



# Educational Technologies WS2006

## Interactive Exercises

George Gogvadze

[george@activemath.org](mailto:george@activemath.org)

# Approximate Plan of the Course

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18.10. Introduction

25.10. Introduction to ActiveMath

XML- Knowledge Representation

8.11. Student Modelling

15.11. Web technologies and security

22.11. Tutorial Planning and instructional design

29.11. Media Principles

6.12. Interactive exercises

13.12. Authoring tools, CTAT

20.12. Diagnosis: model tracing and domain reasoning

10.1. Diagnosis: constraint based

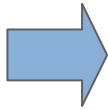
17.1. Tutorial dialogues

24.1. Action analysis and Machine Learning techniques

31.1. Cognitive tools

7.2. Meta-cognitive support

14.2. student projects



# Overview on this Lecture

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## ▶ Existing Approaches

- ▶ Exercises in CAI systems
- ▶ ITS Exercises

## ▶ ActiveMath approach

- ▶ Exercise System Architecture
- ▶ Knowledge Representation
- ▶ Tutorial Strategies
- ▶ Exercise Generation

# Computer-Aided Instruction (CAI) or CAL

- ▶ store and retrieve data, exercise bank with answers
- ▶ pre-defined branches of problem solving
- ▶ no ,understanding‘ of problems, few anticipated wrong answers
- ▶ Independent of student‘s understanding, preferenes, behaviour
- ▶ linear (not individualized) progression of instruction
- ▶ no diagnosis of errors

# Authoring Tools

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- ▶ **It is hard to Program each exercise**
- ▶ **Generic markup languages describe exercises**
  - ▷ QTI1
  - ▷ QTI2, MathQTI
- ▶ **Authoring tools help constructing exercises**
  - ▷ Many authoring tools for QTI1
  - ▷ Tools for QTI2 in progress
  - ▷ Mqat for MathQTI
- ▶ **Still for sensible exercise all answer possibilities have to be encoded for a question (lack of semantic expertize)**

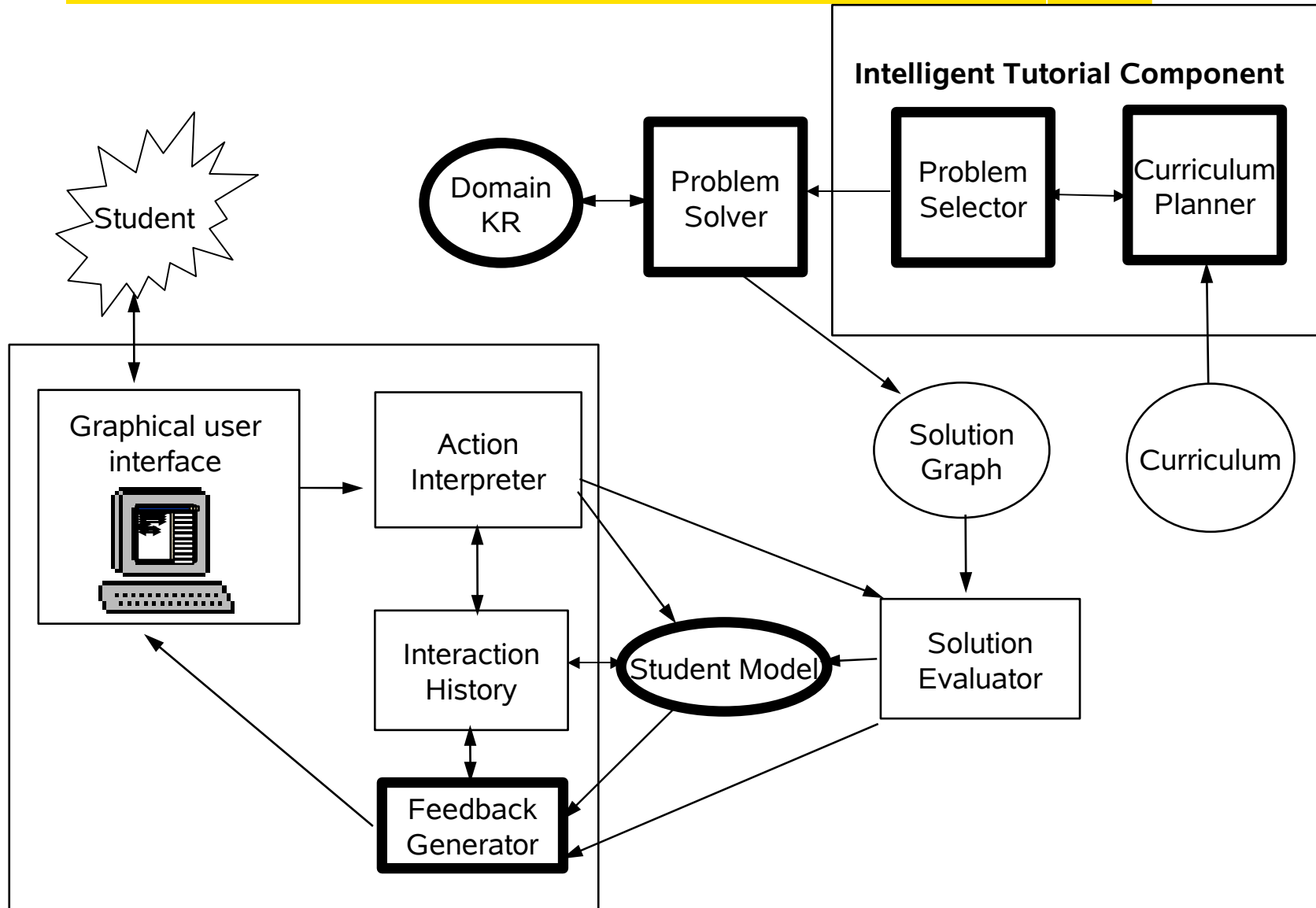
# Intelligent Tutoring Systems (IST)

