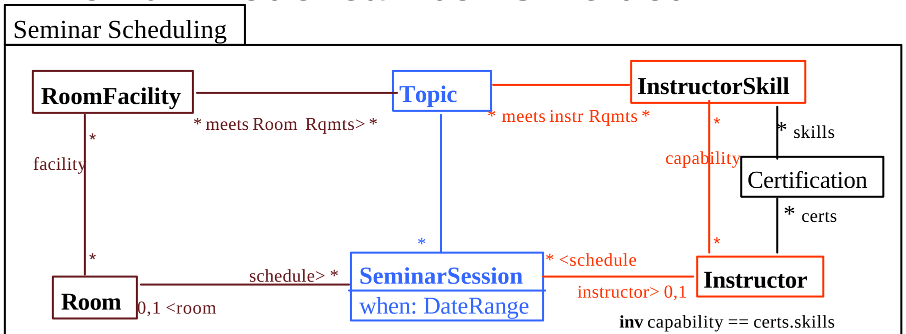
Resource:: // resource not double-booked: its jobs dates do not overlap
schedule->**forAll** (j,k | j <> k **implies not** j.when.overlaps(k.when))

"Applying" frameworks to build a Model

- Built by plugging into pre-existing framework (twice)



The Full Model can be “Unfolded”



SeminarSession:: //only allocate suitable instructors and rooms
instructor <> nil **implies** instructor.capability.meets instr Rqmts **->includes** (topic)
room <> nil **implies** room.facility.meets Room Rqmts **->includes** (topic)

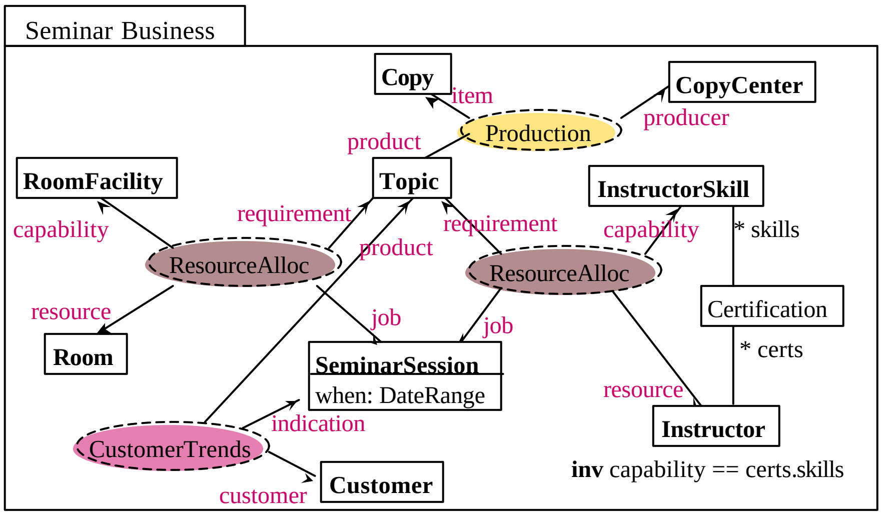
Room:: // room not double-booked: its session dates do not overlap
schedule->**forAll** (j,k | j <> k **implies not** j.when.overlaps(k.when))
Instructor:: // instructor not double-booked: its session dates do not overlap
schedule->**forAll** (j,k | j <> k **implies not** j.when.overlaps(k.when))

Some Business Model Frameworks

- **Resource Allocation**
  - *Assign a resource to a job if the resource capability meets the job requirement, watching for overbooking*
- **Customer Trends**
  - *Track a customer’s preferences for different products by monitoring how frequently he/she has indicated an interest in that product (e.g. by purchasing, calling, requesting samples, …)*
- **Production and Inventory**
  - *Manage just-in-time inventory of some products by tracking the number of items of that product in inventory, and placing an order for the production facility when inventory drops below some threshold*
- Note: these could be used in very different combinations

A Complete Seminar Business Model

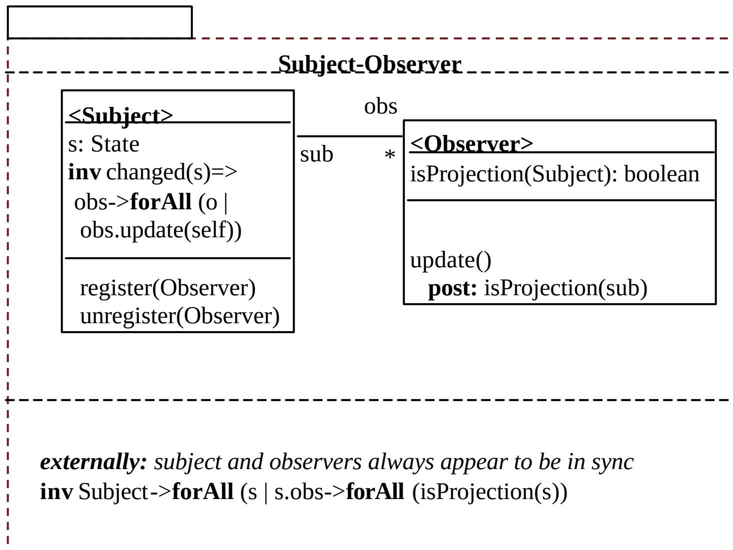
- Built by specializing three different pre-existing model frameworks



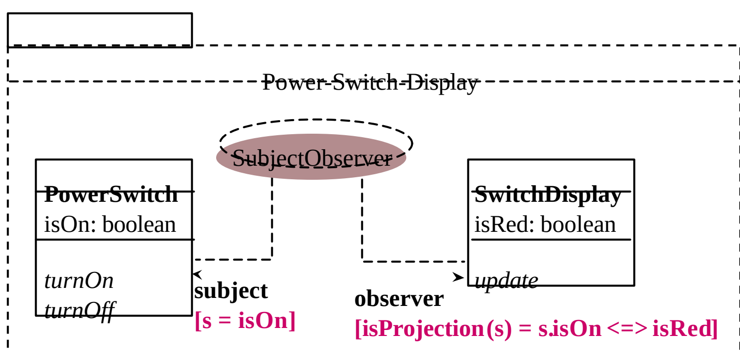
Range of Frameworks

- Systematic Reuse with Frameworks
  - Domain Models
  - Design Patterns
  - Abstract and Concrete frameworks via Refinement
  - Architectural Connectors
  - JavaBeans Frameworks
  - Layered Frameworks - Fundamentals to Domains

