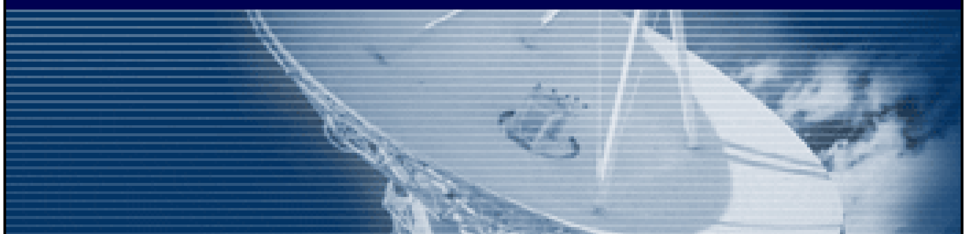
Pathfinder Solutions

Put MDA to Work

MDA in Eclipse

for Embedded and High Performance Systems

version 1.0 6/9/04



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Introduction

- **Tutorial goals:**
  - Outline challenges in developing complex, high-performance systems
  - Demonstrate MDA PIM modeling, system deployment, and topology tuning
  - Highlight key characteristics of an effective MDA development environment

Complex System Development

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- **Building RT/E Software is Difficult:**
  - Escalating Feature Complexity
  - Challenging System Execution Requirements
    - Reliability, Availability
    - Speed, Space, Environment
    - High Availability
  - Aggressive Competition
  - Diverse, Unique Platforms

Complex System Development

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- **Common approaches have a poor record:**
  - 76% late or cancelled
  - 53% over budget
  - 87% delivered functionally incomplete

    (source: Electronic Market Forecasters)

Code-Driven Development

- **Code-focused development approach**
  - Architecture with implementation focus
  - Primary communication through code
  - All software maintained at implementation-level
- **Single concept space**
  - Mix of problem space and implementation detail
  - Hard to *effectively* decompose

Realities of Code-Driven Development

- **More Complexity**
  - Abstraction level quickly drops to code level
  - OOP over-generalization leads to inefficiency
  - Difficult to maintain
  - Achieving runtime performance is increasingly elusive

Realities of Code-Driven Development

- **Brittle and Short Lived**
  - Requirements Change
  - Platform Migration
  - Calcified by Optimizations and Patching

Realities of Code-Driven Development

- **Difficult to Conceive, Implement and Follow**
  - Coding conventions, rules and review can be critical to success
  - Architecture enforcement is manual
- **Project must invent and implement**
  - Interface mechanism layers
  - Portability and convenience mechanisms
  - Project-specific checking

Key Challenges

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- **Managing Complexity**
- **Communication**
- **Architectural Flexibility and Durability**
- **Achieving Runtime Performance**

MDA for Real-Time Embedded

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- **Architecture-focused approach for developing high-complexity, high-performance systems**:
  - Facilitate an architectural focus throughout system lifecycle
  - Manage overall system complexity with separation
  - Transform models to deployable code

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MDA for Real-Time Embedded

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- **MDA leverages modeling technology to gain independence and separation:**
  - Problem space from implementation space
  - One logical component (subject matter domain) from another

MDA for Real-Time Embedded

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- **Partitioning inherent within MDA provides:**
  - Independence from any specific implementation**.**
  - Ease integration among heterogeneous components**.**
  - Large-grained reuse and system longevity.

MDA – PIM

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- **Platform Independent Model (PIM):**
  - Complete, executable, verifiable UML model
  - Focused on problem-space solution analysis
  - Divorced from implementation space
- **PIM semantics facilitate**
  - Rapid development
  - Ease of adoption and understandability
  - Deployability