- ▶ Domain Expert Module
  - ▷ Domain reasoner, generating solution paths
  - ▷ Possibly generating erroneous paths
- ▶ Student Model
- ▶ Tutoring module

Examples.

- ▶ **ANDES** – (van Lehn et al)
- ▶ **Cognitive Tutors** (Koedinger et al)

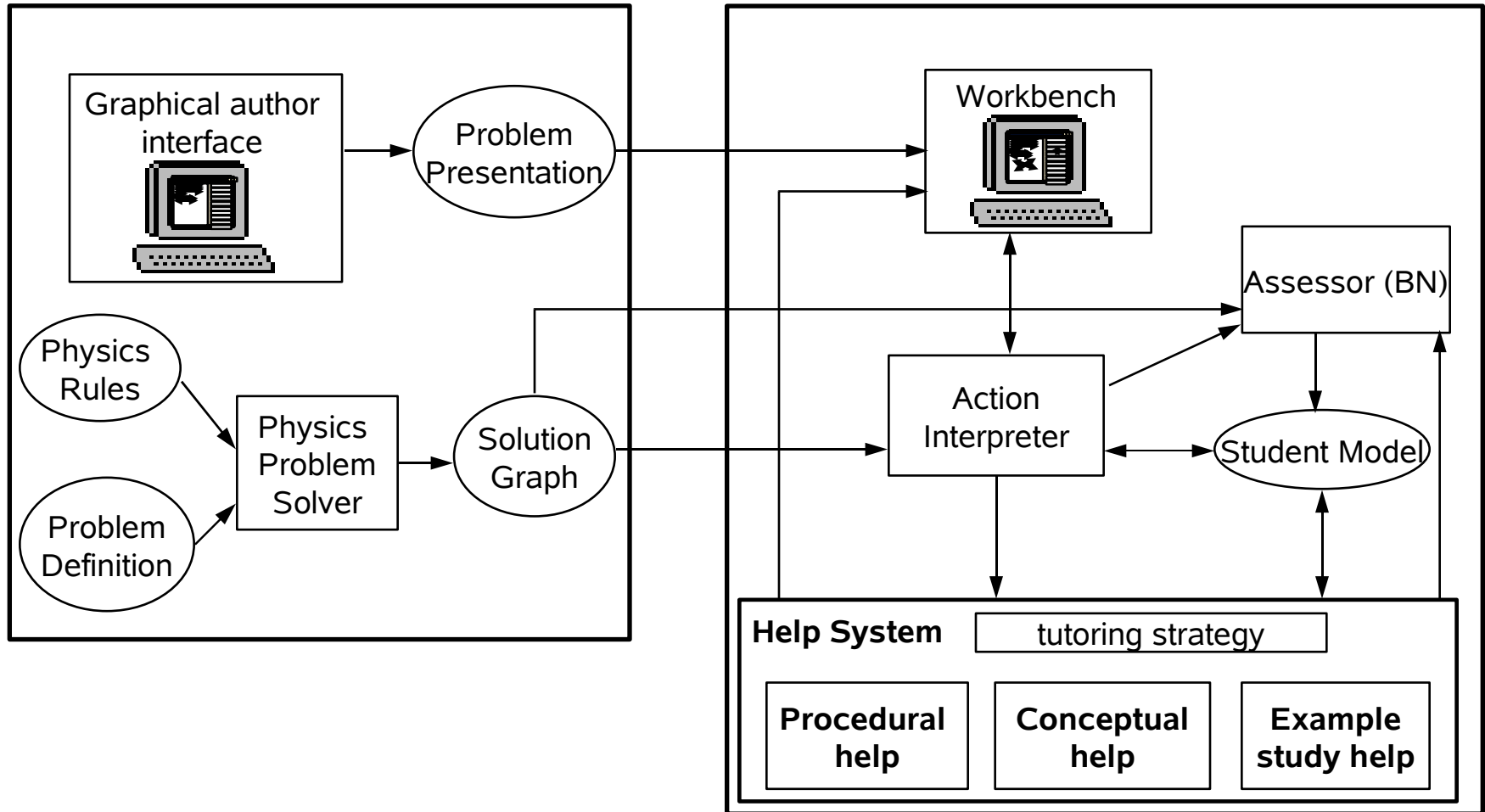
# A Generic ITS Architecture



# Andes Architecture

## Authoring Environment

## Student Environment





# Authoring Tools for ITS

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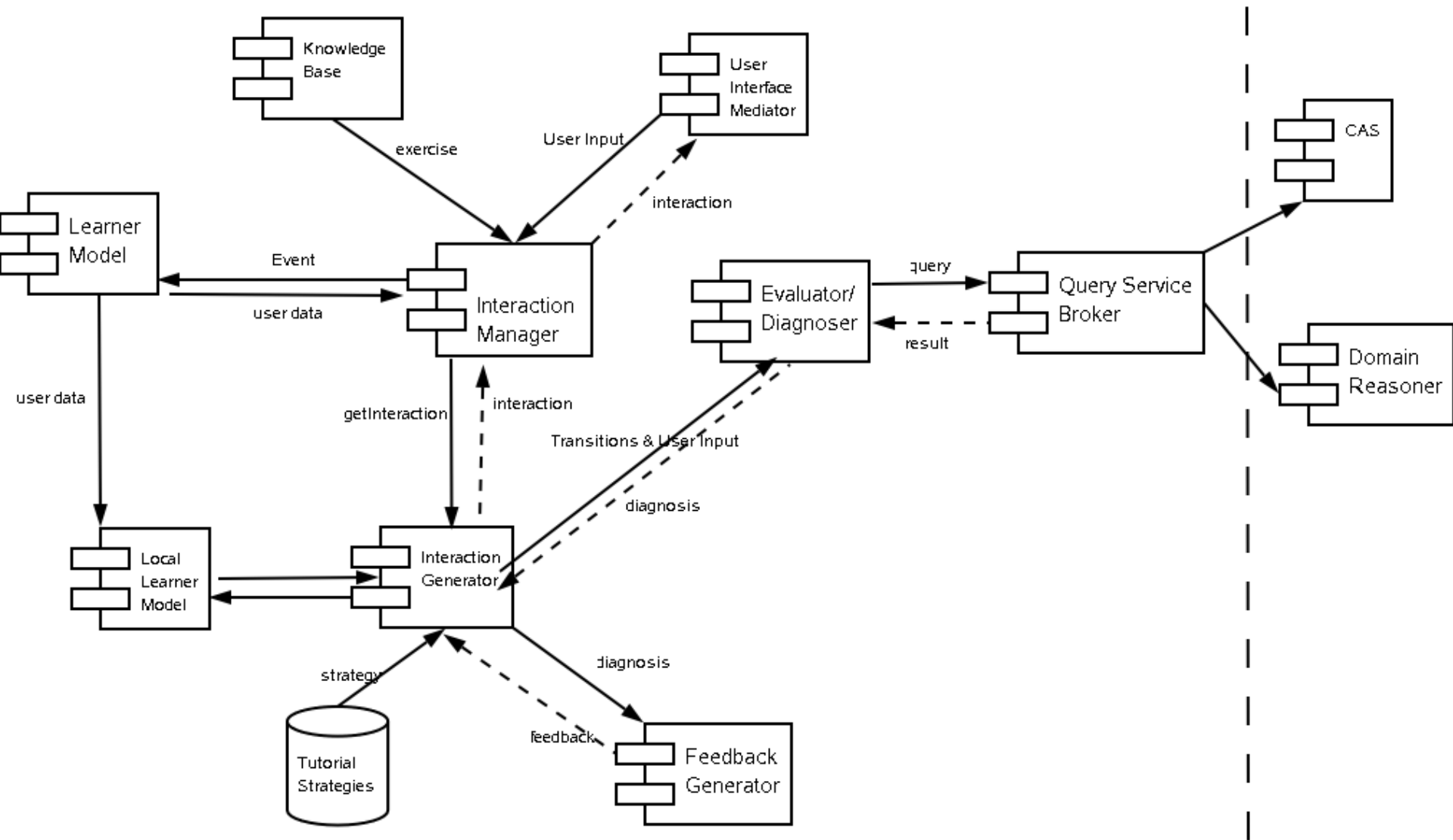
- ▶ CAI authoring tools are not enough
  - ▷ **Template based authoring suitable for manually authored exercises**
  - ▷ **Complex domain model requires programming**
- ▶ Domain Expert Module has to be implemented
- ▶ Student model has to be programmed
  - ▷ **In principle domain independent procedure**
  - ▷ **But for each domain it has to be programmed**
- ▶ Tutoring module
  - ▷ **In principle domain independent**
  - ▷ **Tutorial strategies differ dependent on the domain**
- ▶ Interface depends on the domain as well
  - ▷ **e.g. ANDES interface is suitable for physics problems**
  - ▷ **Generic interface would be too complex**
- ▶ In practice
  - ▷ **ITS has to be programmed separately for each domain**
  - ▷ **Very expensive**
  - ▷ **Requires developers to be domain experts and pedagogists**
- ▶ No more human control possible

