

Saleh Al-shomrani  
Department of Computer Science  
Kent State University

# Design and Implementation of a Web-based Distributed Mathematics Assessment System (DMAS)

Progress and Demo

# Outline

- **Introduction**
- **DMAS System Views**
- **DMAS System Components**
  - DMAD -- The Core Component
  - Authoring Tool
  - Assessment Test Giving
  - Grading and Results Administration
  - Comprehension Diagnosis and Linking to Remedial Materials
  - Assessment Markup Language: MAML
  - DMAS System Interface to Web Applications
  - Assessment Web Service
- **DMAS Actual Implementation and Trial**
  - Building of experimental system to work with WME
  - Pilot use in schools to collect teacher and student feedback
- **DMAS and Formulas, Geometry, and other fields**
  - DMAS and Mathematical formula handling
  - DMAS and geometrical graphing
  - What prevents DMAS from becoming a useful tool for "Assessment in other areas such as English or history?"
- **Conclusions and Future Work**

## Introduction

Teaching and learning Mathematics on the Web are increasingly popular with school teachers, educational experts and even by normal people due to easy Internet accessibility, flexibility, and interactivity.

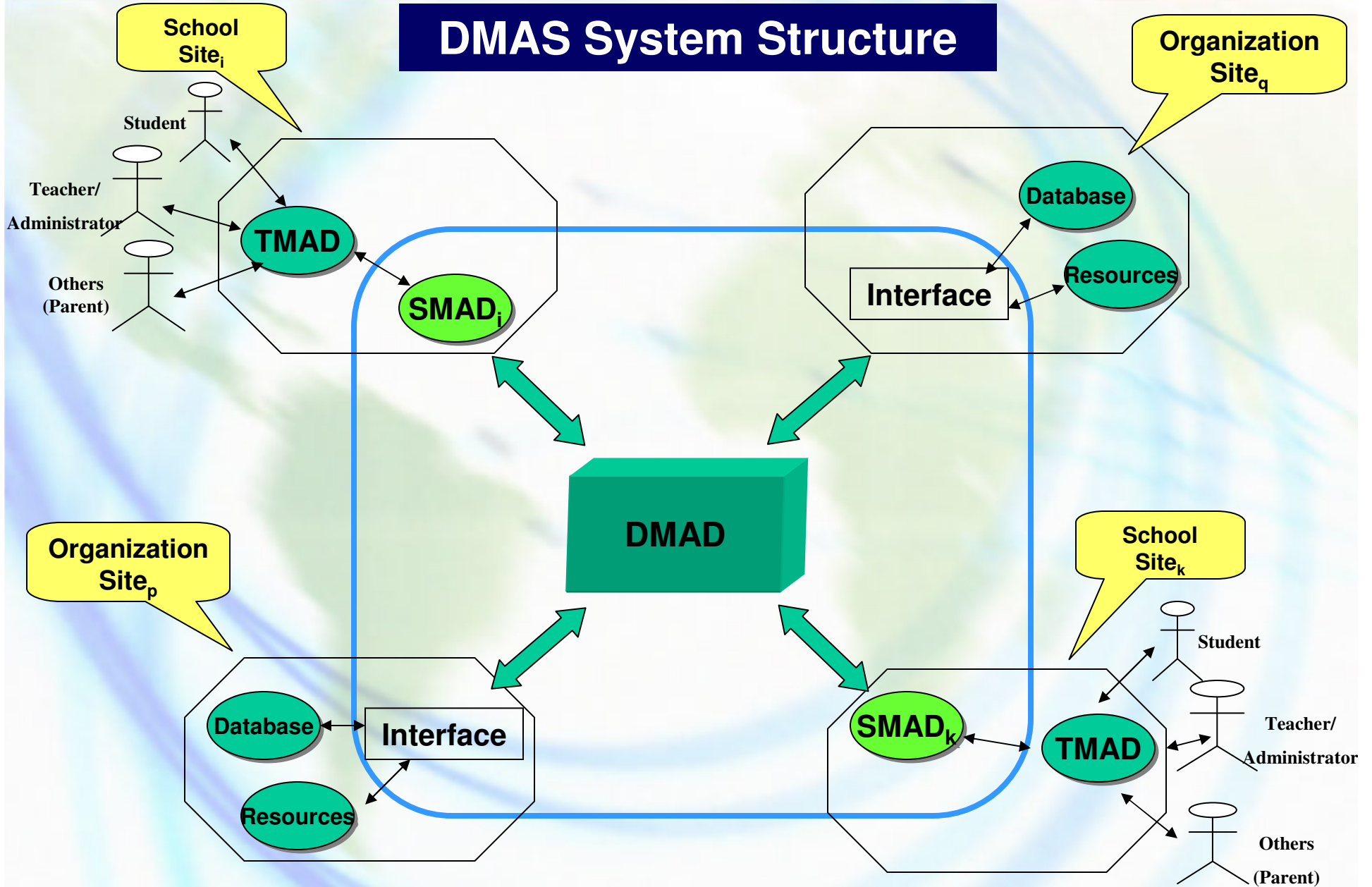
Assessment, measuring the effects of educational concepts, student performance and comprehension, is a very important.

Assessment tests should also diagnose learning difficulties and determine knowledge shortfalls. The United States *No Child Left Behind Act of 2001 accountability components* include “performance on state designated assessments in reading and mathematics”.

To support assessment, I am developing a comprehensive and distributed system called DMAS.

DMAS is a *Web-based Distributed Mathematics Assessment system* that can support the assessment needs of Mathematics teachers and students and can serve and interoperate with other online systems such as WME as well as work independently.

# DMAS System Structure



09/20/2006



# DMAS System Views

## (1) Global View

This view represents a general picture of the whole DMAS system:

- **Importing and exporting questions:**

DMAS user can *import questions* of interest simply by marking (selecting) them, choosing the destination assessment, and then all selected questions will be copied to the teacher's TMAD database. Imported materials can be customized and used in assessment tests, homework assignments, and quizzes. On the other hand, Teachers can select questions from his/her personal TMAD and *export them* either to the local SMAD or to the public DMAD.