MDA

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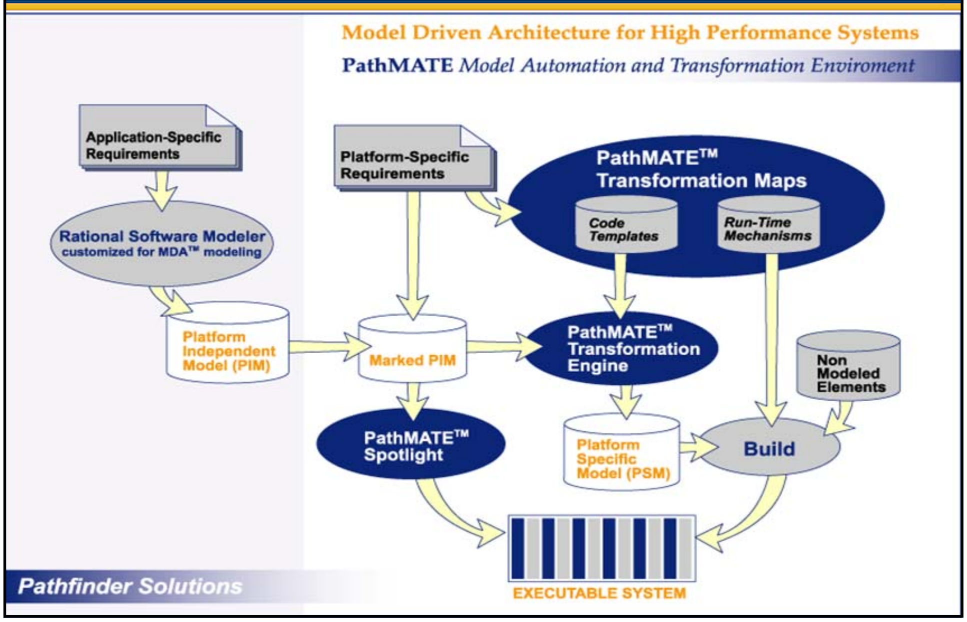

MDA - PSM

- **PSM - *Platform Specific Model***
  - Combines PIM with details for a particular execution platform
  - Incorporates needed adaptations and optimizations
- For RT/E systems, the PSM is in a 3GL – implementation code:
  - Executable, deployable without manual edits
  - Rapidly re-generates for quick debug cycles

MDA - Transformation

- **Transforming a PIM to Implementation**
  - Convert PIM elements to implementation
  - Apply implementation patterns via code templates
  - Designer guides transformation via markings
  - Customized templates facilitate project-specific optimizations

MDA – Key Characteristics

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- **The PIM is the *source* for the system:**
  - Models are executable and complete
  - Problem-space features are defined in analysis models
  - Execution-specific extensions such as porting and performance optimizations
    - Done in Design
    - Automatically leveraged across all models

MDA – Key Characteristics

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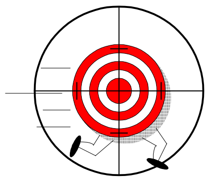
- **The architecture of the product is enforced by the process**
  - Models, code, and doc are always synchronized
  - Reuse is independent of deployment environment and topology
  - High software quality and flexibility through product life

MDA Benefits

- **Improved Software Quality**
- **Increased Productivity**
- **More Predictable Schedules**
- **Smoother Integration**
- **Reduced Maintenance Costs**



MDA Summary

- **MDA is an approach for engineering software where:**
  - Complexity is managed by separation.
  - Communication is facilitated with raised abstractions, based on industry standards
  - Problem-space focus and automated transformation maintain architectural focus and longevity.

System Development

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- **Architectural Analysis**
  – Use Cases
  – Domains
- **Platform Independent Modeling**
  – Classes
  – Scenarios
  – State Machines
  – Actions
  – Dynamic Verification