# ActiveMath Approach

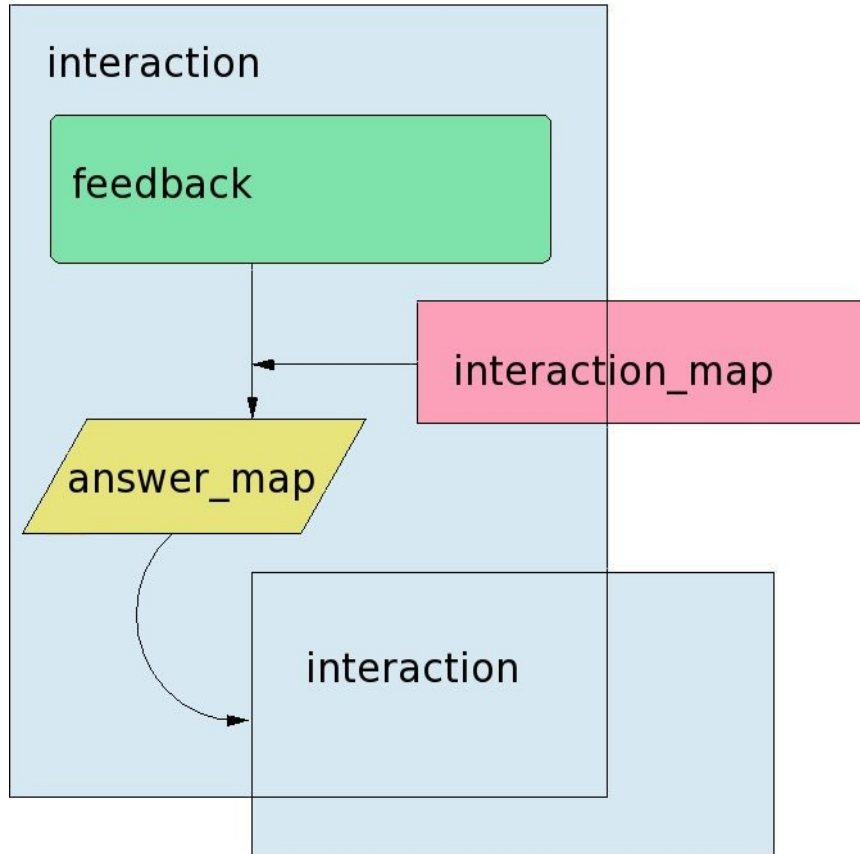
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- ▶ **Exercises were originally manually authored**
  - ▷ Rich knowledge representation for manual authoring
- ▶ **More diagnosis was necessary**
  - ▷ Employing Computer Algebra Systems (CAS)
  - ▷ Connecting to External Domain Reasoners
- ▶ **More feedback was necessary**
  - ▷ generating feedback based on intelligent diagnosis
  - ▷ designing automatic feedback strategies
- ▶ **More exercises were necessary**
  - ▷ encoding classes of exercises
  - ▷ generating exercises using Domain Reasoner

