Implementing a General Purpose Framework Using Multi-Agents for CM Education

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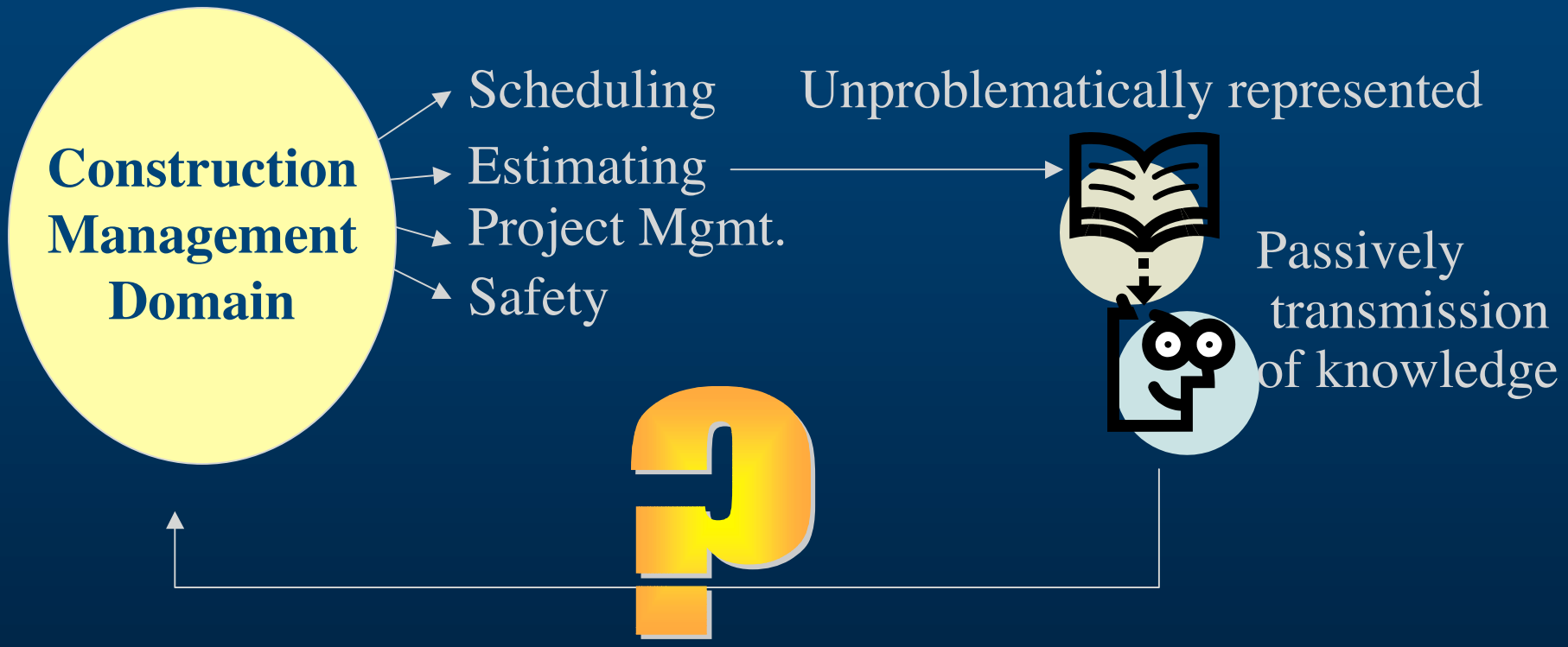
Overview

- Motivation
  - CM Education
- Why Situational Simulation?
- Why do we need a General Purpose Framework (GPF)?
- The Multi-Agent Framework
- Experiments and Results

CM Education

De-contextualized knowledge

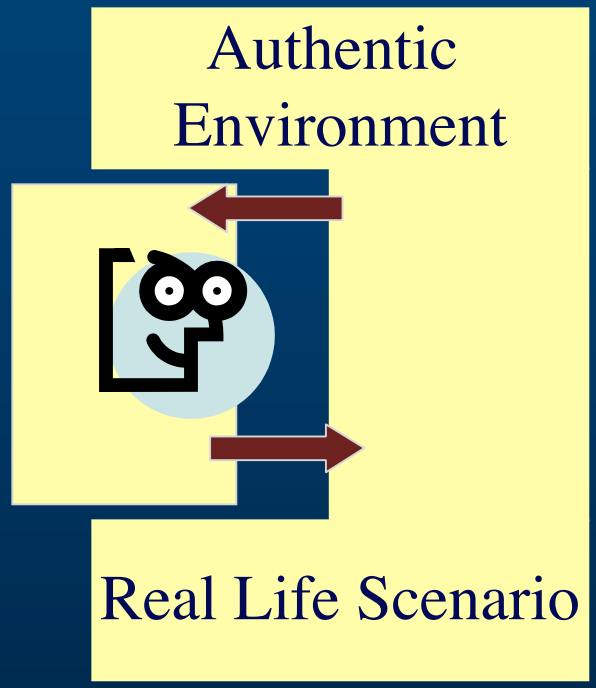
Separate Courses



Results: Inability to apply "learning" to relevant situations.

Instead . . .