PIM - Use Cases

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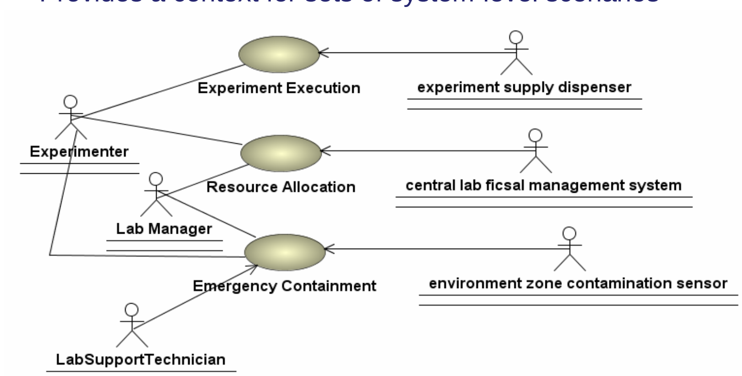
- Use Cases start modeling at the requirements level:
  - Focus on system interactions with user/operator and other external entities
  - Outline key capabilities and identify system boundaries
  - Provides a context for sets of system-level scenarios



PIM - Domains

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- Partition a product or product family into logical components - subject matter *domains*:
  - Separate, conceptual universe
  - Inhabited by a related set of abstractions
  - Pertaining to a distinct subject matter
  - Interacts with other domains exclusively through published services

PIM - Domains

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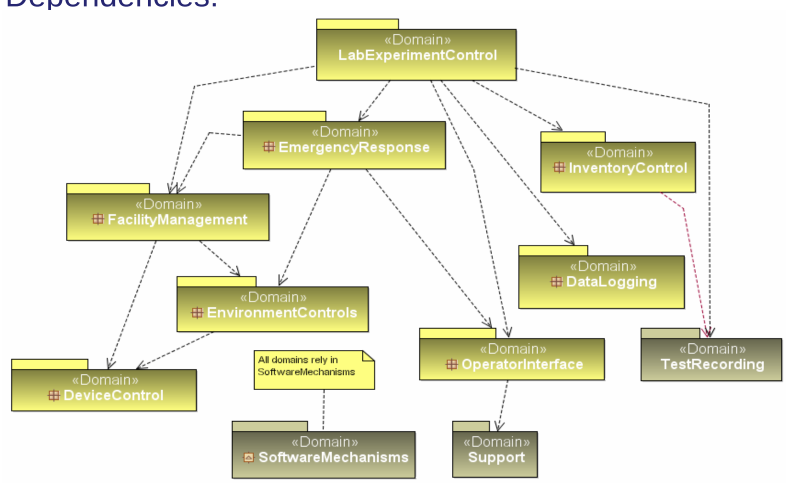
- Domain Chart is captured with Packages and Dependencies:



PIM - Domains

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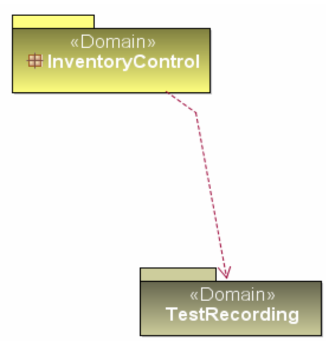
- Manages the subject matter complexity of the system
- Provides a durable foundation for system development
- Domain Modeling is not inherently object oriented
  - applies equally well to all system software elements