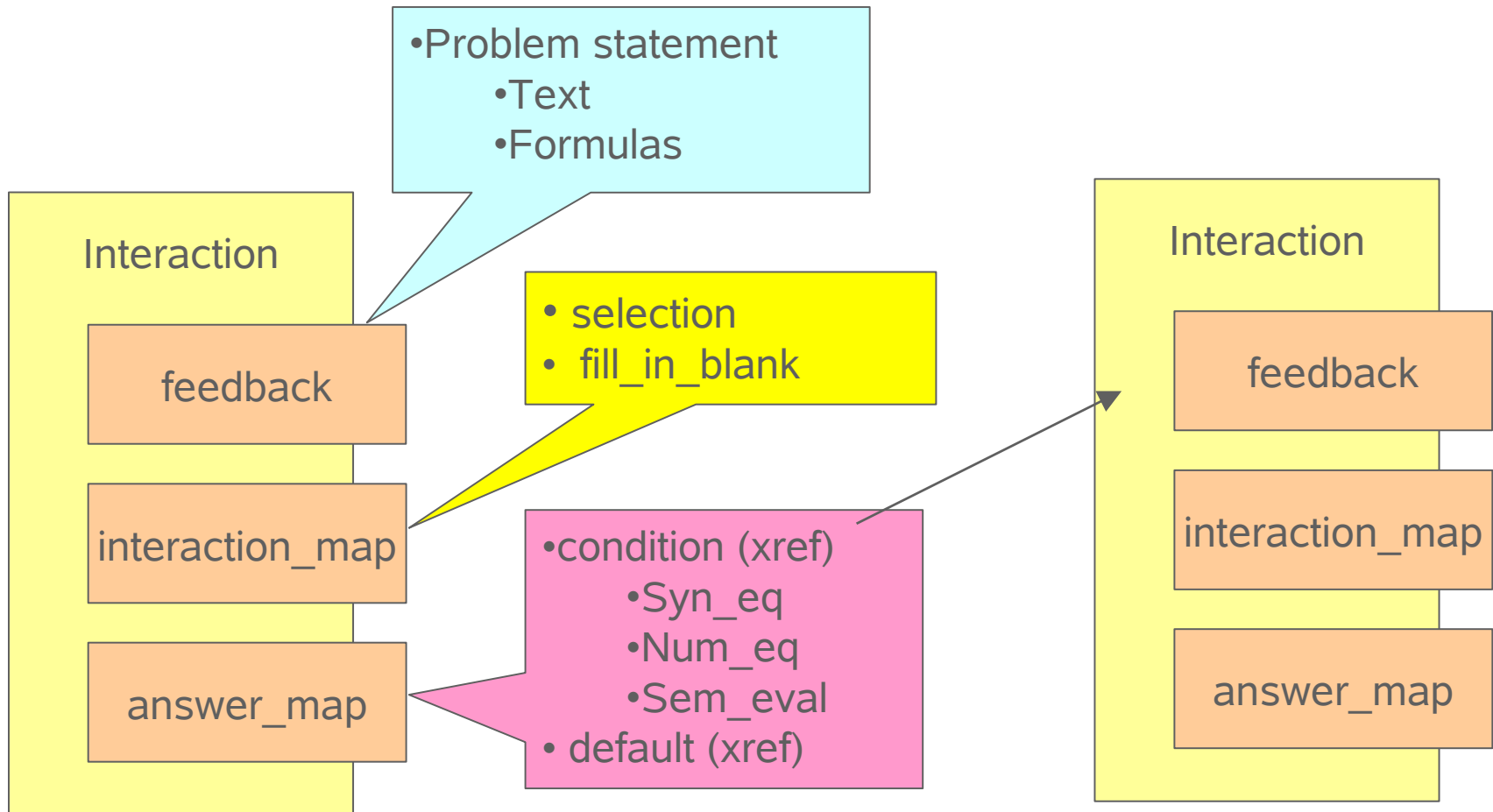
# ActiveMath Exercise System Architecture