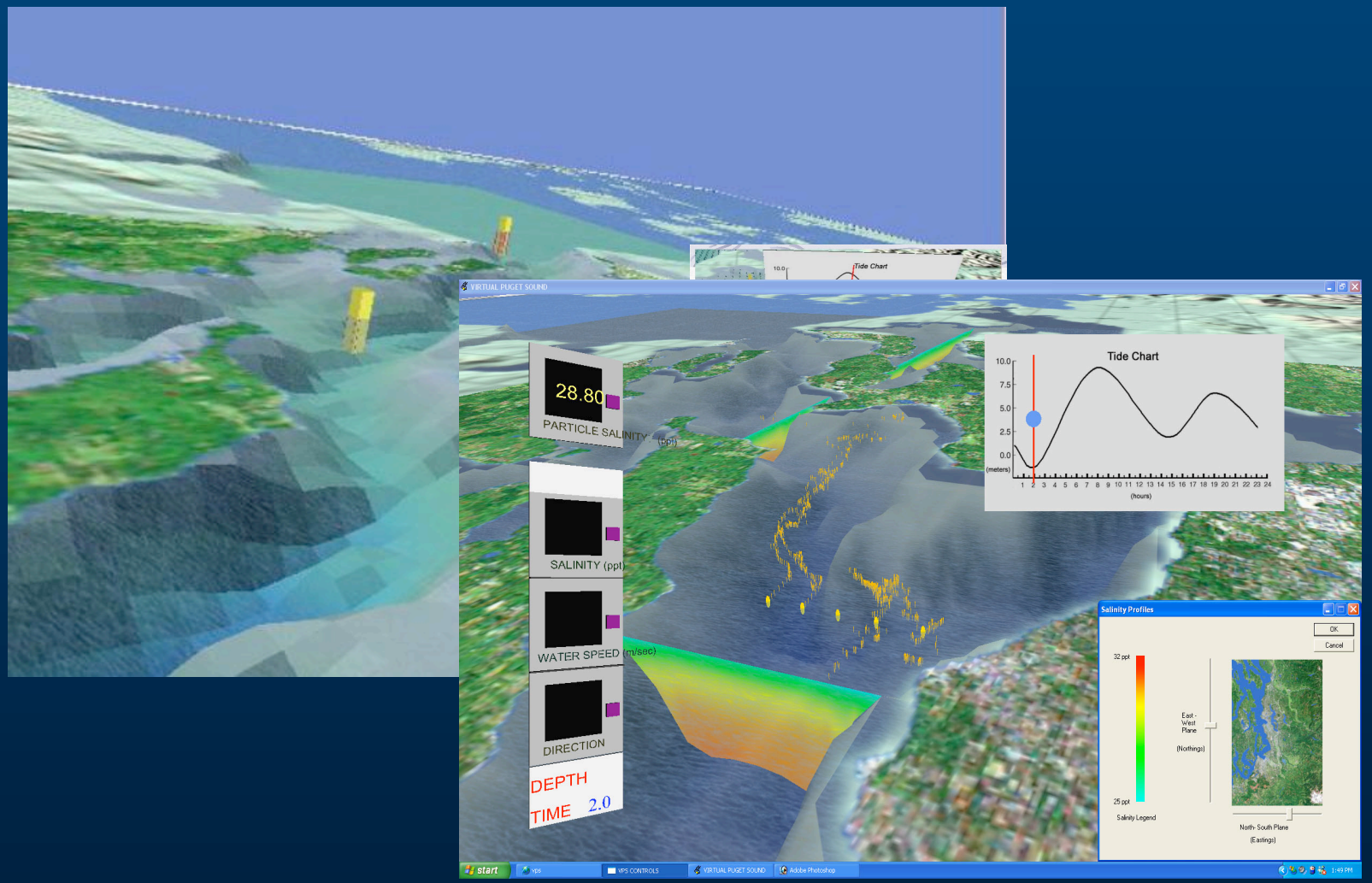
- Situated Contextualized Learning
  - Embedded in the environment
  - Physical Embodiment
- Adaptation
  - Student and environment:
    - coupled system
    - self-organizing
    - dynamically evolving



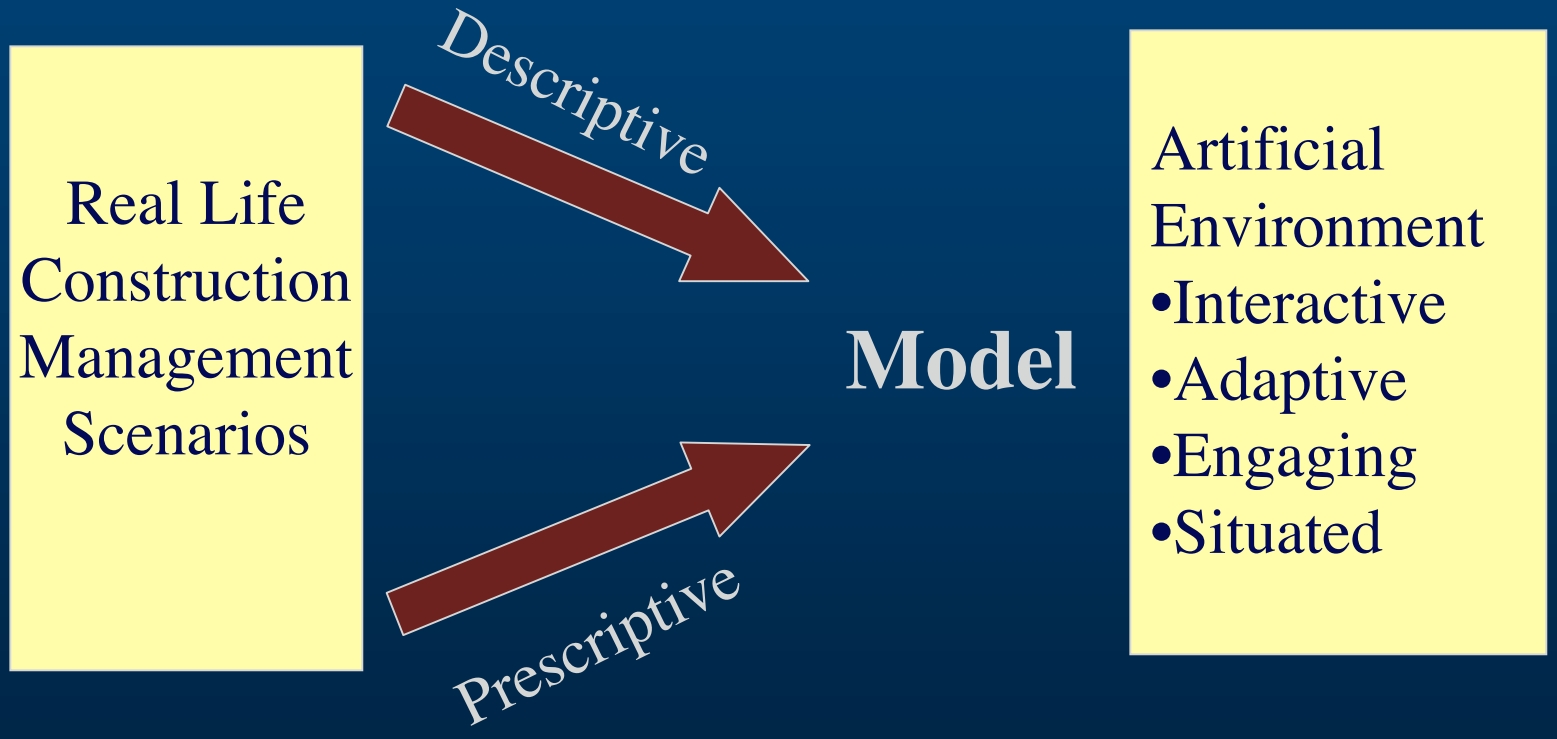
Simulations in Learning

- Explore “What-if” Scenarios
- Understand Inter-relationships
- Apprehend Feedback
- Take Risks