- **DMAS search:**

A teacher can easily *search for assessment questions* on particular subjects and at specific grade levels. The search covers the local SMAD and transparently the rest of DMAD. The search can be narrowed by subjects, topics (for example, fractions, algebra, geometry, and measurement), keywords and grade levels.

- **Adding/Deleting TMADs/SMADs from the DMAS system:**

Since DMAS system consists of different participating schools (SMADs) and Teachers Assessment Databases (TMADs) in different locations or sites, adding a new participating school site (new SMAD) or deleting existing one is an essential to the DMAS structure. Unlike central systems, the distributed nature of the DMAS system adds an extra burden on the DMAS Search engine to successfully handle issues of adding new site or removing existing school sites from the collection in such good and transparent way.

## DMAS System Views (cont.)

### (2) Local View

This is related to doing Assessment in schools *locally*, which may include:

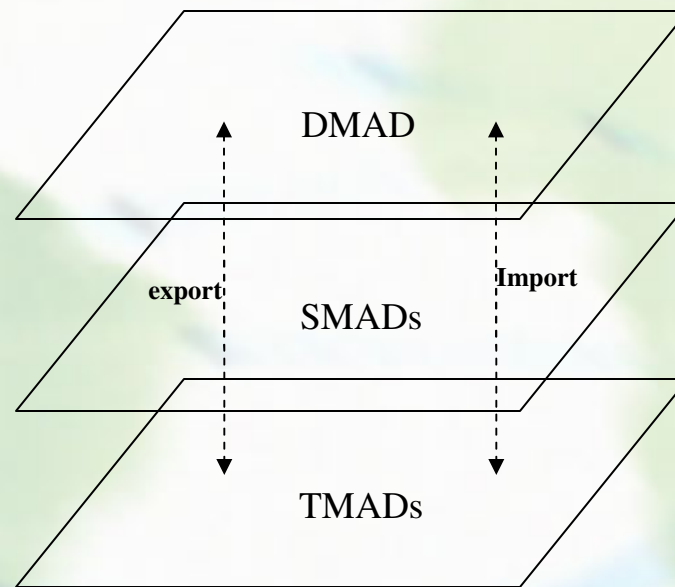
- **Authoring Tool:** Teachers can create new questions/tests, view, edit (reword) and delete existing ones. Questions/tests may include text, graphs, images, or formulas.
- **Managing Assessment Tests :** Teachers can prepare/generate their own assessment tests, homework assignments, or quizzes either from scratch (by authoring their own questions) or by importing questions from the DMAD bank.
- **Conducting Assessment tests** – DMAS provides teachers with two testing options: online testing and paper testing.
- **Grading and results administration.**
- **Comprehension diagnosis and linking to remedial materials.**

# DMAS System Components

DMAS system generally consists of the following **components**:

- **Core database DMAD** (*Distributed Mathematics Assessment database*) and other local databases,
- **Authoring tool for teachers**
- **Assessment test giving**
- **Grading and student results administration** comprehension diagnoses and linking to remedial materials,
- **New Assessment Markup Language MAML**: *Mathematics Assessment Markup Language to be used in assessment material representations and encoding,*
- **DMAS system interface to Web Applications, and**
- **Assessment Web Service.**

## DMAD -- The Core Component



**DMAS System Levels**



## DMAD -- The Core Component (cont.)

- **DMAD** (Distributed Mathematics Assessment Databases): *is a distributed database with local databases at different school sites.* Within DMAD we have:
  - **TMAD** (Teachers Mathematics Assessment Database): *is a database assigned to mathematics teachers of same school.*
    - It stores and manages assessment tests, homework assignments, questions, student answers, grades, statistics and other info for each individual teachers.
  - **SMAD** (School Mathematics Assessment Database): *is created for individual school as part of its school site.*
    - A SMAD connects TMADs within the school and SMADs at different schools through the DMAS system.
    - The SMAD performs a critical role in enabling the sharing of assessment materials within and without a school.

## Authoring Tool

- One of the most powerful features and basic components of the DMAS system is offering an **Authoring Tool** for assessment tests and questions.
- Questions and tests can include text, graphs, images, or formulas. Teachers can *create new questions, view, edit (reword) and delete existing ones*.
- Different types of questions that DMAS system can support: true-false, multiple-choices, short-answer, essay (extended answer), and two-menu-matching questions.
- The test author can also connect incorrect answer options to common mistakes, misconceptions, or missing background knowledge.
- DMAS can help correlate such diagnostic information with school Lesson Pages, which can help students overcome difficulties exposed by the assessments.
- Authors can import pre-made questions from DMAD into their tests. Once that happens, all those imported materials can be customized and modified if needed and included in assessment tests. Any question created or imported can be exported to again to DMAD.

## Authoring Tool (cont.)

- Teachers can also prepare/generate their own assessment tests, homework assignments, or quizzes either from scratch (by authoring their own questions) or by importing questions from the DMAD bank and then the teacher can store assessment test for future use. The default status of these assessment tests (questions) is hidden from students. That is for additional security purposes and also the teacher can prepare her test long before class time. Hence the teacher has to clearly make her assessment test public to be shown to students.
- DMAS system provides teachers with two testing options: online testing and paper testing. Automatic grading and other useful statistics are only supported for the online testing. However, teachers can have hard-copies of their assessment tests for in-class testing at any time. Teachers also have control over students who can/can't take assessment tests and who is eligible for test retake.

# Authoring Tool (cont.)

What is the correct value of x for the following formula?

Edit Formula (Infix):  
(-x+8)/4 + sqrt(x) \* x = 9 Convert to MathML

$$\frac{-x+8}{4} + \sqrt{x} \times x = 9$$

A:

9

4

2

Please enter the correct answer number:

Commit Changes



# Authoring Tool (cont.)

http://wme.cs.kent.edu - MagicMath - Teacher New Question - Windows Internet Explorer

## New Assessment Question

Solve the following?

$$x^2 + 3$$

and compare to:

$$x + \sqrt{4}$$

Explain?