PIM - Classes

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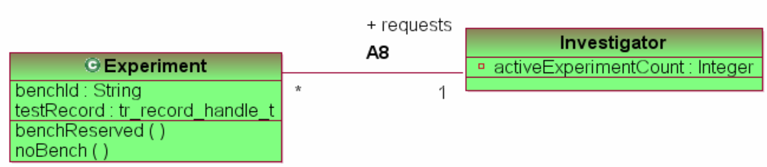
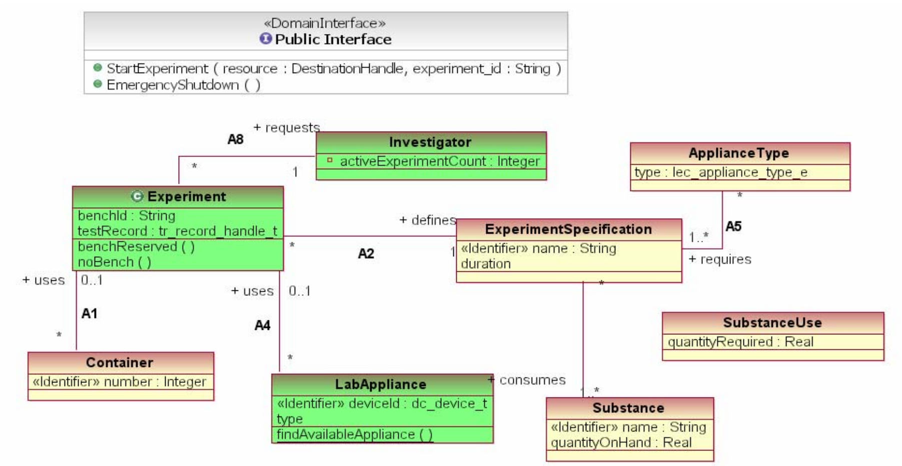
- The Class Model shows a static view of data for a domain:
  - Classes belonging to domain
  - Attributes - characteristics of a class
  - Associations - relationships between classes
  - Generalization - hierarchies
  - Class Models are readily understandable by non-developers
  - Facilitates communication between marketing and developers



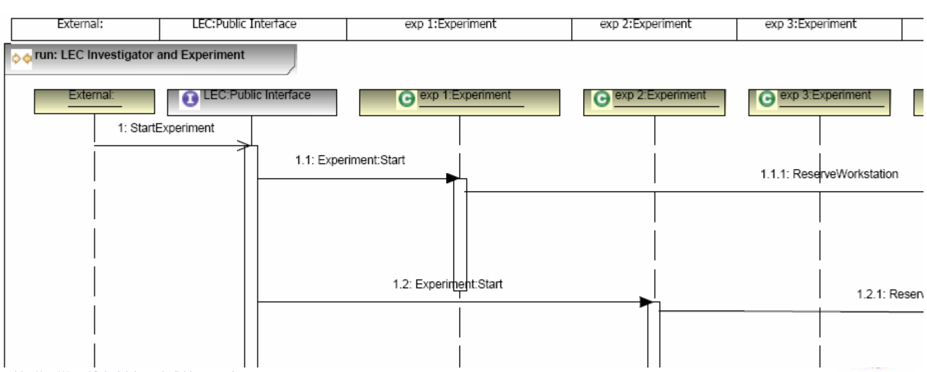
PIM - Classes

- Class Model is shown with a UML™ Class Diagram:



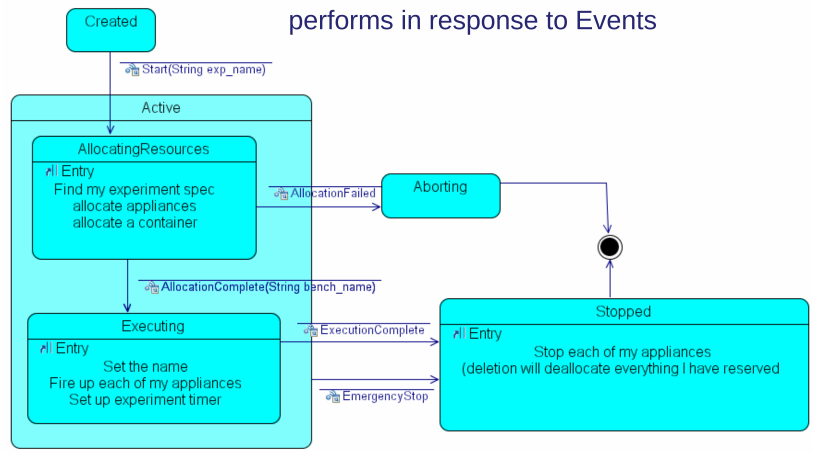
PIM - Scenarios

- Scenario Models show the behavior of class instances participating in domain-level scenarios:
  - Establish the pattern of interaction between operations, states actions, and server domains
  - UML™ Sequence Chart shows interactions:



PIM – State Machines

- State Modeling:
  - Defines the lifecycle for a Class
  - Outlines the Actions that a Class instance performs in response to Events