Design Patterns as Frameworks

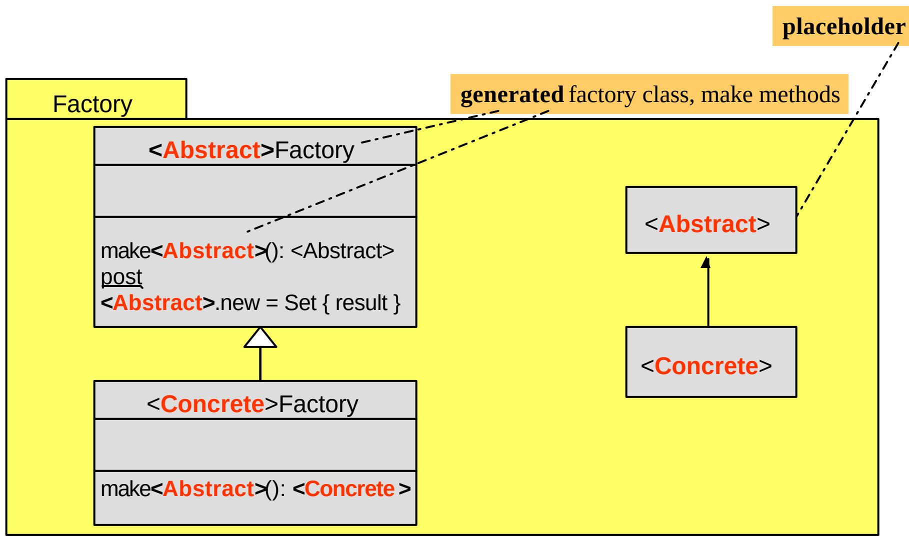


Applying Design Patterns

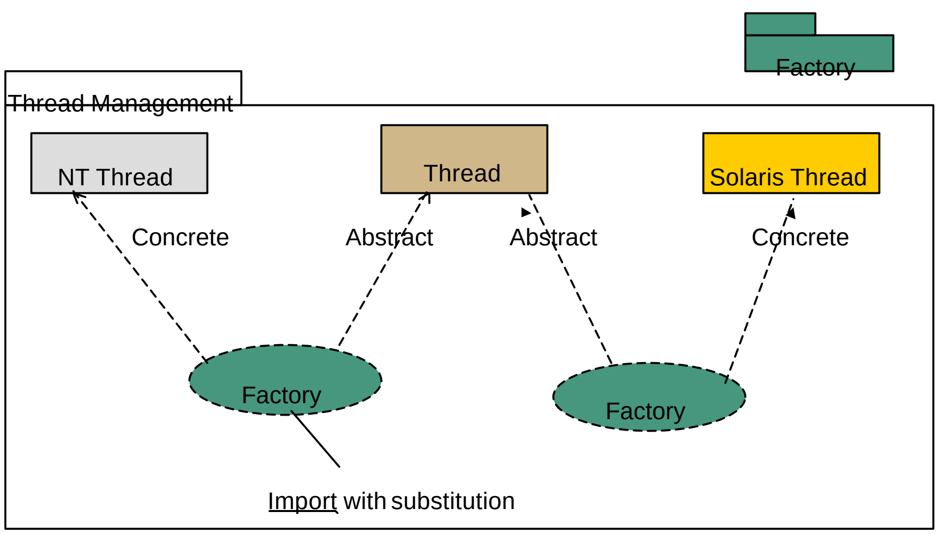


- Application defines mappings of types, attributes, actions

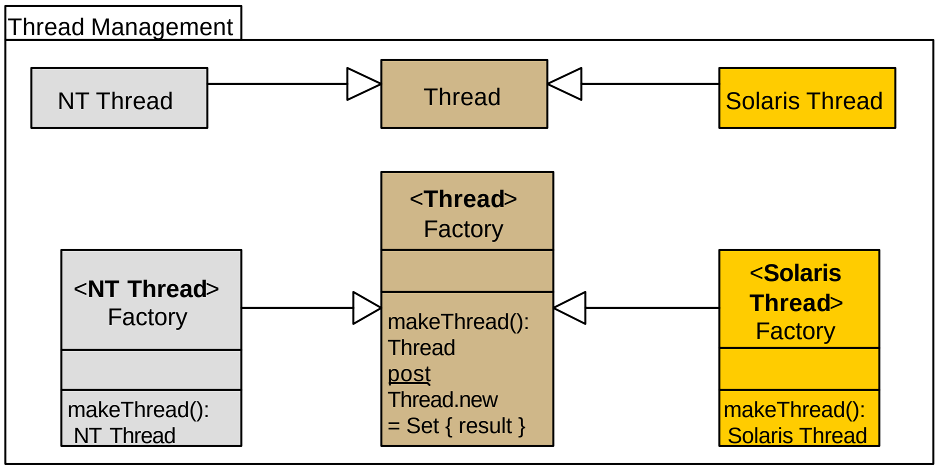
Factory Pattern : Generative Aspects



Applying Factory Framework

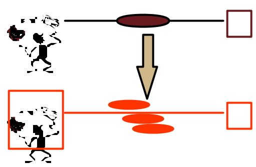


The Model is Automatically Generated

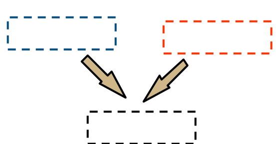


Frameworks: Two More Dimensions

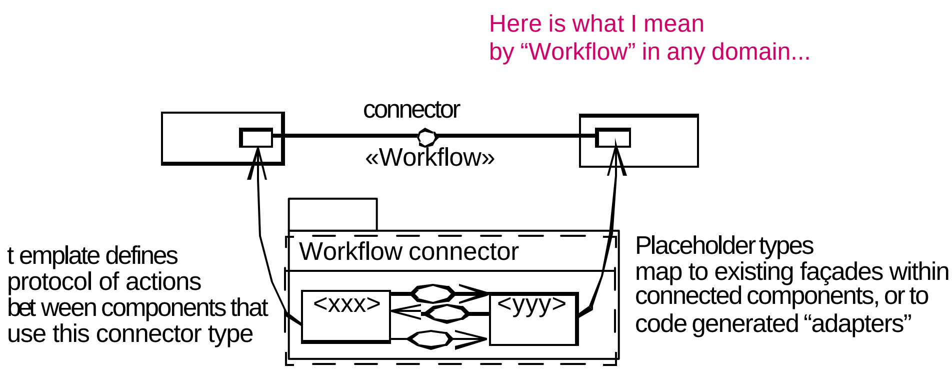
- Frameworks can be described at different levels of *refinement*