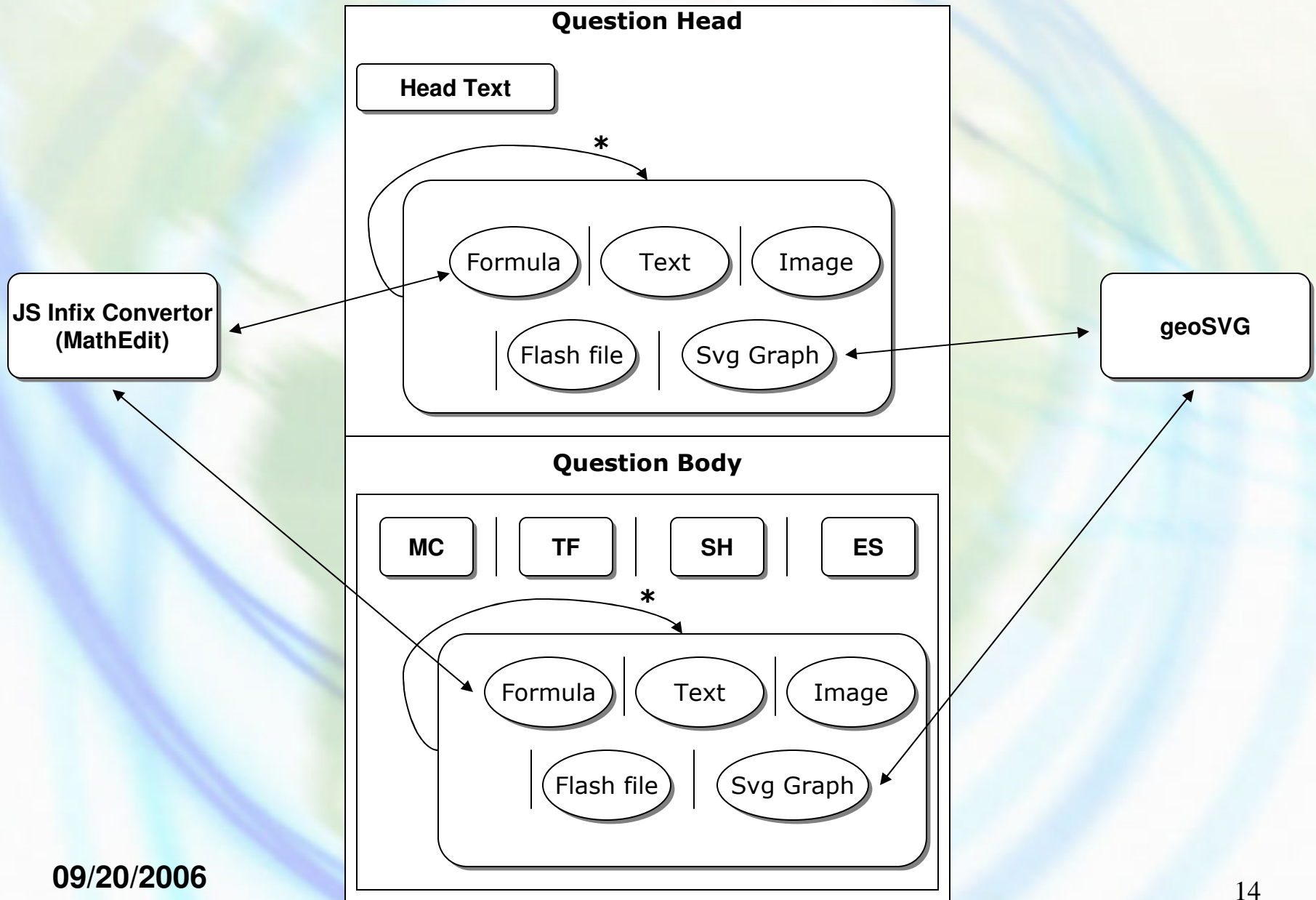
Please Type your Question:  
Solve the following?

(1) Formula:

(2) Text:

(3) Formula:

# Question Structure

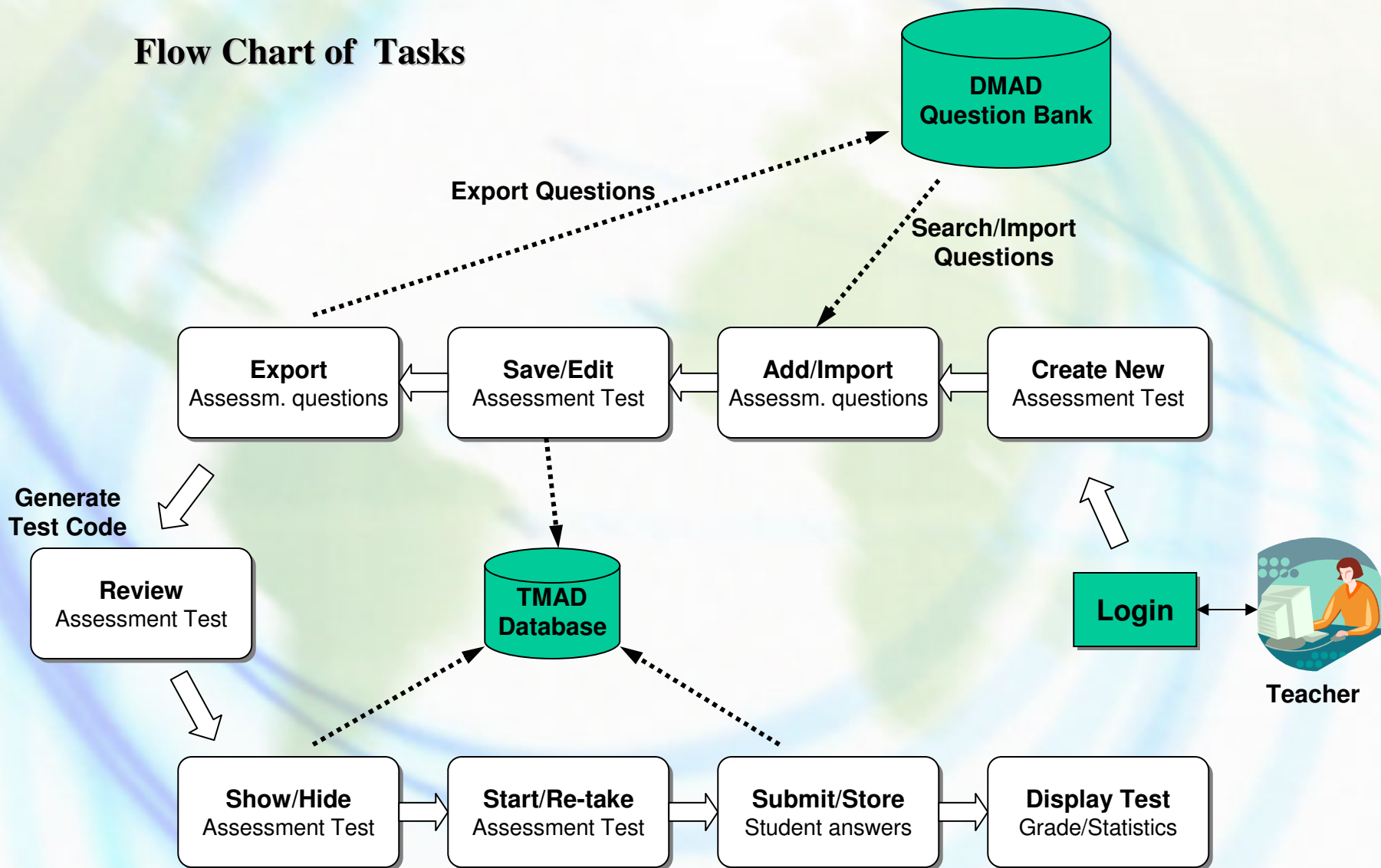


## Assessment Test Giving

- DMAS system enables teachers to author, store, and conducts assessment tests either in class or as homework assignments.
- It provides teachers with different ways or *permutations* of Test display and can have multiple forms of same exams.
- It supports the two types of testing: online testing and paper testing.
- It also supports an *accumulative submission and storage* of student answers on question-by-question basis.
- Moreover, it allows some specific students (controlled only by their teachers) to *Retake* assessment tests if needed.

# Assessment Test Giving (cont.)

## Flow Chart of Tasks





## Assessment Test Giving (cont.)

- **Online Test Security**
- *Security* is a basic requirement of assessment testing in general and in an online testing more specifically.
  - Students usually forget their usernames, passwords, or both especially at the lower grade levels which has been considered time consuming or class time wasting by their teachers helping students to login.
  - Using already known usernames and passwords is considered not secured enough and vulnerable. Because students may give their login personal information to friends or even to classmates to help them in their tests.
- **Special Test Codes**
  - For the reasons mentioned earlier and other security concerns, I have come to conclusion that I have to avoid such types of standard login systems and find a better way as an alternative. So I have decided to use an easier yet more secure login system using *per-test codes* generated by teachers through an API (Application Programming Interface).

# Assessment Test Giving (cont.)

http://wme.cs.kent.edu - MagicMath - Test Codes Form - Windo...

seq.	Student Name	Student Code	Re-take Test?	Student Code(2)
1	Adam Ben	1550	Enabled	7347
2	David	2199	Enabled	9078
3	Jack	2466	Disabled	
4	Alina K.	3143	Disabled	
5	Jim II	3986	Disabled	
6	Alan	4161	Disabled	
7		5572	Disabled	
8		7787	Disabled	
9		8793	Disabled	
10		9443	Disabled	

Save Changes

http://wme.cs.kent.edu - MagicMath - Test Codes Form - Windows Internet ...

For Test: Mid\_Term

Please choose code type:

- Numeric (numbers only)
- Alphabetic (Capital letters only)
- Alphabetic (Small letters only)
- Alphabetic (Mix capital and small letters)
- Alphanumeric (Capital letters only)
- Alphanumeric (Small letters only)
- Alphanumeric (Mix capital and small letters)

Please enter code length (number of digits): Integer (4 - 20):

Please enter number of students (no of codes needed), Integer (1 - 99):

continue

http://wme.cs.kent.edu - MagicMath - Login form - W...

### Student Login

Student Name:

Student Code:

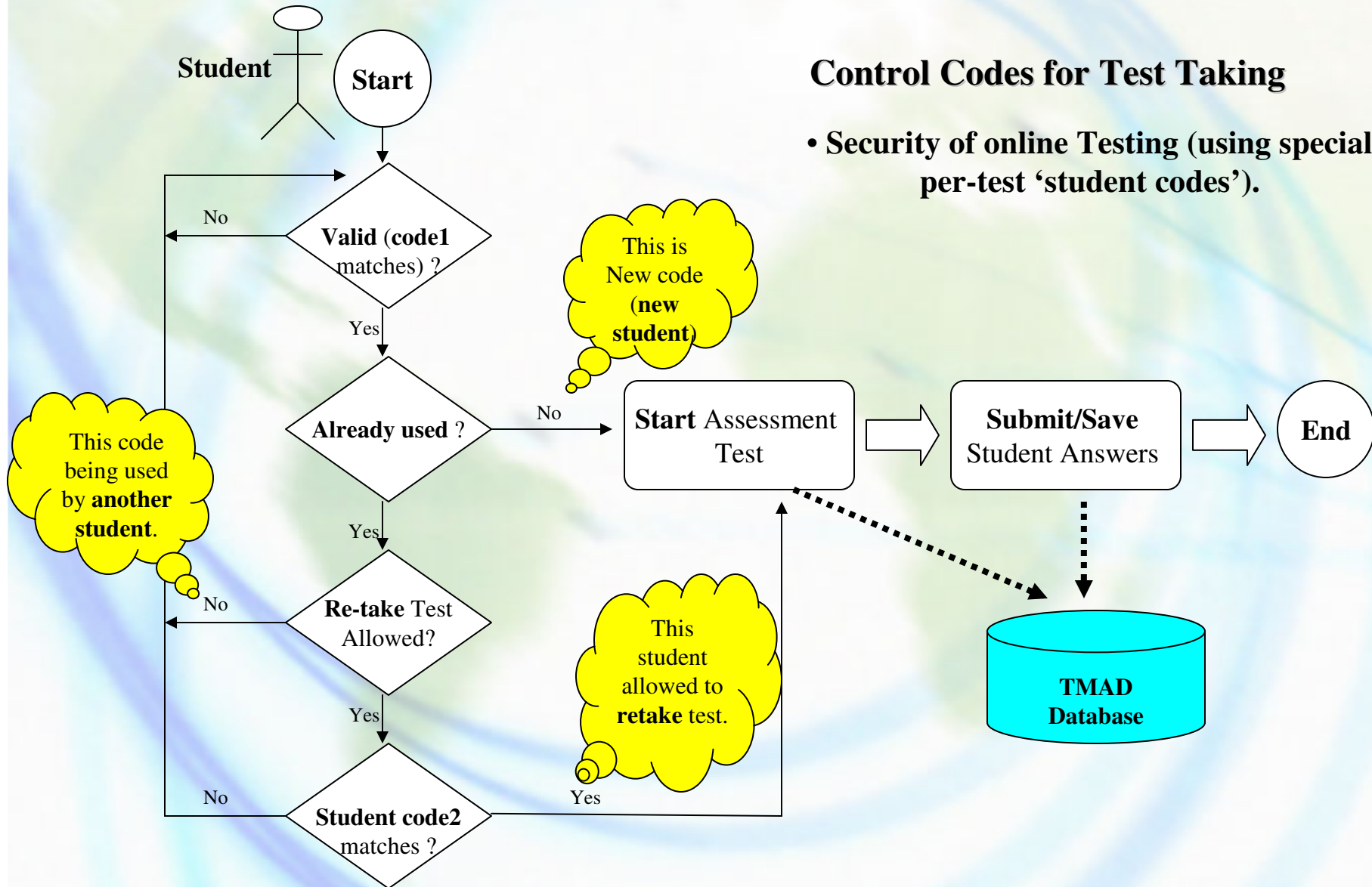
Login

---

Re-take test?

Second Code:

## Assessment Test Giving (cont.)



### Control Codes for Test Taking

- Security of online Testing (using special per-test 'student codes').

## Grading Results Administration

- After students take the test and submitted their answers online, they will be stored in the local teacher database TMAD.
- Since DMAS system uses the accumulative submission of student answers, grading the test can be done when the teacher logs in and clicks on display student results. At this moment, grading the test takes place and scores calculated for TF or MC questions. That is because any student, authorized by his teacher, can resume or retake a test at any time. Teachers can see their students performance quickly and instantly and they can display student results in two forms: by student name or by question.
- The program provides useful statistics and instance feedback of student performance to their teachers that can help identify problems or weakness of students that might have and then make some suggestions or decisions based on that. For example, *if 60% of students got wrong answers for same question* and may be having same or similar mistakes, that is not a good sign and the system can diagnose the problem and suggest some solutions to go through some Lesson Pages, for example. The teacher can also know exactly student names who chose what option/answer.



# Grading Results Administration (cont.)

http://wme.cs.kent.edu - MagicMath - Assessment Results - Windows Internet Explorer

back to: Results form

Student Name: Adam Ben Total student Score: (30.00/40.00) = 75.00%

Adam Ben [Select]

(Wrong Answer) Score: 0.00

**Q: (true or false) The number 3.333.... is greater than 3.333.**

A:  
 True  
 False

(Correct Answer) Score: 10.00

**Q: Which sign would complete the statement  $-3 [ ] 2$  indicating that 2 is greater than  $-3$ .**

A:  
 <  
 >  
 =  
 ≠

(Correct Answer) Score: 10.00

http://wme.cs.kent.edu - MagicMath - Assessment Result ...

## Your assessment Test:

Please choose a test:  
 Mid\_Term [v]

Display Student results by:  
 A Student Name.  
 A Question.

[Select]

http://wme.cs.kent.edu - MagicMath - Assessment Results - Windows Internet Explorer

back to: Results form

Please choose a question:  
 (true or false) The number 3...  
 Which sign would complete the ...  
 four to the third power is: ...  
 Is X times 4 equal to 4 times ...  
 Explain what a prime number is ...  
 Is  $(3 + 4) + 5$  the same as  $3 + 5$  ...

[Pick]

Total no. of students= 5	Correct answer(s)= 3, This means: (60.00%) of students got it correct	Wrong answer(s)= 2, This means: (40.00%) of students got it wrong!
--------------------------	--	---

**Q: (true or false) The number 3.333.... is greater than 3.333.**

A:  
 True  
 False

3 student(s)  
 2 student(s)

**. True**

Student names:

seq.	Student Name
1	Alina K.
2	David
3	Jim II

09/20/2006

## Comprehension Diagnosis and Linking to Remedial Materials

- One of the strong properties of the DMAS system is *offering the cure or suggestions for teachers to help identify their student weakness and shortcomings.*
- The test author can connect incorrect answer options to common mistakes, misconceptions, or missing background knowledge.
- DMAS can help correlate such diagnostic information with pre-made school Lesson Pages, which can help students overcome difficulties exposed by the assessments.
- Using Content-based knowledge Techniques based on (for example, semantic of Web (Ontology) Language such as RDF and OWL)

## Comprehension Diagnosis and Linking to Remedial Materials

- One of the strong properties of the DMAS system is *offering the cure or suggestions for teachers to help identify their student weakness and shortcomings.*
- DMAS can help correlate such diagnostic information with pre-made school Lesson Pages, which can help students overcome difficulties exposed by the assessments.