PIM - Actions

- Action Programming:
  - Defines the processing performed by an operation or state action
  - Platform-independent Action Language (PAL):
    - OMG standard UML Action Semantics
    - PIM-level, not implementation code
    - Convenient and complete set of modeling processing primitives
    - Enables automated transformation to optimized implementations

PIM - Actions

- Each domain interface operation, class operation, and state/transition action is defined by PAL:

```
String msg;
//# Find my experiment spec
Ref<ExperimentSpecification> spec = FIND CLASS
ExperimentSpecification WHERE (name == exp_name);
IF (spec)
{
    msg = "Experiment " + exp_name;
    DataLogging:LogRecord(SoftwareMechanisms:
        DestinationHandleLocal(), msg);
    LINK this A2 spec;

    //# allocate appliances
    FOREACH required_appliance_type = spec->A5
    {
        Ref<LabAppliance> appl =
        LabAppliance:findAvailableAppliance(
            required_appliance_type.type);
        IF (appl != NULL)
        {
            LINK this A4 appl;
```

(continued . . .)

PIM - Dynamic Verification

- Dynamic Verification
  - Execution of analysis models to verify behavior of analysis
  - Independent of target execution environment
  - Within the context of a single domain, or a tightly related set of domains
  - Unique to translation - only a rigorous and complete PIM-based approach affords this early opportunity to validate behavior
- Test scenarios are derived from Scenario Models

PIM - Dynamic Verification

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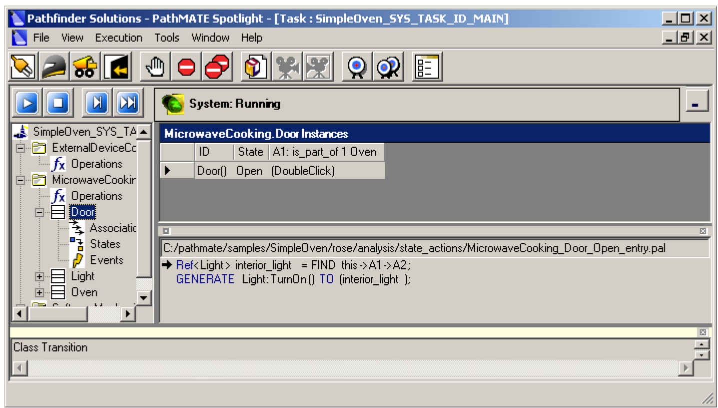
- Dynamic Verification
  - Spotlight provides visibility into the execution of analysis via "model-level debugging":



PIM Lifecycle

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analysis	
	Class Modeling
	Behavioral Modeling - Scenarios and States
	Action Modeling
	Dynamic Verification

Tutorial Example Overview

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- **ExperimentControl**
  - Sample system with moderate complexity
  - Multiple subject matters for some domain complexity
  - Some synchronous domains, some state machines

ExperimentControl – Overview

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- **Controls experiment execution in a laboratory setting**
  - Secure required resources
  - Track budgets for supplies
  - Initiate experiment execution
  - Work area climate (temperature) control
  - Monitor environment contamination

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ExperimentControl – Use Cases

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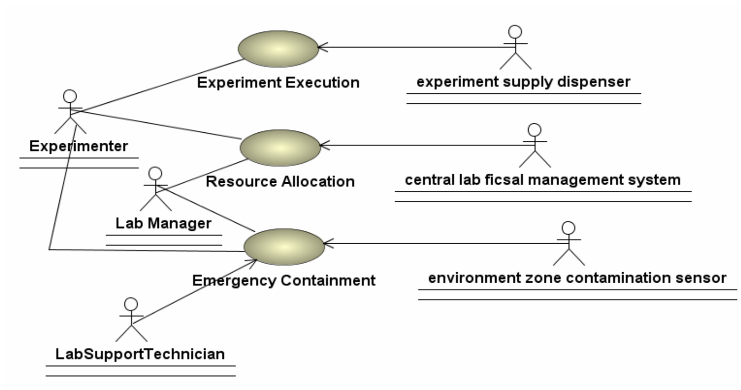
- **Core operational Use Cases:**