The Virtual Puget Sound



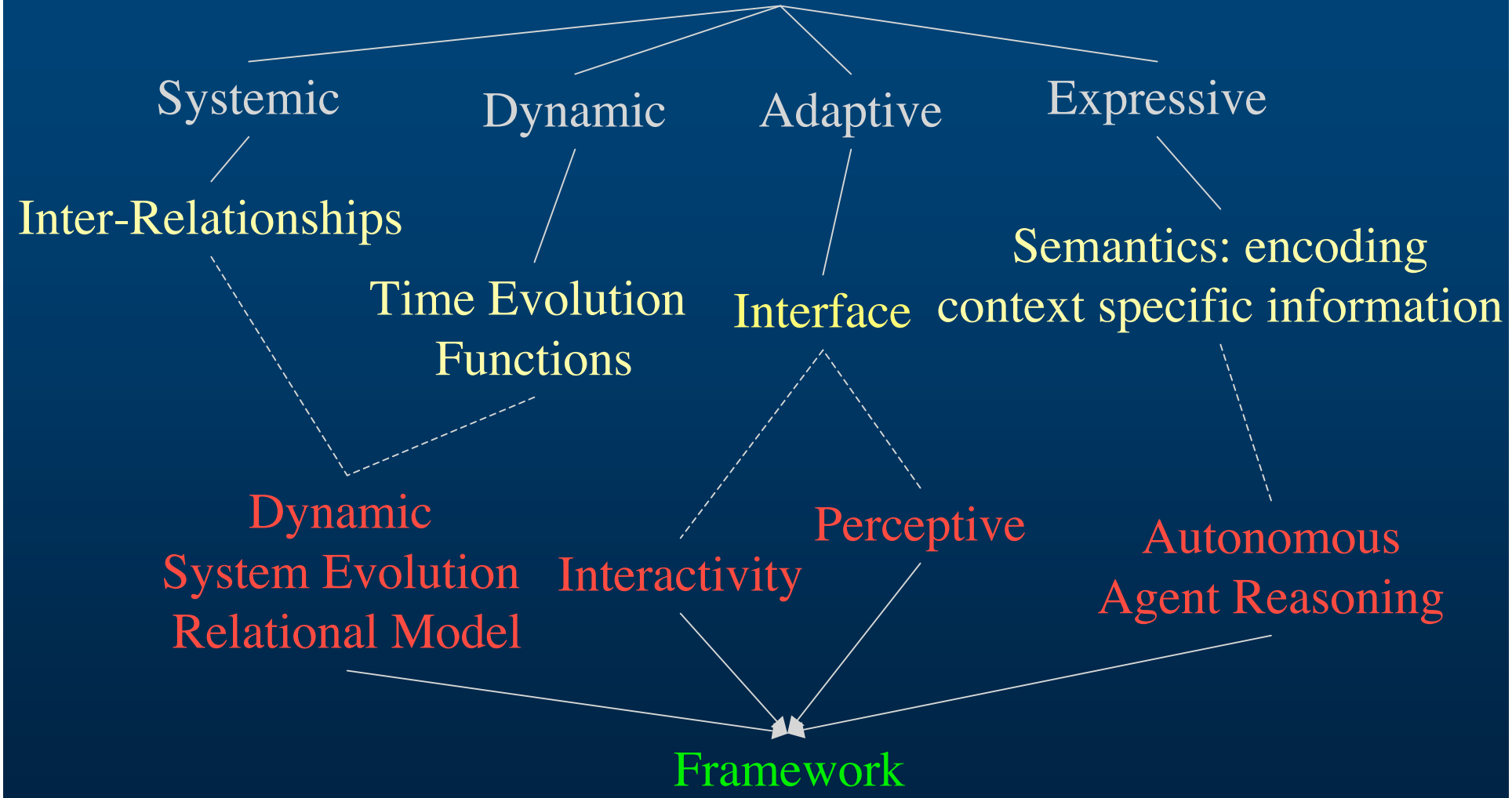
Challenge

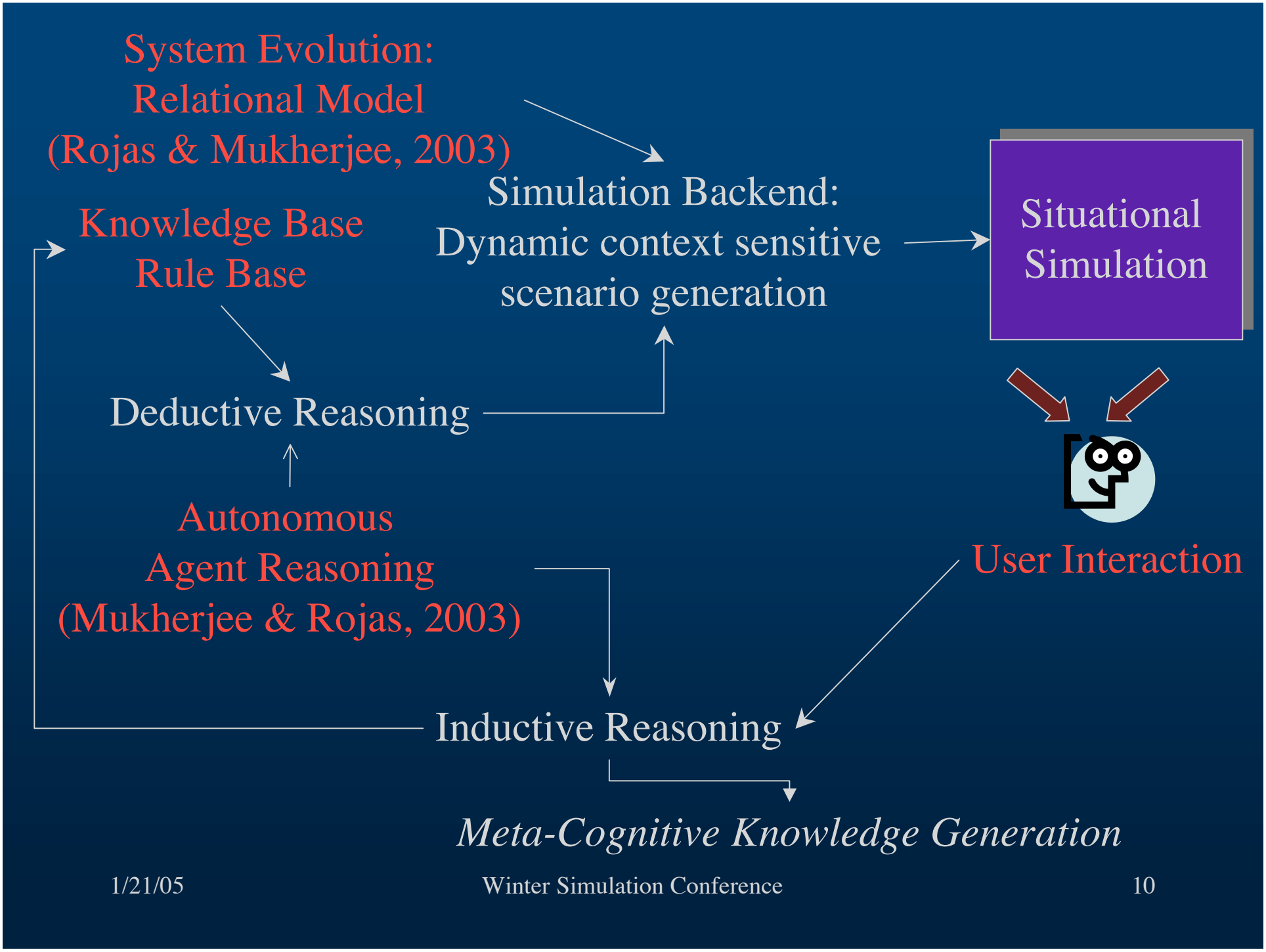

Real Life
Construction
Management
Scenarios
Descriptive
Prescriptive
Model
Artificial
Environment
•Interactive
•Adaptive
•Engaging
•Situated

Challenge

- Extensible
  - Variety of operations/ processes / scenarios
  - Levels of granularity
- Re-usable
  - Reuse reasoning components
- Scalable (!)