- Frameworks themselves are *composed* of smaller frameworks



Framework for Architectural Connector

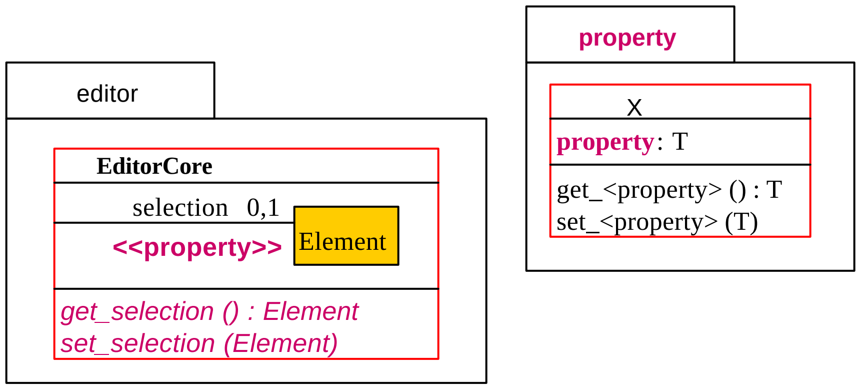


- A connector abstracts some interaction protocol
- Connector is used by “plugging” into that framework
- Different “connector” frameworks: workflow, events, properties

Summary - Generative Architecture

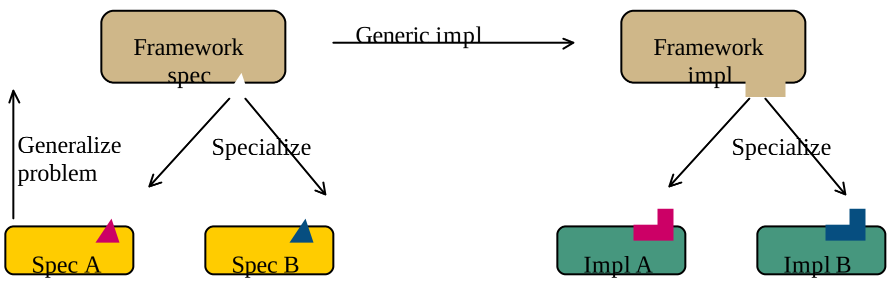
- Architectural style defines language and rules for valid realizations of some specification
  - Style = Set of <spec, realization, refinement>
- Style either defined as constraint or “generative”
- Generative style = construct + its realization pattern
- **Frameworks** capture any model pattern
  - Framework is a package
  - Pattern application is import + substitute

Framework for JavaBean <<property>>



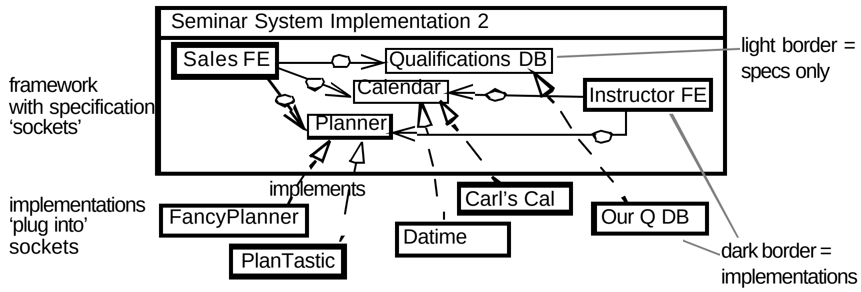
- <<property>> stereotype means a read-write accessor
- Stereotype implies import with substitution
  - import **property** [X \ EditorCore, property\selection, T\Element]

Implementation Frameworks



- Frameworks can include both models and implementations
- An implementation framework configures a particular set of code components to realize a particular model framework
- Like any framework, it leaves some code "plug-points" for customization - via delegation, sub-classing, code-generation…

Component Framework: Seminar System



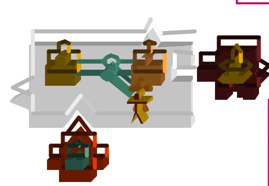
- Partial implementation with specs of the missing pieces

Framework for Architectures - All Levels

Business Models
Barter
Trader
Authorizer

Domain Models
Resource Allocation
Account Settlement
User-Interface Patterns

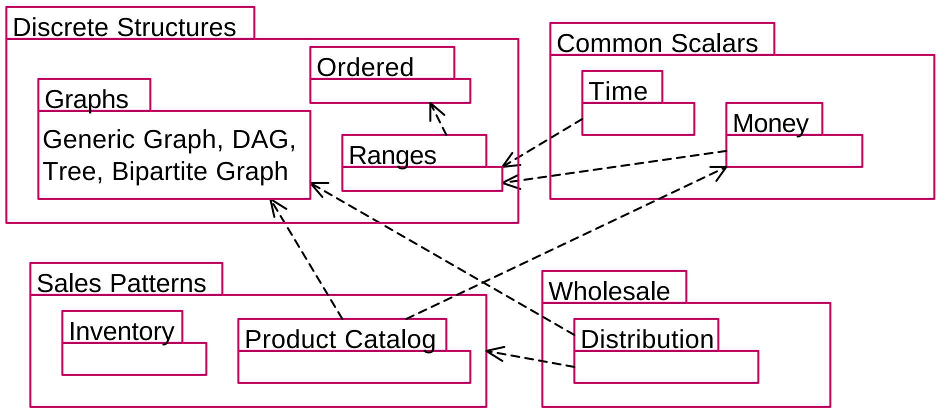
Design Patterns
Corba-CGI Gateway
Data Marshalling
Thread Pooling
Subject-Observer
2-Way Link
Moving Window



Fundamentals
Total Ordering
Groups
Range
Descriptors

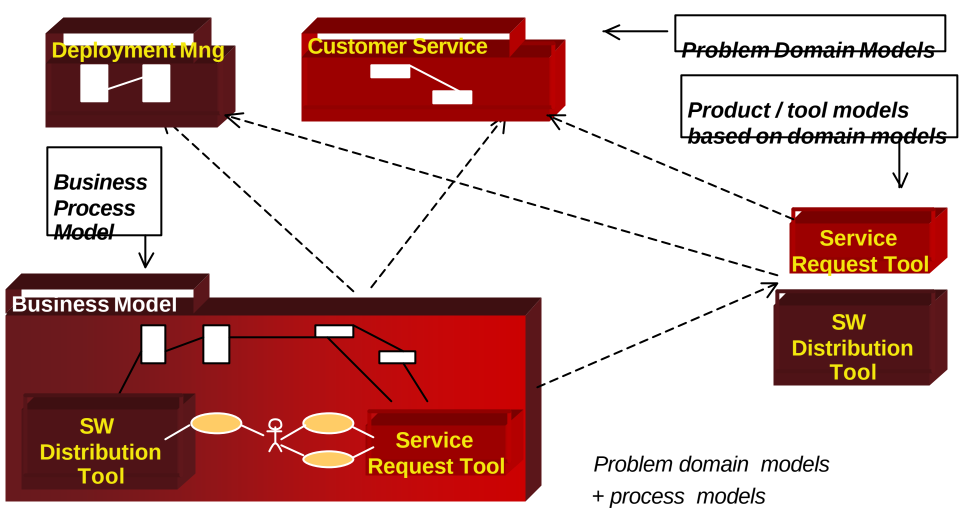
- Constructive approach to modeling and design with full traceability
- Libraries and commerce of frameworks of models, designs, and code