# ActiveMath Exercise Knowledge Representation



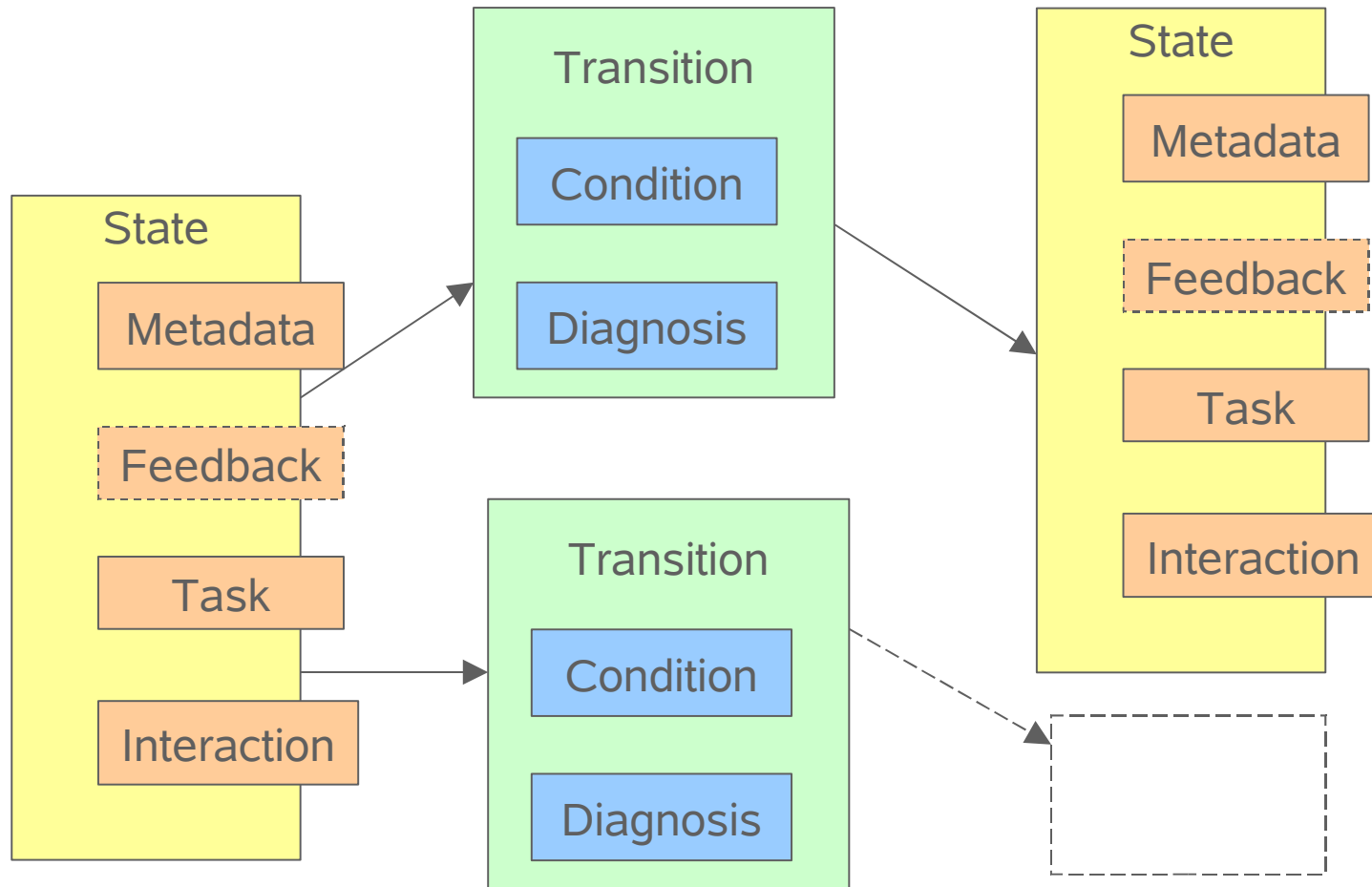
# ActiveMath Exercise Knowledge Representation