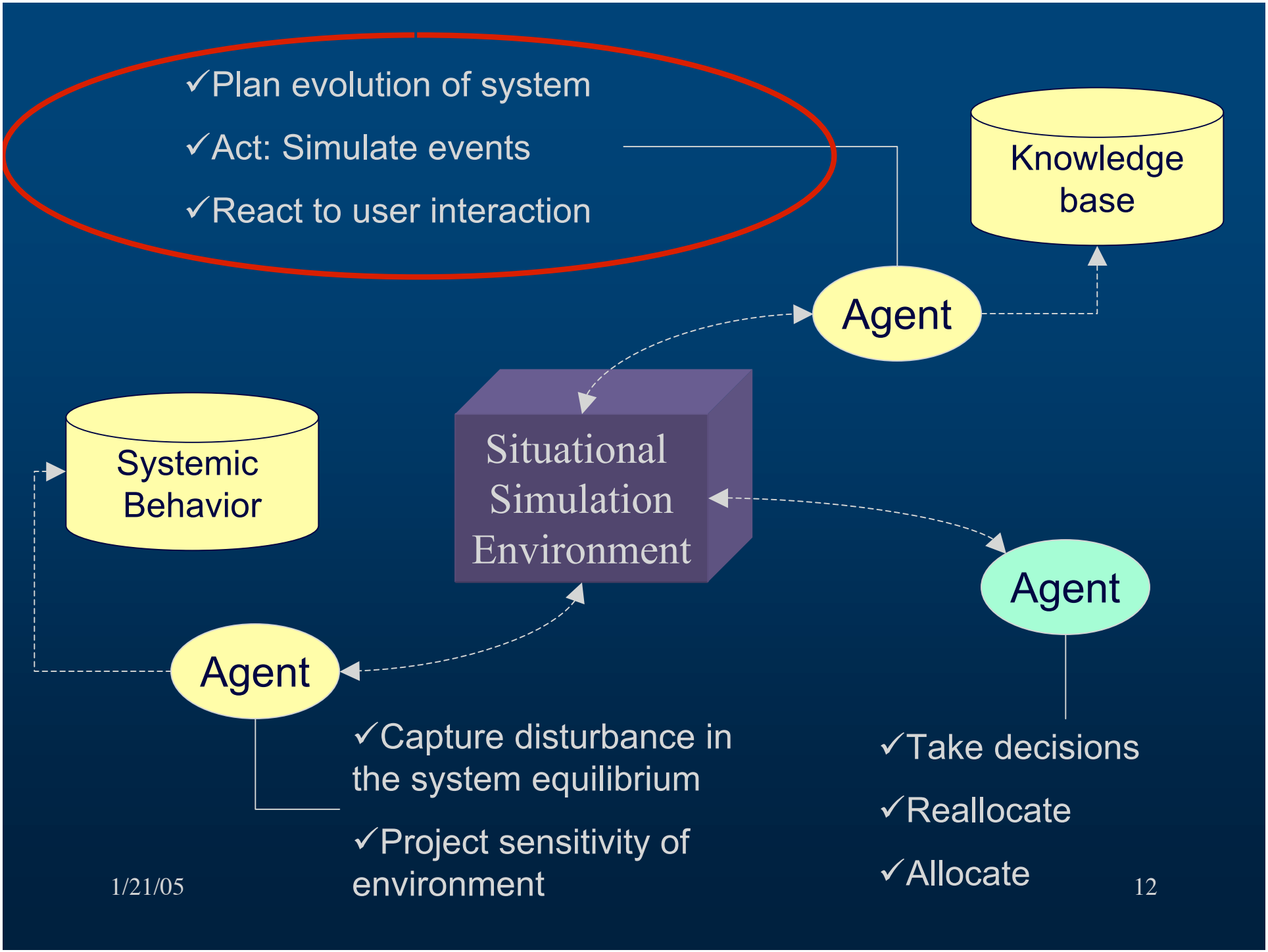
The Framework

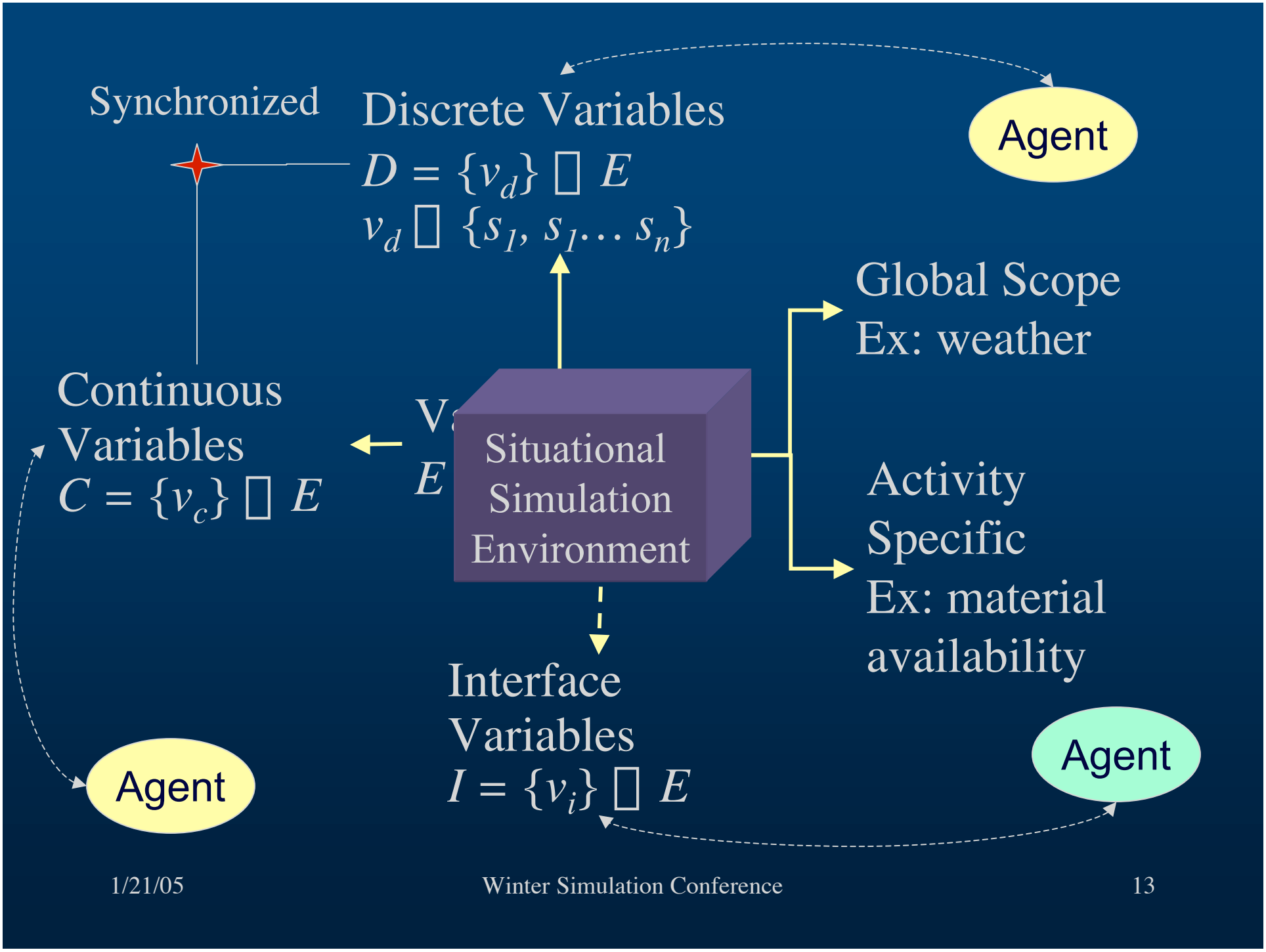



System Evolution:
Relational Model
(Rojas & Mukherjee, 2003)
Knowledge Base
Rule Base
Simulation Backend:
Dynamic context sensitive
scenario generation
Situational
Simulation
Deductive Reasoning
Autonomous
Agent Reasoning
(Mukherjee & Rojas, 2003)
User Interaction
Inductive Reasoning
Meta-Cognitive Knowledge Generation