The Vision of Layered Frameworks



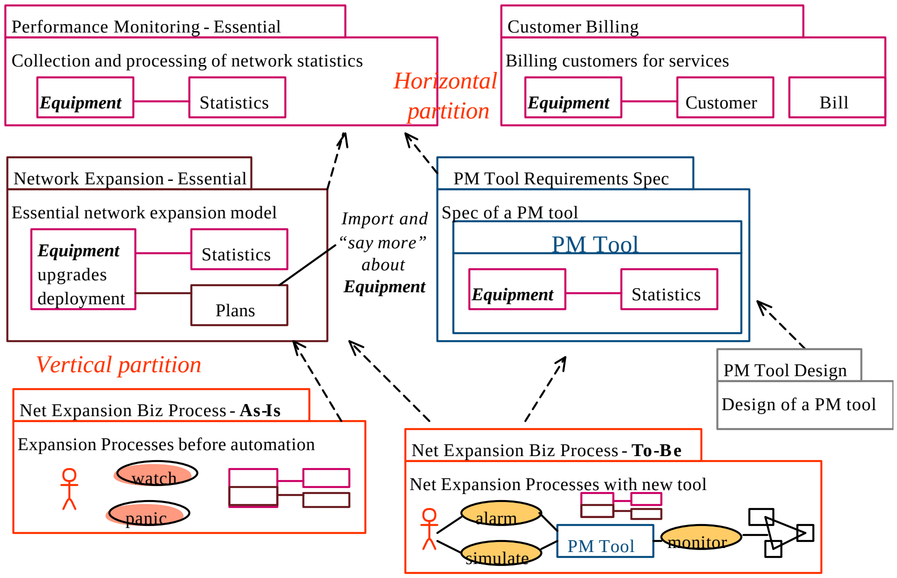
- Layered frameworks - fundamentals to domain-specific
- Example of Catalysis frameworks in business
  - **CBOP** (Consortium of Business Object Promotion), Japan
  - Business Domains: Wholesale sales, Financial Accounting

Problem Domain to Business Solution

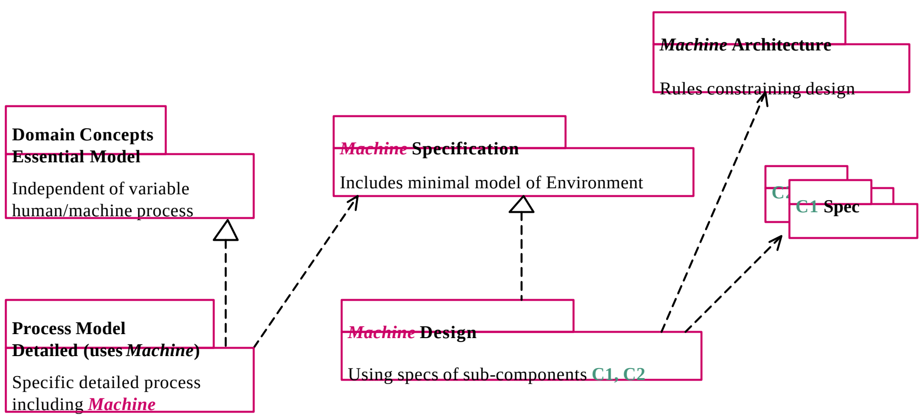


Problem domain models
+ process models
+ product models
= Business Solution Model

Enterprise Models - Package Partitions



Domain, Process, and Machine

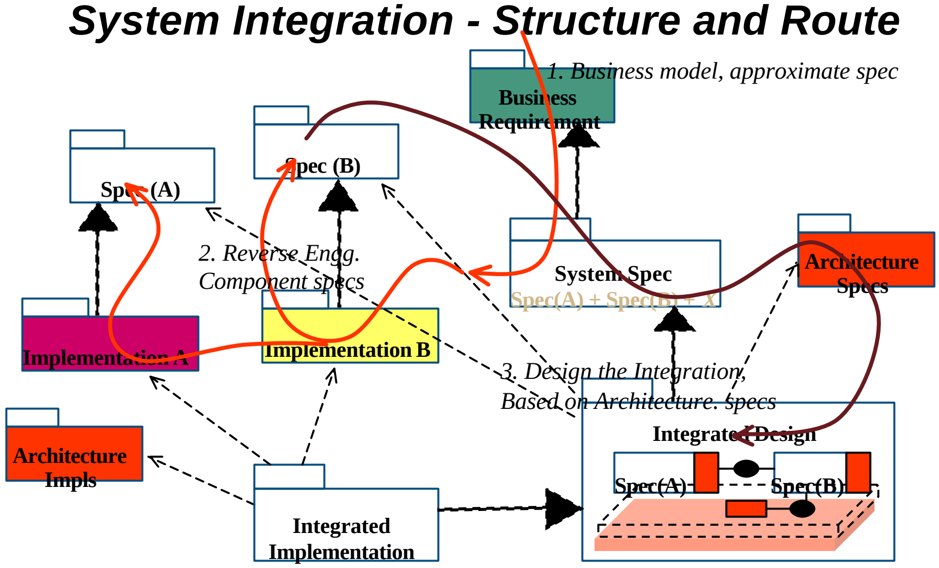


- Uniform structure of specification, refinement, architecture
- Clear separation of specification, implementation, usage

Component and Enterprise Similarities

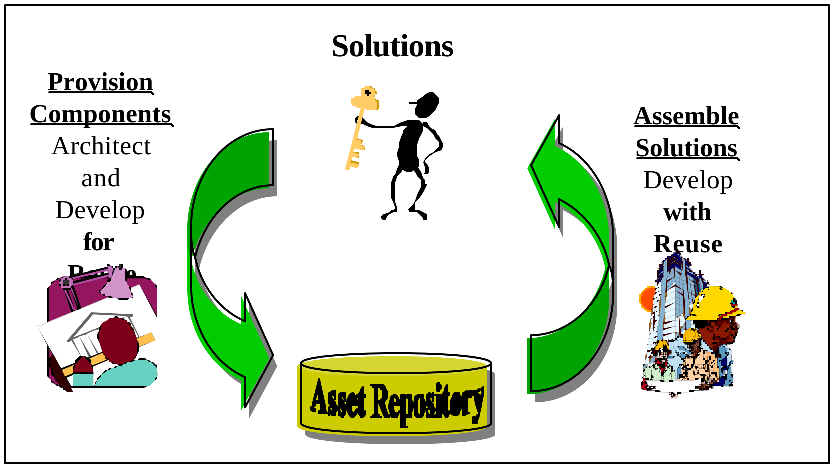
	Components	Enterprise
Levels of abstraction	Interface vs. Implementation	Problem Domain vs. Business Process vs. Application Spec vs. Application Impl
Multiple Views	*Shipper* has different view of *Customer* than *OrderTaker*	*Customer Care* department vs. *Network Expansion* department
Architecture standards	*Security*, *Transactions*, *naming*	*Approval levels, escalation and notification, centralized support operations,…*