## Assessment Markup Language: MAML

- ✓ MAML (Mathematics Assessment Markup Language) is an XML markup language for DMAS.
- ✓ To transmit assessment questions to and from DMAS system and to interact with outside systems.
- ✓ MAML will be used for representation/encoding of assessment questions and exams..
- ✓ MAML defines markup elements and attributes such as question head, type, classification, body, rubric, and so on.
- ✓ The XSLT style sheet for MAML (maml.xsl) will be responsible to translate MAML markup into XHTML + SVG + MathML.



## MAML (cont. )

- Multiple Choice Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="maml.xsl"?>
<dmad>
<question type="multiple_choice">

<q_head>
  <author>Johe Bob</author>
  <keywords>Measurement, Area, Rectangle </keywords>
  <classification>Plan Geometry</classification>
  <answer>choice 2</answer>
</q_head>

<q_body>
  <q_text>What is the Area a rectangle with height=h and base=b?</q_text>
  <q_diagram>
    <svg xmlns="http://www.w3.org/2000/svg">
      <rect x="100" y="20" width="40" height="60" />
    </svg>
  </q_diagram>

```

## MAML (cont. )

### • Multiple Choice Example (Cont.)

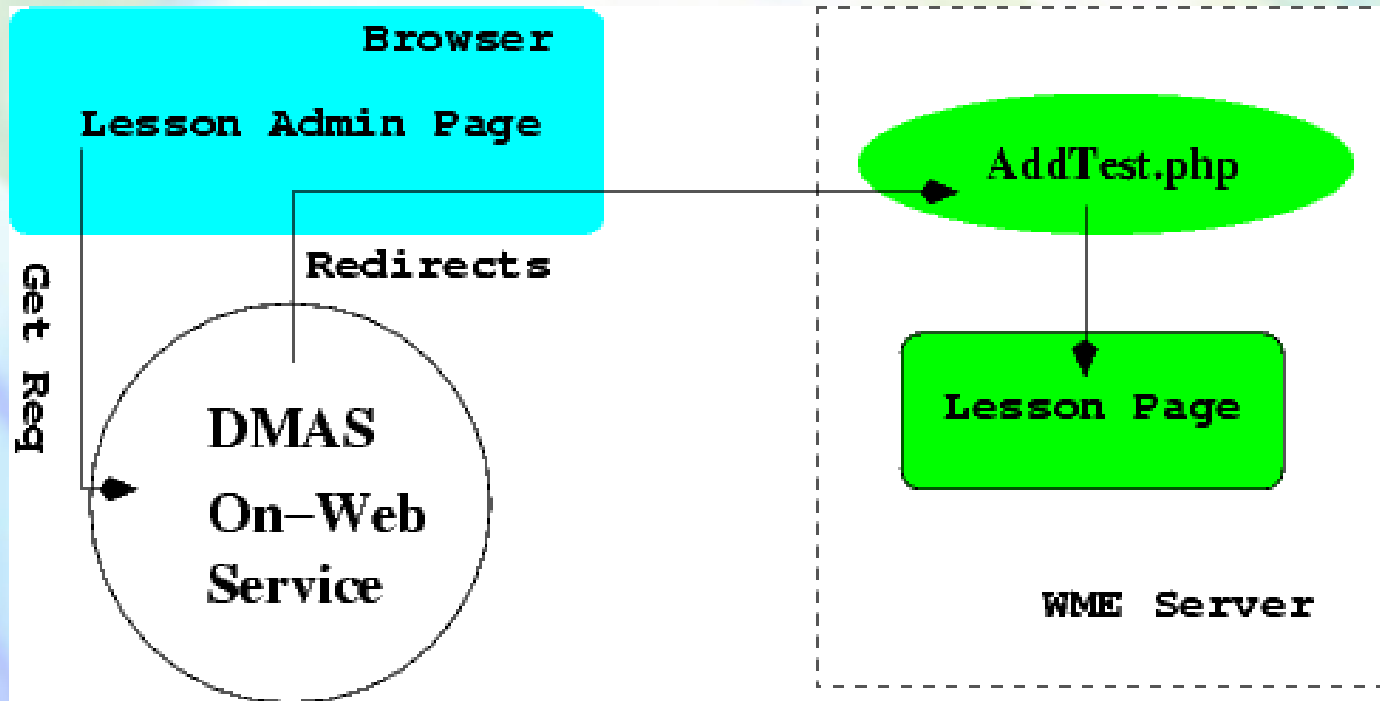
```
<q_choices>
  <choice id="1">
    <math xmlns='http://www.w3.org/1998/Math/MathML'>
      <mi>h</mi><mo>+</mo><mi>b</mi></math>
    </choice>
  <choice id="2">
    <math xmlns='http://www.w3.org/1998/Math/MathML'>
      <mi>h</mi><mo>*</mo><mi>b</mi></math>
    </choice>
  <choice id="3">
    <math xmlns='http://www.w3.org/1998/Math/MathML'>
      <mi>h</mi><mo></mo><mi>b</mi></math>
    </choice>
  <choice id="4">
    <math xmlns='http://www.w3.org/1998/Math/MathML'>
      <mi>h</mi><mo>/</mo><mi>b</mi></math>
    </choice>
</q_choices>