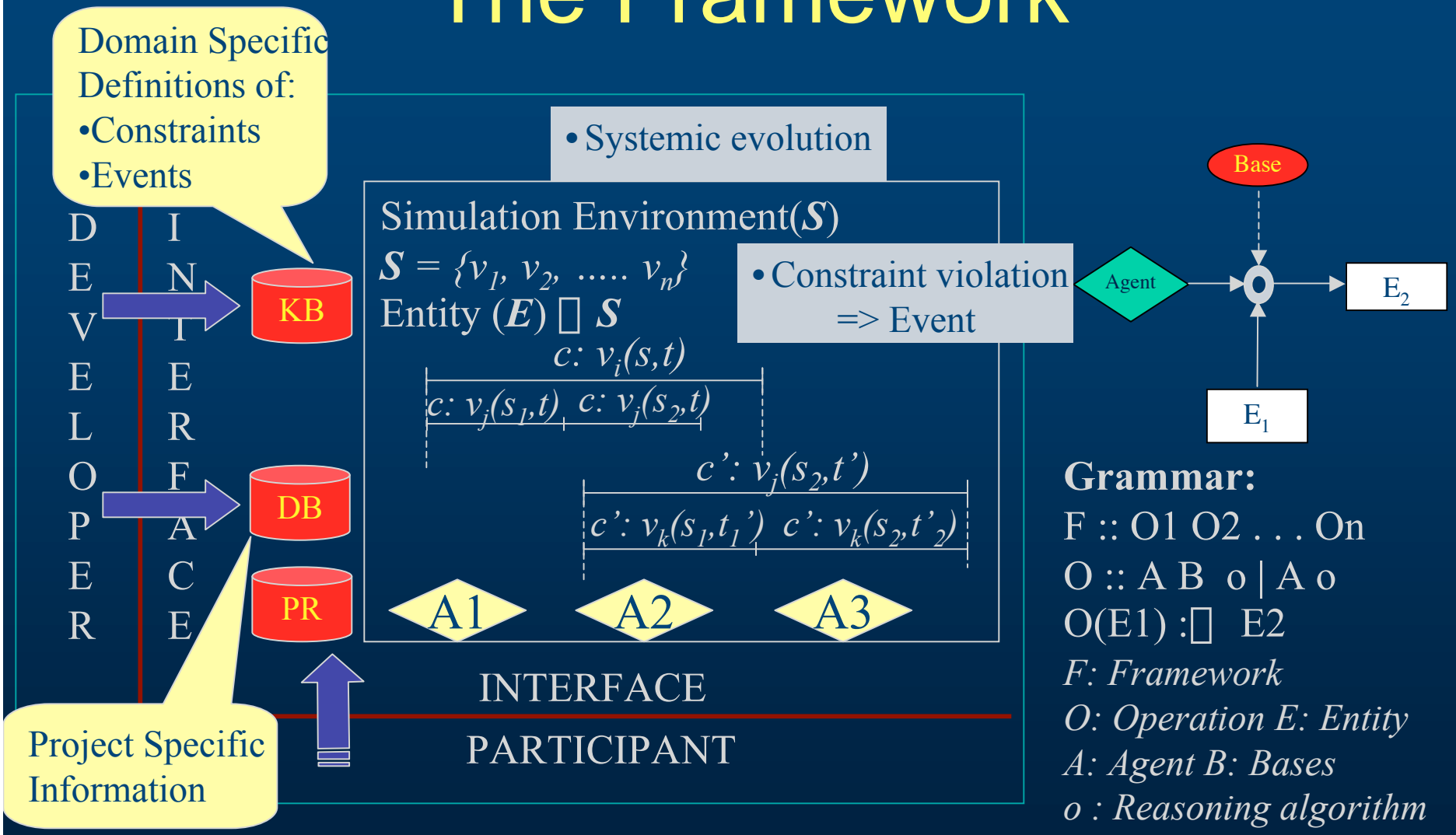
Problem Classification in CM Domain

- Precedence Constraints
  - Finish to start, start to start, start to finish
- Resource Constraints
  - Requirement Availability
  - Specification checks
- Events: Constraint Violations
  - Rescheduling of activities
  - Reallocation of resources


✓Plan evolution of system
✓Act: Simulate events
✓React to user interaction
Knowledge base
Agent
Systemic Behavior
Situational Simulation Environment
Agent
Agent
✓Capture disturbance in the system equilibrium
✓Project sensitivity of environment
✓Take decisions
✓Reallocate
✓Allocate


Synchronized
Discrete Variables
$D = \{v_d\} \subset E$
$v_d \in \{s_1, s_1 \ldots s_n\}$
Agent
Global Scope
Ex: weather