System Integration - Structure and Route

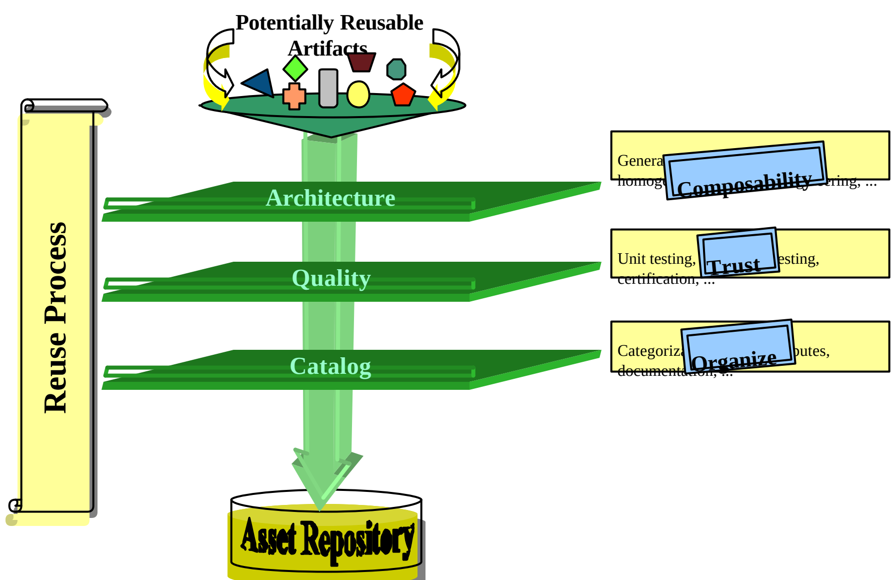


- Fixed underlying structure, different route and techniques

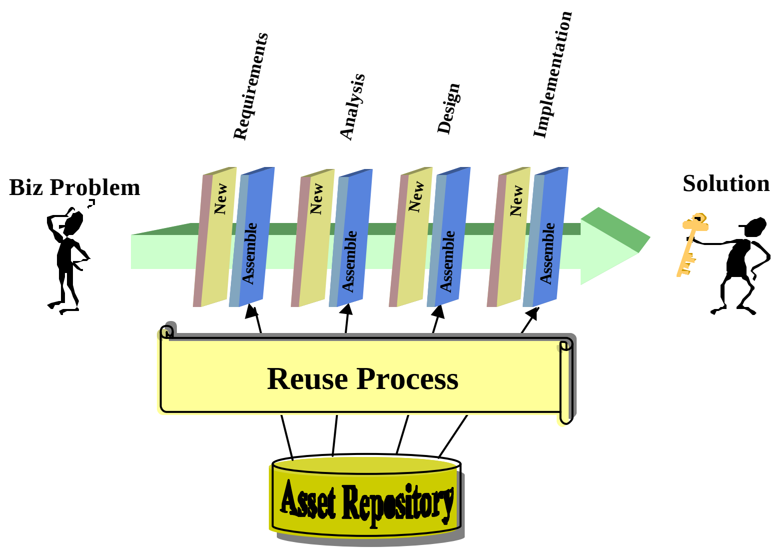
Reuse - Two Distinct Processes



Reuse - Investment in Building Assets



Reuse-Driven Development Architecture



Component-Based Development

Component-based Development: a development approach in which

… all artifacts — from executable code to interface specifications, architectures, and business models …

… scaling from complete applications and systems down to individual components …

… can be built by assembling, adapting, and "wiring" together existing components into a variety of different configurations

Outline

Introduction
- What problem are we setting out to address?

Components
- What they are, how they interact, how to describe them

Architecture
- What it is, why it is essential, how to describe it

Frameworks
- The basic idea

Reuse
- What it is (and is not), reuse at all levels

Systematic Reuse with Frameworks
- Making models, designs, code reusable

Summary
- **Catalysis in Perspective**

What is Catalysis™*?*

UML partner, OMG standards, TI/MS standards

Precise models and systematic process

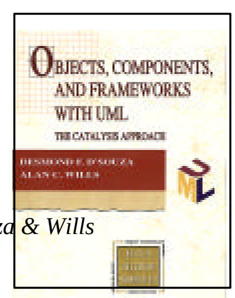
Dynamic non-"stovepipe" systems

A next-generation standards-aligned method
For open distributed component systems
from components and frameworks
that reflect and support an adaptive enterprise

From business to code

Compose pre-built interfaces, models, specs, implementations...

…all built for extensibility



More info at www.catalysis.org and www.platinum.com
Catalysis has been in development and use since 1992
Supports components, OO, legacy, heterogenous systems
Addison Wesley, *"Objects, Components, Frameworks…" 1998, D'Souza & Wills*

Catalysis: Beyond UML

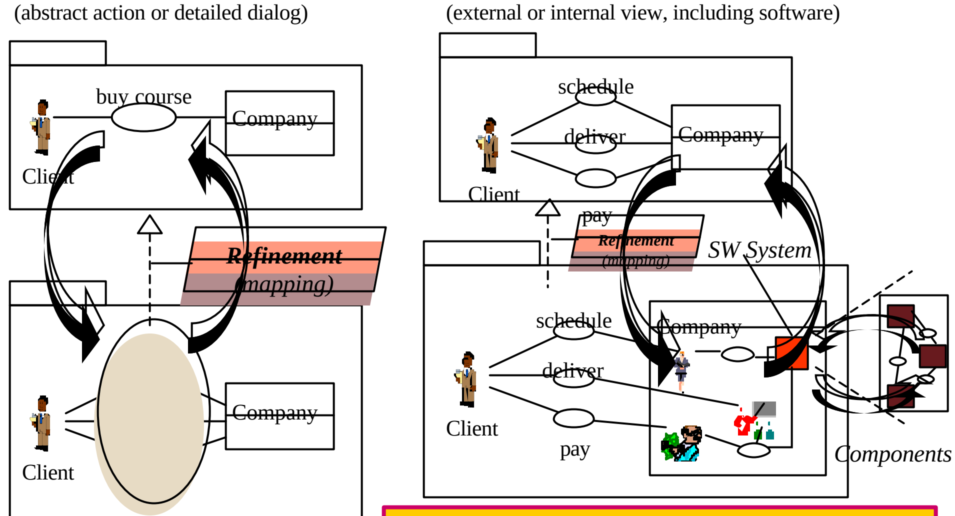
- **UML +** simple consistent approach, process, techniques
  - **Traceability** from business models to code
    - Business-driven, improved change management, quality assurance
  - **Precision**, with clear unambiguous models and documents
    - Uncover issues early, explicit shared vocabulary and understanding
  - **Component** Based Development
    - Interface-centric flexible assembly from parts based on common architecture
  - **Reuse** of designs, specs, problem domain models, architectures, ...
    - Consistent and rapid architecture via patterns and frameworks
  - **Scalability** from small to large teams and projects
    - Consistency, completeness, adoption spectrum, incremental development
  - **Process** that is flexible yet repeatable, with multiple “routes”
    - In terms of flexible process patterns with full process implementation