ExperimentControl – Use Cases

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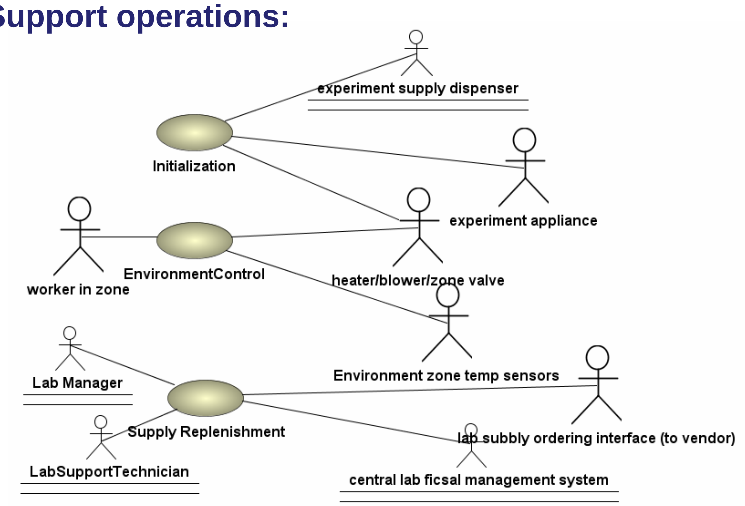
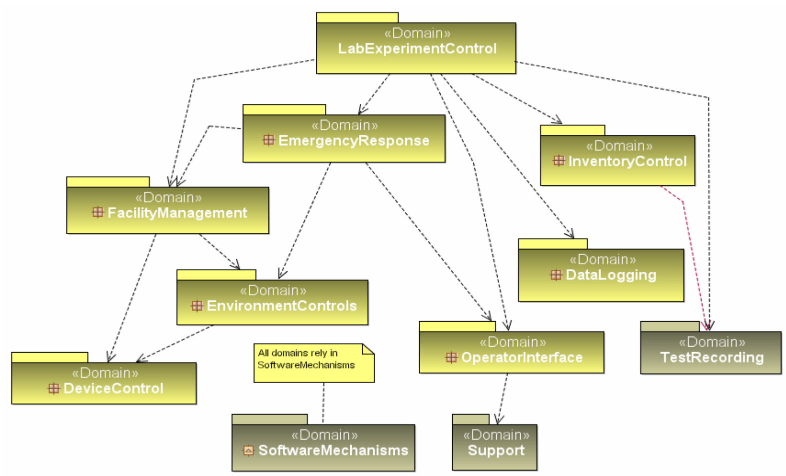
- **Support operations:**



ExperimentControl – Domain Chart



ExperimentControl – New Requirements

- **Add Upsadaisium replenishment capability:**
  - Add executive capability to FacilitiesManagement domain
  - New hardware to be added – liquefied gas pump
  - Add new domain to implement gas transfer controls

Use Case

Perform Required Model Changes

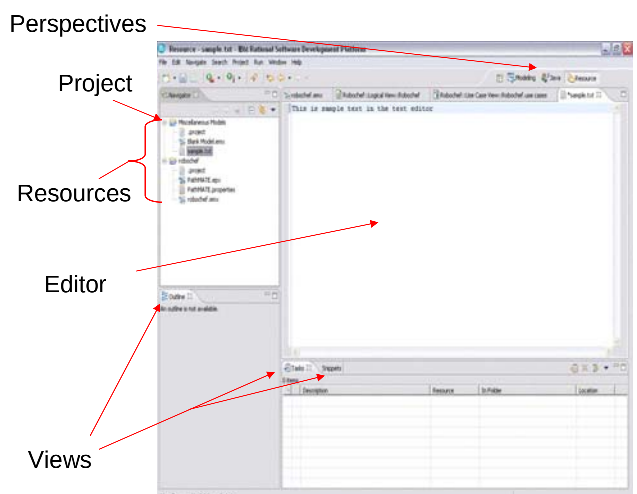
- **System Scenario Analysis**
- **Class Modeling**
- **Domain Scenario Analysis**
- **State Modeling**
- **Action Programming**
- **Dynamic Verification**