Continuous
Variables
$C = \{v_c\} \subset E$
Situational
Simulation
Environment
Activity
Specific
Ex: material
availability
Interface
Variables
$I = \{v_i\} \subset E$
Agent
Agent

The Framework



Grammar:

F :: O1 O2 . . . On

O :: A B o | A o

O(E1) :: E2

F: Framework

O: Operation E: Entity

A: Agent B: Bases

o : Reasoning algorithm

The Framework

- Environment defined as a set of variables
- Operation defined on Environment
  - *O(E)*
- Agents implement Operations
  - *A.O(E)*

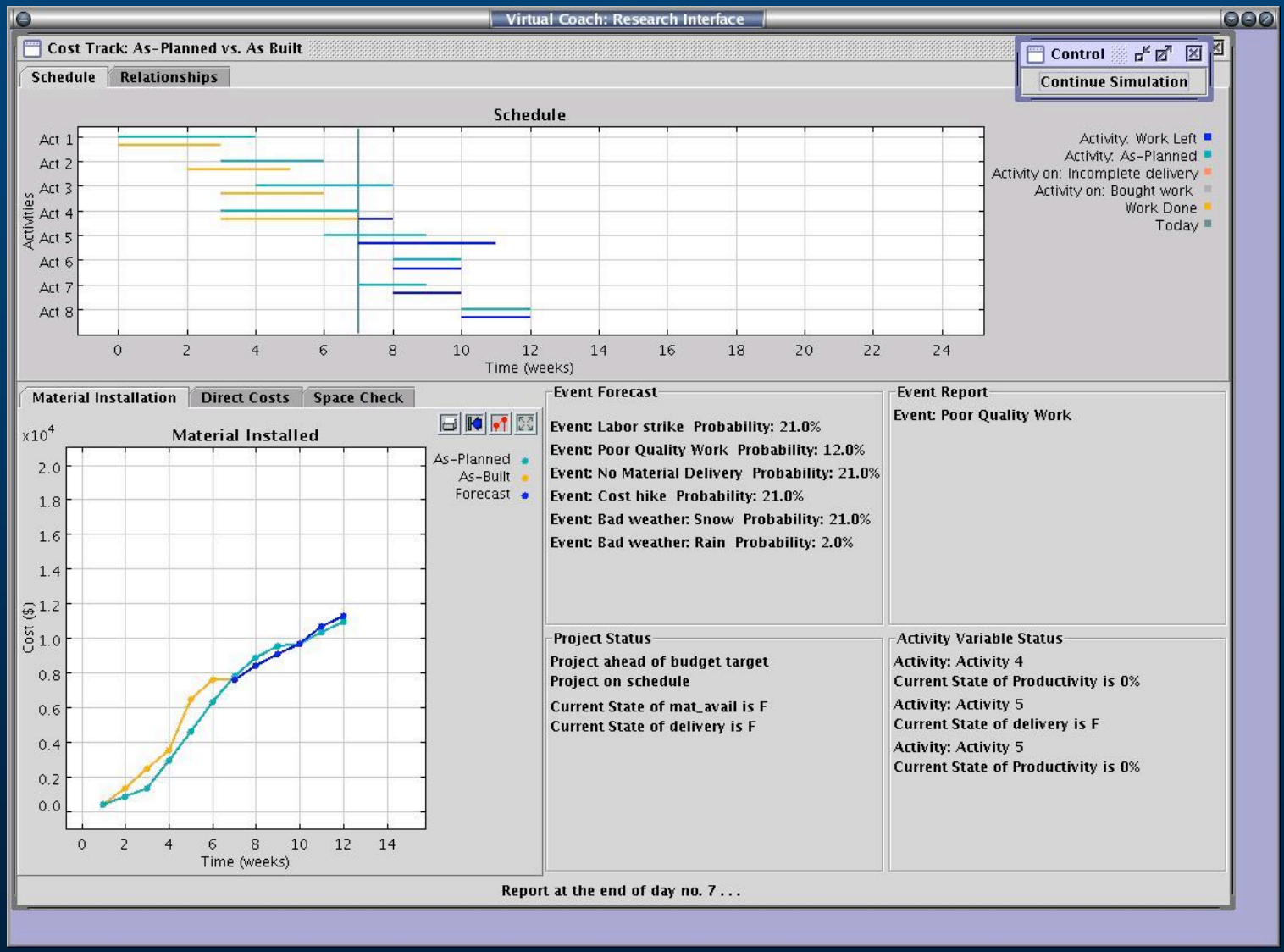
The Virtual Coach

- Database (DB)
  - As-Planned Schedule
  - As-Planned Resource Allocation
  - Unit Resource Costs
- Knowledge Base (KB)
  - Event definitions {Pre-Cond} □ {Post-Cond}
  - Event frequency