Next Generation Solutions including methods, tools, content

Traceability from Business to Code

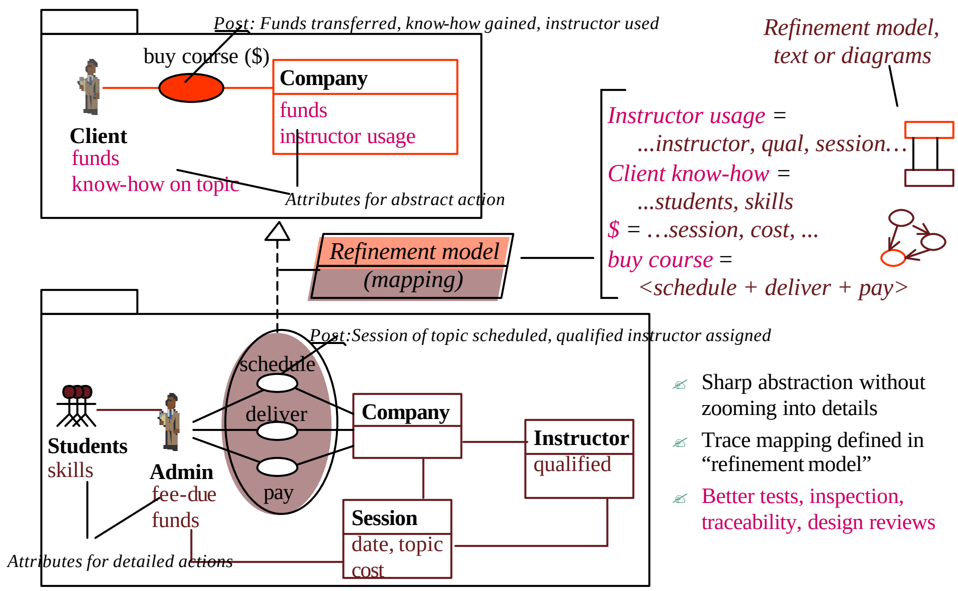
Zoom in/out of use-case (user task)
(abstract action or detailed dialog)

Zoom in/out of objects
(external or internal view, including software)



Fractal zoom in/out with equal sharpness

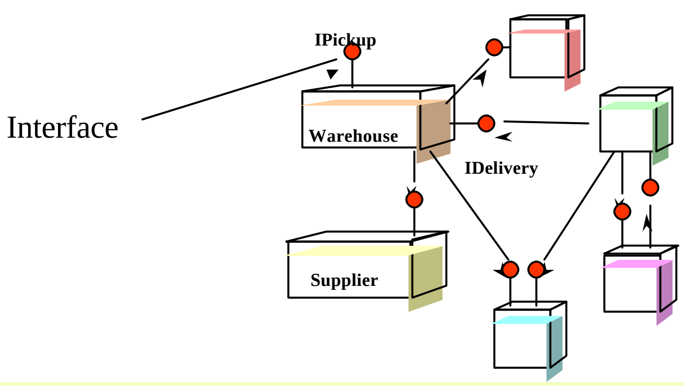
Precise Traceability via Refinement



- Sharp abstraction without zooming into details
- Trace mapping defined in "refinement model"
- Better tests, inspection, traceability, design reviews

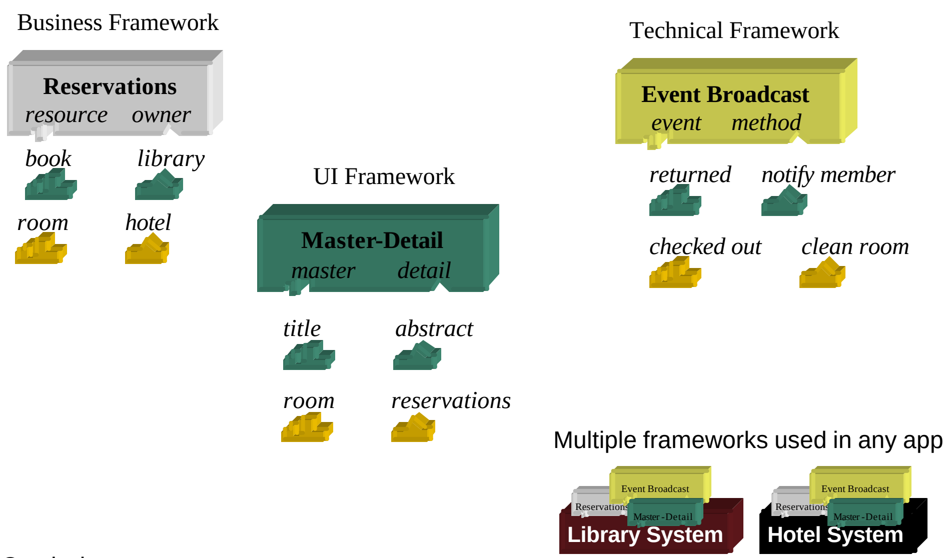
How do Components Interact?

Components interact via clearly specified interfaces

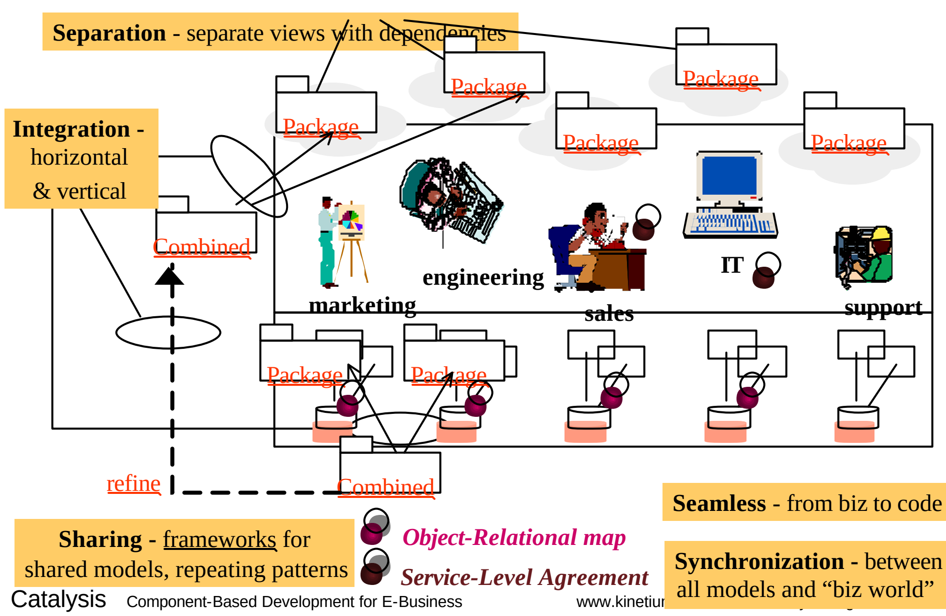


Use higher-level parts and connectors
Focus on individual interfaces
- precise external behavior (provided + required)
- all implementation aspects completely hidden