</q_body>
</question>
</dmad>
```

## DMAS System Interface to Web Applications

- DMAS system will provide APIs interface to other applications on the Web.
- These APIs can serve different requests either from:
  - server-to-server (i.e. from other servers such as WME server to DMAS server) or
  - client-to-server (from an Internet browser to DMAS server).
- In either case, DMAS system interface will handle all different calls in proper way.

## DMAS System Interface to WME

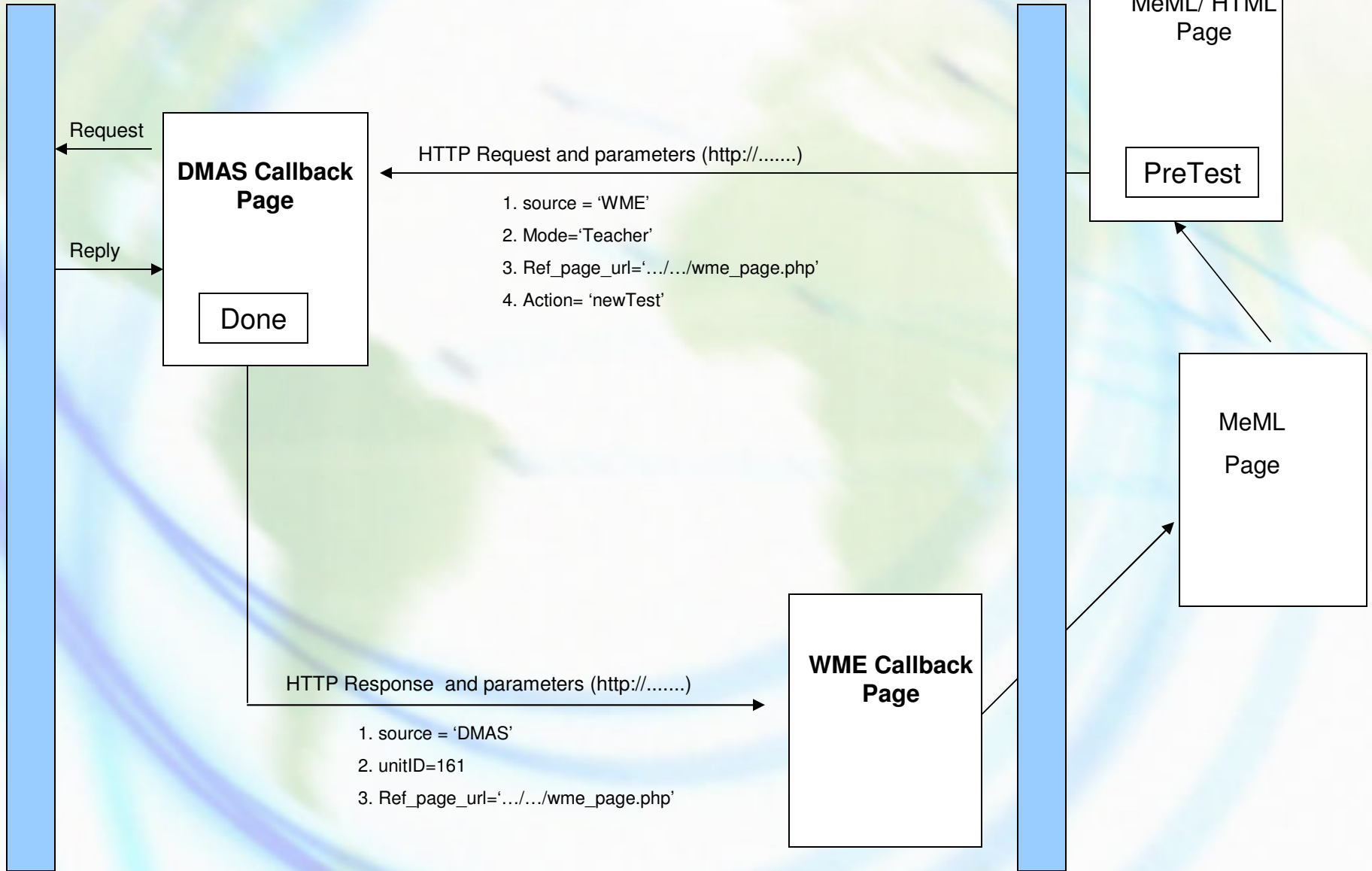




# DMAS-WME Interface Implementation

**DMAS System**

**WME System**



## Assessment Web Service

- The DMAS system aims to support interoperability and inter-communications with other applications on the Web.
- Thus, many DMAS functionalities are accessible as Web Services. Consequently, a well-defined API (Application Programming Interface) is needed to communicate and serve other applications on the Internet to achieve this goal.
- The DMAS Interface will capture all the info of interaction between the Web Service and Client Service.
- In DMAS system I will use the new created MAML language for this purpose and the assessment Web Service will provide full functionalities of data encoding and data transfer on the Internet using standard Web protocols such as SOAP (Simple Object Access Protocol).
- Later and in this chapter I will explain how Assessment Web Service will work with standard Web protocols and what kind of functionalities will support and how they work.

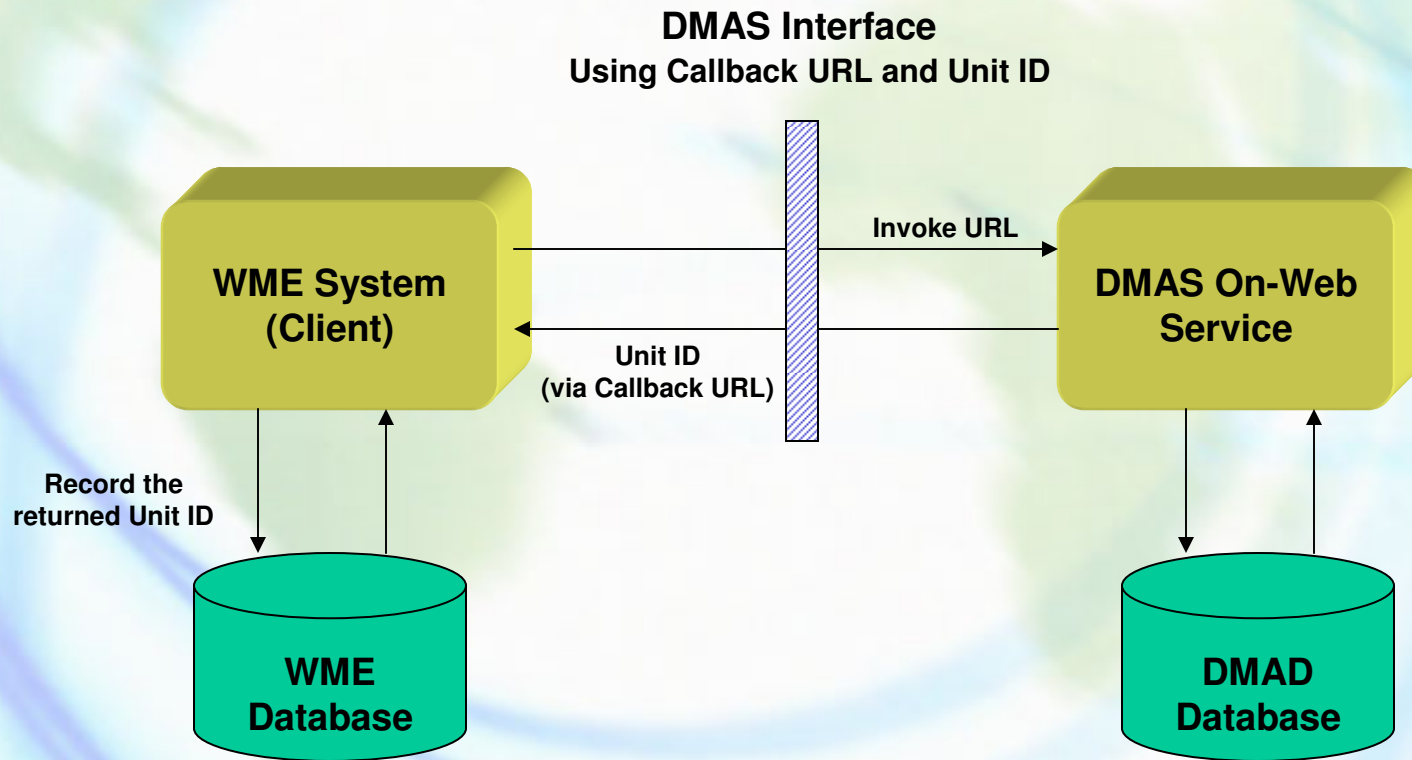
# DMAS Actual Implementation and Trial

## Building of experimental system to work with WME

- The DMAS system is being used in WME. It interoperates and interacts with other parts of the WME components such as Lesson Pages.
- It provides WME Lesson Pages with pre-assessment and post-assessment set of questions to prepare students and measure their understanding of lesson concepts. For example, a teacher logging in into WME administration interface can click pre or post assessment link to trigger DMAS system to author or import assessment questions that can be included in her particular lesson pages.
- Teachers using WME can also make their own assessment tests, probably independent from any specific Lesson Page such as Midterm exams, using DMAS and have them automatically stored and graded.
- In such cases, DMAS system can give useful performance statistics and provide diagnostics and suggest some remedial Lesson Pages and materials.

# Integrating DMAS with WME

(DMAS as On-Web Service in WME )





## Integrating DMAD with WME (cont.)

### ➤ Procedures:

- ✓ DMAD is invoked via a URL to author a new "Assessment Unit". This URL will receive POST or GET data including a "callback URL".
- ✓ The user can author (or import/export) questions in "Assessment Unit" and a new "UnitID" will be generated for the stored Assessment Unit.
- ✓ When authoring ends, the user will be redirected to the callback URL using something like ( ...?UnitID=...) appended at the end of it.
- ✓ This call back URL is a program that knows how to take the UnitID and records it in the database for the WME page involved.

## **Pilot use in schools to collect teacher and student feedback**

- In the future and in this section, I will list the feedback, results, and suggestions from both teachers and students and any changes or improvements made to the DMAS system by system users.