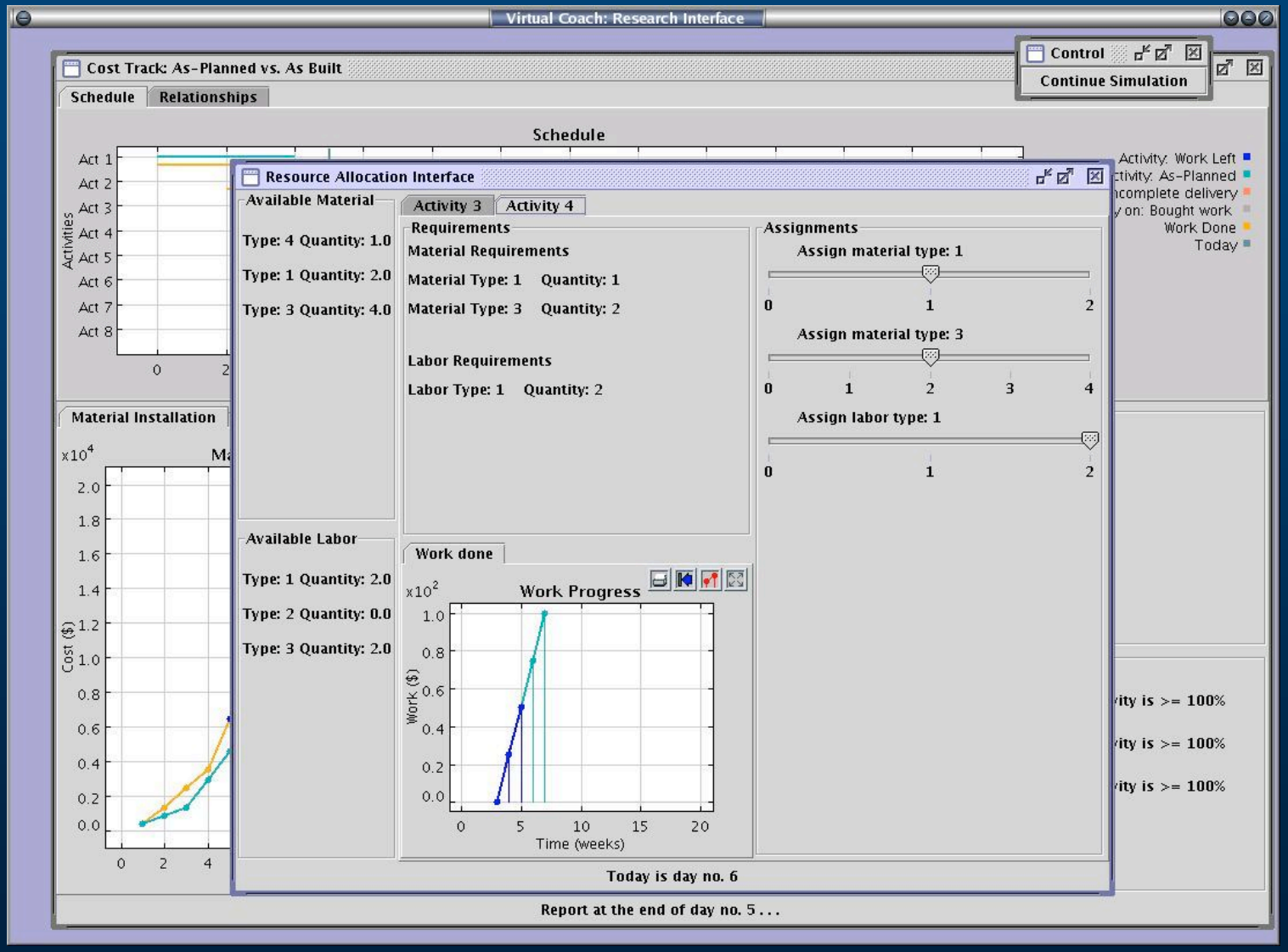
The Virtual Coach

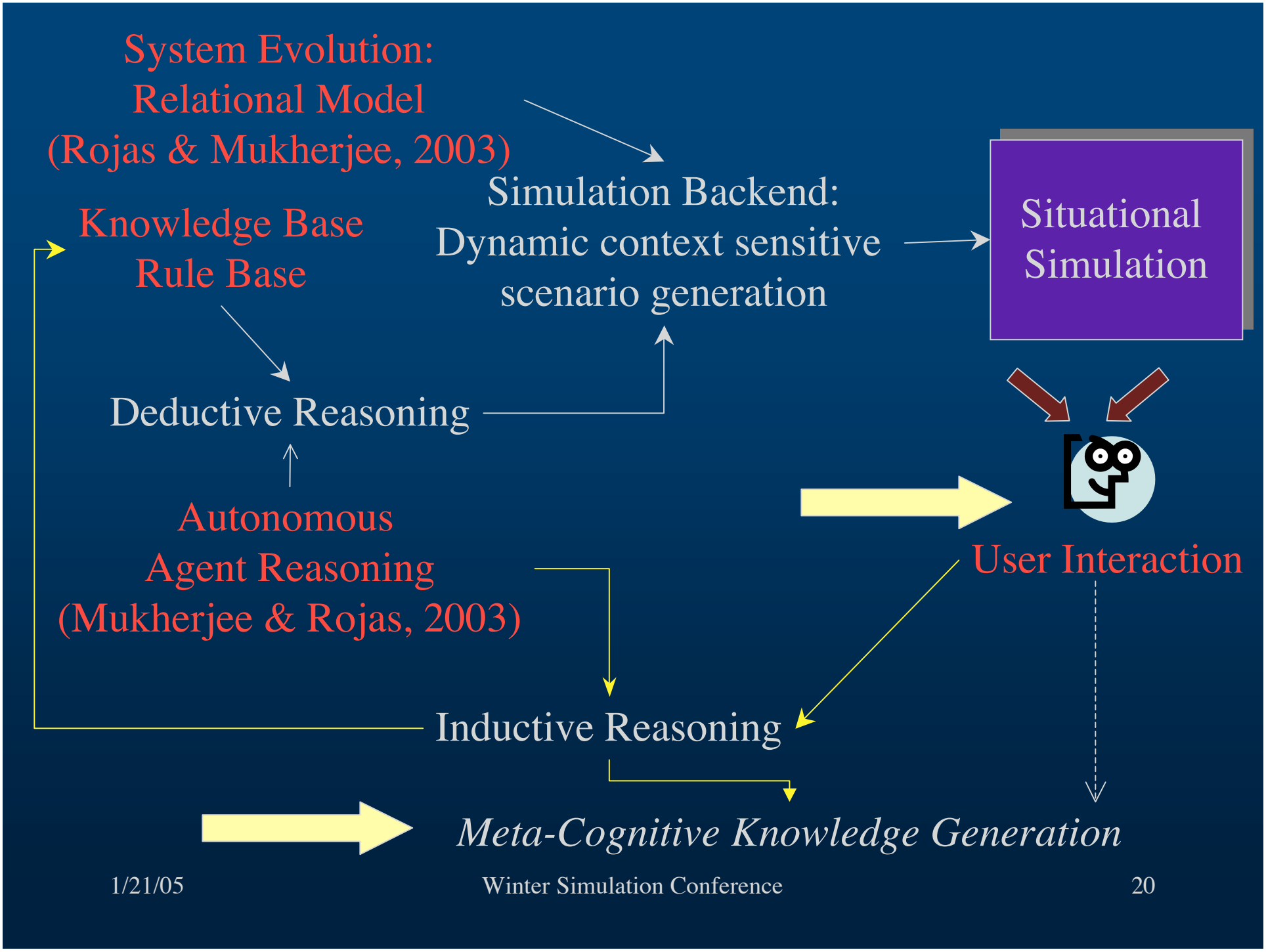
- Three Agents and Operations
  - LA: Create, Infer
  - MA: Unite, Compute
  - VA: Visualize
- Utilities
  - Scheduling