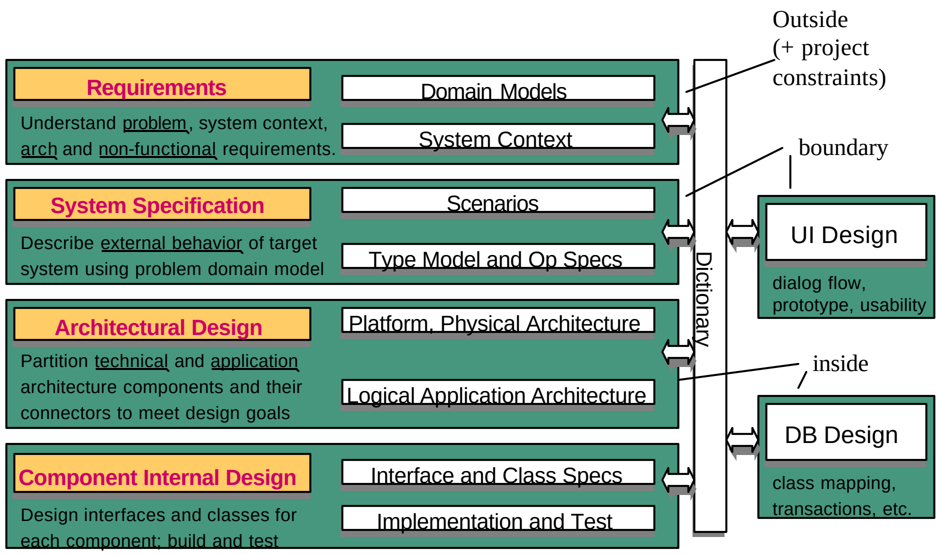
Systematic Framework-based Reuse



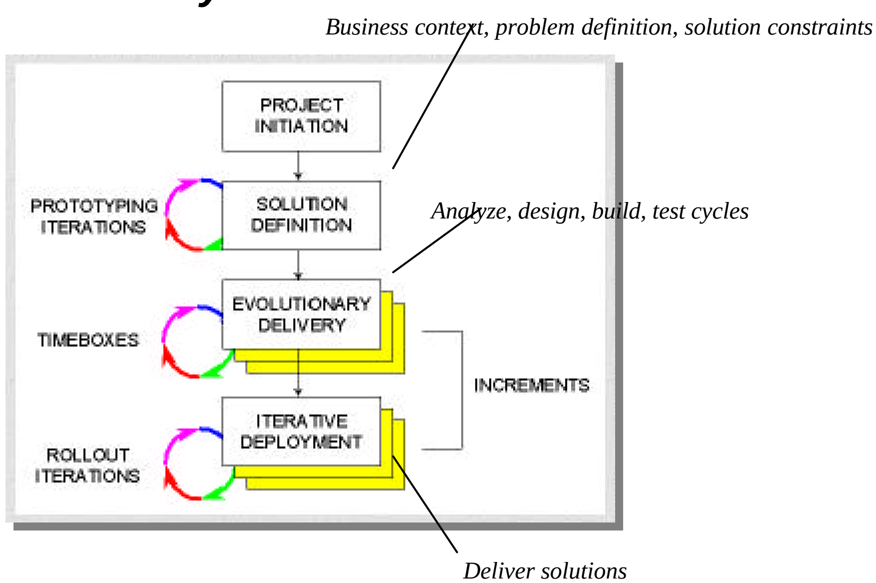
Scalable to Enterprise Modeling



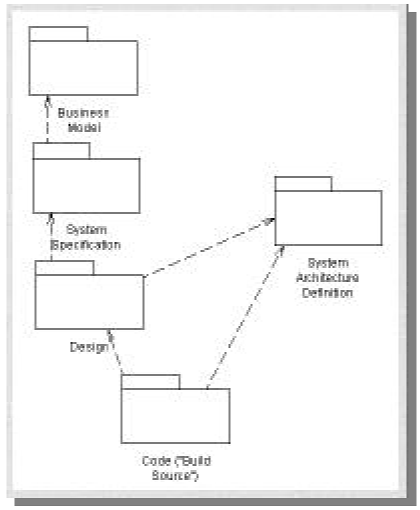
Typical Business System with Catalysis



CBD/Catalysis Process - Web Site version



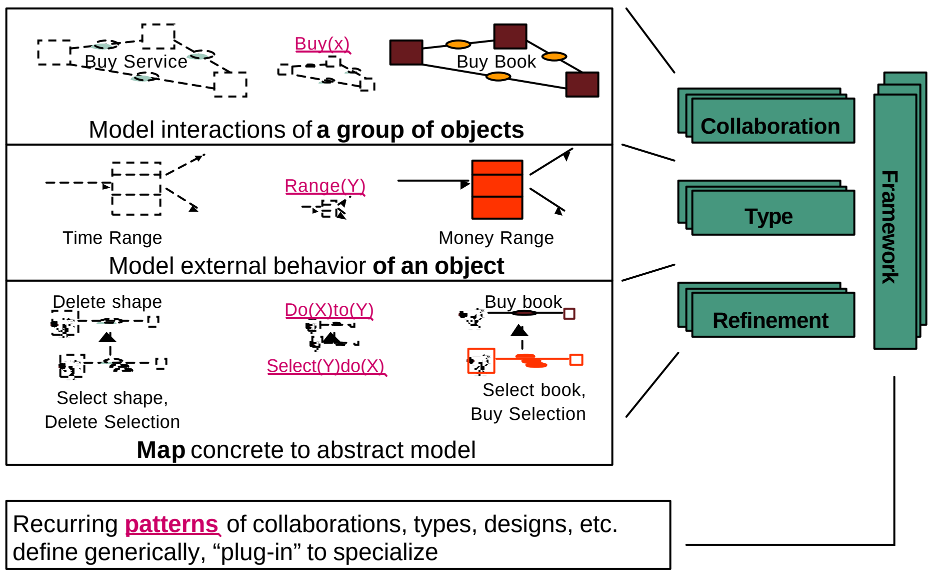
Process - High Level Package Structure



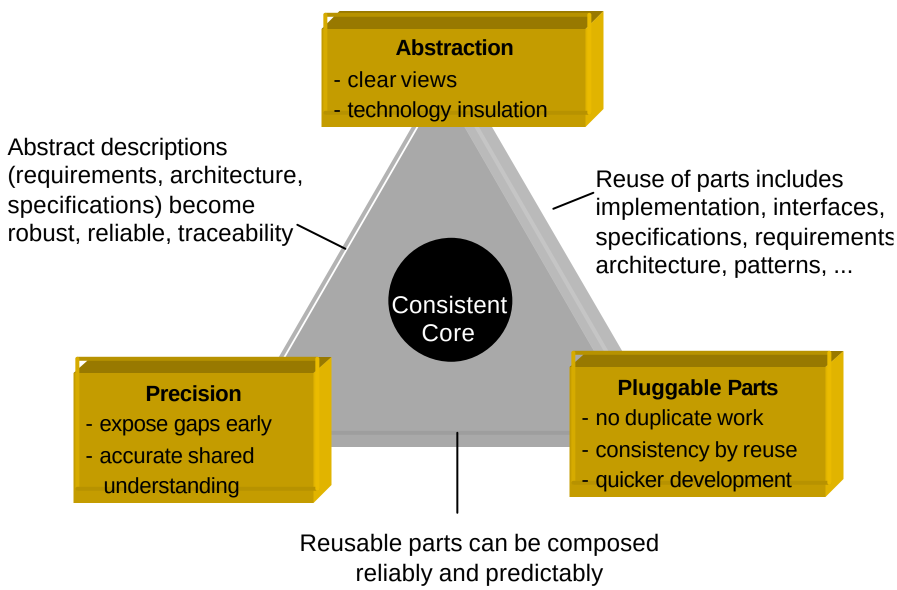
Three Modeling Scopes or Levels

Level/Scope	Goal
Domain/Business	"Outside": Identify Problem, Solution establish problem domain terminology understand business process, roles, collaborations build ***as-is*** and ***to-be*** models
Component Spec	"Boundary": Specify Component scope and define component **responsibilities** define component/system **interface** specify desired component operations
Internal Design	"Inside": Implement the Spec define **internal architecture** define internal components and collaborations recursively design insides of each component

Three Modeling Constructs

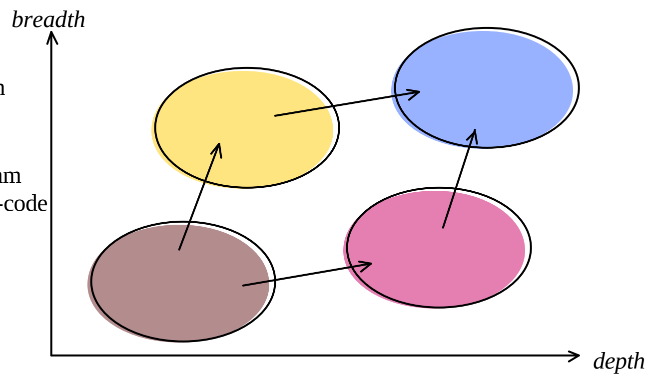


Three Principles



Adoption Spectrum - Think Big, Start Small

Enterprise
organization
roles
standards
reuse program
business-to-code



Project
team skills
mentoring

Lite
type diagrams (or text glossary)
component models
implementation code

Sophisticated
standard frameworks
testable refinement
formal architecture
repeatable process
repeatable infrastructure impl
business-to-code

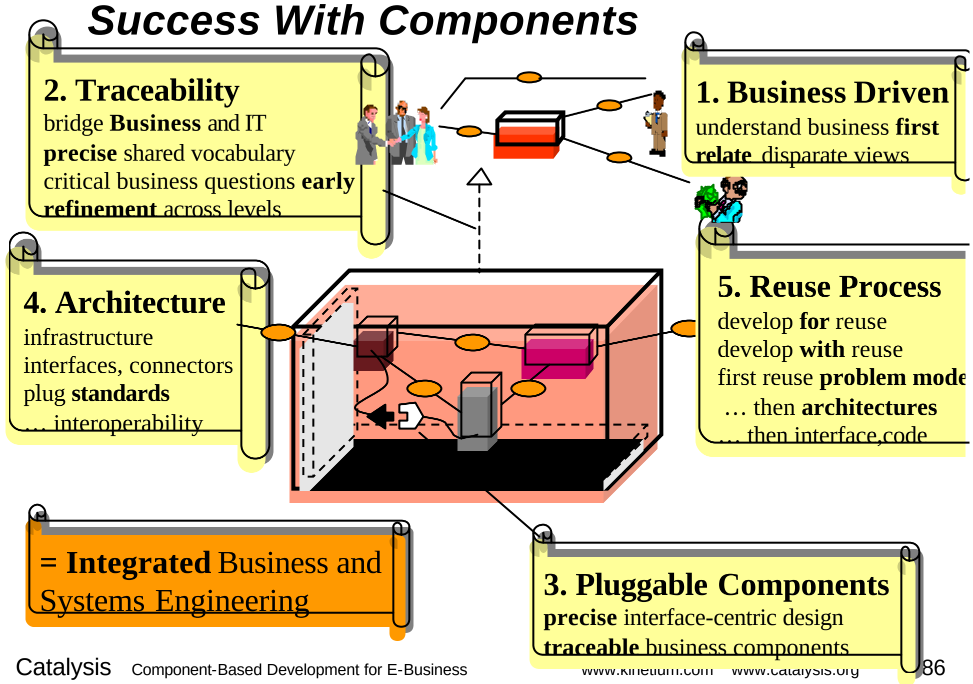
The Key to Catalysis

- Minimize the “magic” that happens in a development process
  - Gaps between business process, software solutions, technical infrastructure