The Eclipse Environment

- **What is Eclipse**
  – Software engineering data and control backplane
  – Extendable IDE
  – Open source
- **Originally developed by IBM**
  – Streamline development process
  – Configurable solution, easy to extend and adapt
  – Provide the mechanical infrastructure for an “ecosystem” of practitioners and providers.

General Eclipse IDE Layout

- **Workbench**
  – Perspectives
  – Views
- **Workspace**
  – Projects
  – Resources



MDA Modeling in Eclipse

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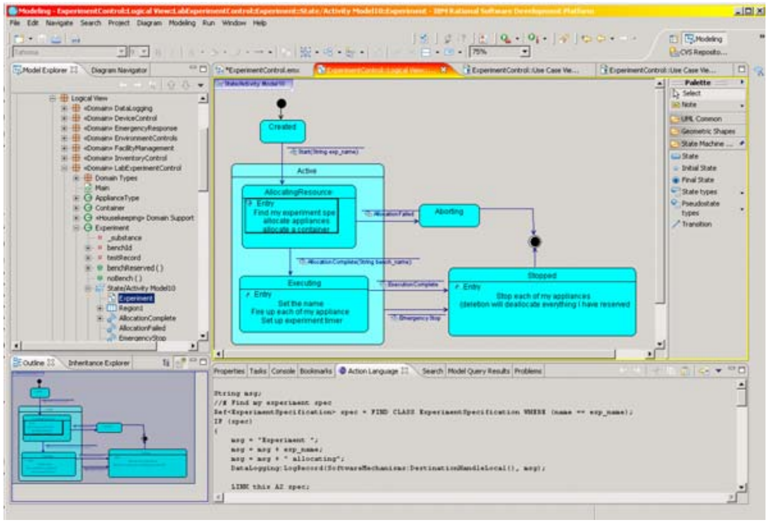
- **Rational Software Modeler (RSM)**



MDA Modeling in Eclipse

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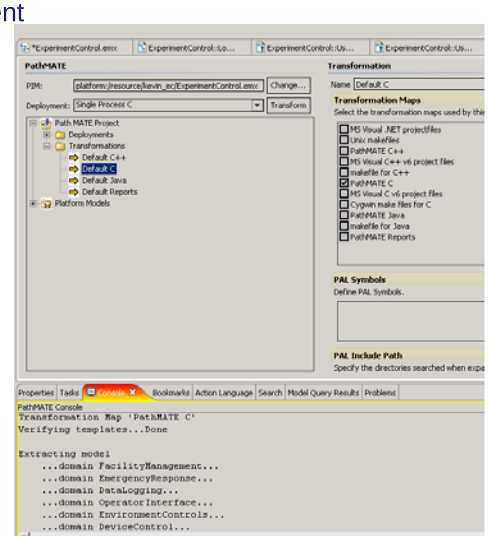
- **PathMATE transformation environment**
  - Powerful, open MDA environment
  - Template-based transformation
  - Extensive model checking
  - Behavior verification
  - Automatic report generation
  - Model-level debug on target
  - Highly optimized C, C++, Java



Initial Deployment

- **Create running version of system with initial topology**

Interface Instrumentation

- **Use Spotlight to trace inter-domain traffic**

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Second Deployment

- **Redeploy system with refined topology**

open discussion

references

- MDA white papers, intro movie, blog, other resources: www.pathfindermda.com
- Additional information about the PathMATE environment: www.pathmate.com
- RSM is available from IBM Rational: www.ibm.com
- General information on UML and MDA: www.omg.org
- Information on Eclipse: www.eclipse.org