# ActiveMath Exercise Knowledge Representation

Sample Source Code

# Future Exercise Knowledge Representation



# ActiveMath Exercises

http://learn-calculus.activemath.org - ActiveMath - Exercise

## Le Math Active

### Exercise

**Computation of the derivative of**

Compute the derivative of the polynomial

$$f(x) = 154x^3 - 9.8x^{7+\sin\pi} - 30.6x^{30-2+1}$$

Editing Element

Edit Option

Editing Element

Basic Arithmetic Relations Analysis Functions Lo

$154x^3 - 9.8x^{7+\sin\pi} - 30.6x^{30-2+1}$

Java Applet Window

http://amath06:8080 - ActiveMath - Exercise - Mozilla Firefox

## Le Math Active

### Exercise

**The total average slope of a curve ★★**

Compute the average slope of the depicted curve between  $A = (x_A, y_A) = (0, 100)$  and  $B = (x_B, y_B) = (4000, 200)$ .

$m_{AB} = \frac{4000}{100}$

Not quite. Please check the formula for the average slope. It seems that you mixed numerator and denominator.

$m_{AB} = \frac{100}{4000}$

Well, this fraction can be further simplified.

$m_{AB} = \frac{1}{40}$

Well done!

Evaluate Give Up

Print | Help

4 ≤ 4 · n - 3

≤ 4 - 3 does not hold in some

≤ 4 · n - 3 fails

nt!

e for all

= 1, it holds

e statement

yntax help Hint Give Up



# Tutorial Strategies



### Exercise with Inequality

Solve the inequality (you have 3 tries):

$$3 \cdot x + 2 < 11$$

$$x < 1$$

Wrong! Try again:

$$x < 2$$

Wrong! Try again:

$$x < 2.5$$

Wrong! You have failed the exercise.

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### Exercise with Inequality

Solve the inequality:

$$3 \cdot x + 2 < 11$$

$$x < 1$$

Wrong! Try again:

$$x < 2$$

If we subtract 2 from both sides of the inequality, we obtain:

$$3 \cdot x < 9$$

Try now:

$$x < 2.5$$

Wrong!

The correct answer would be :

$$x < 3$$

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# Exercise Generation

http://learn-calculus.activemath.org - Active

## Le Math Active



### Berechnen der Ableitung

Berechnen Sie die Ableitung des

$$f(x) = 2 \cdot 7 \cdot x^6 - 6 \cdot 8 \cdot x^7 + \sin \pi - 6$$

Stimmt! Eine weitere Übung auf

Sie haben nun die Möglichkeit, die Übung mitzuteilen.

Wie gefiel Ihnen diese Übung? ga

Wie aufwendig war diese Übung für Sie? ga

Sind Sie mit dem Ergebnis dieser Übung zufrieden? ga

Die Übung ist beendet, bitte das

Schließen

http://localhost:8080 - ActiveMath - Exercise - Mozilla Firefox

Then the derivative function of  $f$  is given by  $f': \mathbb{R} \rightarrow \mathbb{R}$  (resp.,  $f': \mathbb{U} \rightarrow \mathbb{U}$ ) with

$$f'(x) = a \cdot n \cdot x^{n-1}.$$

For  $n < 0$  this requires  $x \neq 0$ .

According to the rule: power rule, the expression  $x \mapsto x^2$  transforms to  $2 \cdot x^1$ .

2 · x

Well Done!

Enter the function to differentiate:

2 · x + sin x

Okay, let us differentiate this:

x + 2 · x' + x + sin x'

Well done!

You have at most 4 steps left!

x + 2 · x' + x + sin x'

Well done!

You are not getting closer to the solution with this step.

2 + cos x

Well Done!

I want to try another function!  No thanks, it was enough.

Evaluate

# Authoring an Exercise

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▶ Interactive Demo with Exercise Authoring Tool