  - Capture known designs, techniques, processes, architectures, …
  - Common vocabulary across business, analyst, architect, programmer
  - Common core techniques for requirements, non-functionals, design, specs...
- Full lifecycle coverage
  - Business problem driven with traceability from requirements to code
  - Rapid application development with reuse of all levels
  - Combine IT Engineering and Business Engineering into one whole

Experiences with Catalysis

- EDS : Internet Multimedia division
  - Adopted as a required part of development standards 1998
- Lockheed Martin: Defense projects
  - Adopted as integral part of standard since 1997
- USAA: Insurance
  - Successful application on risk -profiling project 1998
- Yellow Services: Travel and Transportation
  - In current use in Enterprise Systems Management domain modeling and CBD
- Credit Suisse: Asset Management
  - Adopted as integral part of standard 1998
- Texas Instruments WORKS: Factory Automation 1997-1998
  - Successful and "deep" use on capacity planning and scheduling
  - Successful "lite" use on overall project
- Daimler Benz
  - Used since 1998 with good results
  - "*easy to understand core, very consistent and complete overall method*"
- Visa / Chicago, BMW, Nortel, Olivetti, Siemens, Dutch Ministry of Taxes, KPMG/Germany, LCM/Italy, and more …

Success With Components



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- UML 1.3 Specification: uml.shl.com
- UML 2.0 Working Group documents: uml.shl.com
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