The Virtual Coach



The Virtual Coach

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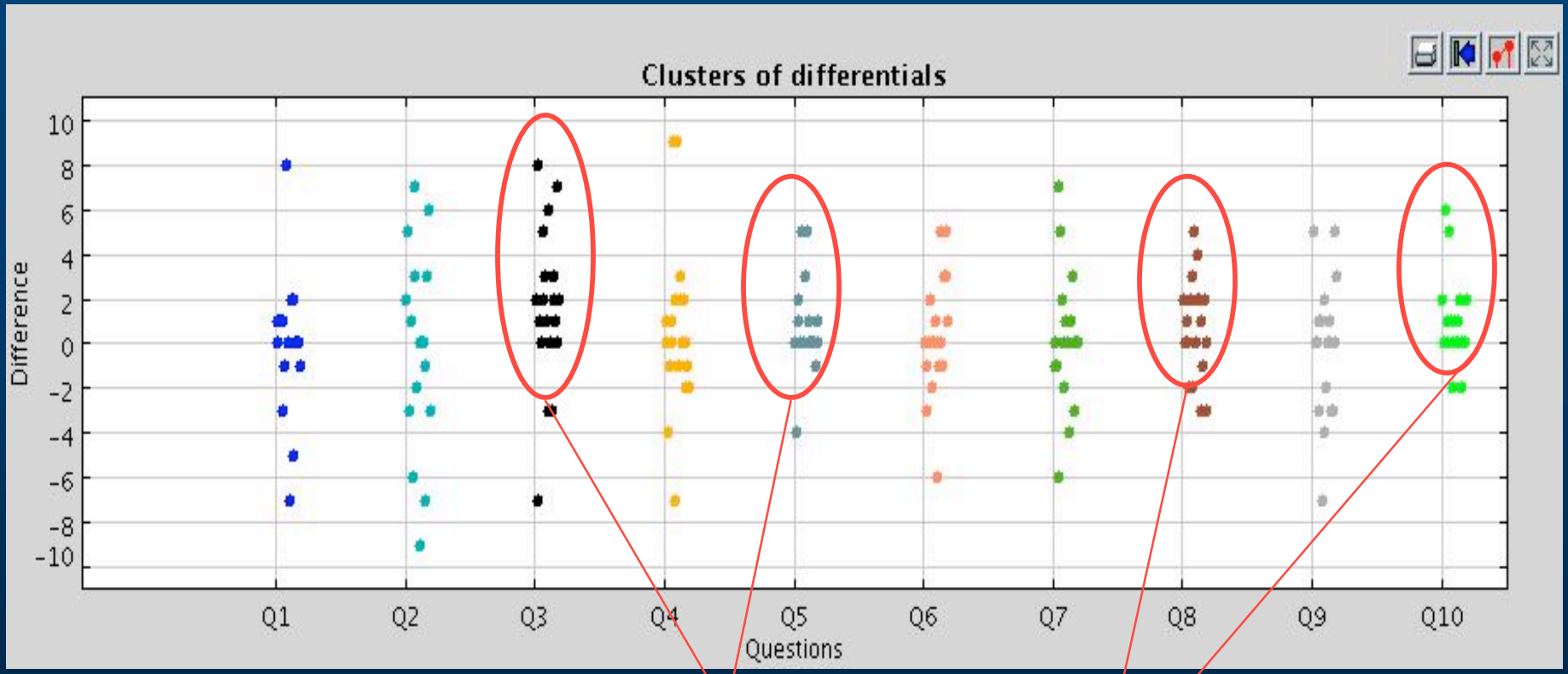
Testing

- Tested with 19 Senior level CM students: Pre-test/ Post-test protocol
- Claim I: The environment is useful for training Construction Managers
- Claim II: Learning in the CM domain is based on an understanding of *Precedence and Resource Constraint Satisfaction*

Results



Temporal Constraint Satisfaction

Event Scheduling / Event Premonition

Discussion

- Learn interactively
- Understand constraints
- Apprehend problems
- Discover systemic relationships

Future Work

- Study the CM domain as a Human-Resource Coupled System
- Explore Mental Models of Experience
- Generate KB from Expert participation
- Develop an ontology for CM applications

Reinventing the Wheel?

- Not simulation of *The Operation*
  - Instead simulate processes *As it Happens*
- Planning and context-sensitive reasoning environment
- Web-based implementation
- Not an “Either-Or”

Acknowledgements

- Human Interface Tech. Lab., UW
- Ted Herb, Principal, GLY Construction, Seattle

Questions ?