# DMAS and Formulas, Geometry and other Fields

## DMAS and Mathematical Formula Handling

- DMAS system supports formulas that can be included in assessment questions and tests.
- Currently, it uses the *Infix mode* to write formulas and uses the Infix-to-MathML WME converter in Javascript.
- Formulas are stored along with their questions in teacher's database, TMAD, in an infix mode which can use the Infix-to-MathML converter to convert them into MathML representations.
- Later on, DMAS system can interoperate with and use other Mathematical formula editors such as MathEdit (future WME Math editor) for creating/editing formulas.
  - For example, when DMAS system user clicks add/edit formula buttons, the DMAS system interface trigger MathEdit editor to create/modify equations.
  - Then the MathEdit editor returns the control and the formula in some form and to DMAS system through same interface to be included in assessment questions.
- All details and communications between DMAS system and MathEdit will be transparent to the users.

# DMAS and Mathematical Formula Handling (old)

http://wme.cs.kent.edu - MagicMath - Teacher New Question - Windows Internet Explorer

Solve the following Formula?

$$\frac{-x+3}{4} + \sqrt{8.5} - \pi \neq x^3$$

Add Image

Please Type your Question:

Solve the following Formula?

Add Formula here (Infix):

View Question

Enter Answer/Rubric:

SUBMIT RESET



# DMAS and Mathematical Formula Handling (new)

http://wme.cs.kent.edu - MagicMath - Teacher New Question - Windows Internet Explorer

## New Assessment Question

Solve the following?

$$x^2 + 3$$

and compare to:

$$x + \sqrt{4}$$

Explain?

Please Type your Question:  
Solve the following?

(1) Formula:

(2) Text:

(3) Formula:

## DMAS and Geometrical Graphing

- DMAS system will be able to include geometrical graphs such as SVG (Scalable Vector Graph).
- I am building an interface that can inter-communicate with other external editors such as geoSVG (an SVG Web-based authoring tool for geometry).
- Through this interface, students and teachers can trigger the geoSVG editor to create and draw geometrical graphs and then the interface can take care of including such graphs in specified questions.
- All interactions and communications between DMAS system and geoSVG will be hidden from the users.
- In this section, I will go much deeper with DMAS- geoSVG interface.

## **What prevents DMAS from becoming a useful tool for “Assessment in other areas such as English or History”?**

- When DMAS system is being used as a huge collection of assessment questions and a perfect tool for doing assessment in Mathematics including complex tasks such as formulas and geometrical graphs, as are my goal and mission, I believe the DMAS system has a potential to be used as a useful tool for assessment in other areas and serve other fields such as teaching and learning English or history.
- I will suggest some good ways and creative ideas of how DMAS system can contribute for doing assessment into other fields and areas.

## Conclusions and Future Work

- The DMAS system aims to be an effective and easy to use assessment tool for mathematics education. A systematic way of authoring, importing, customizing, and exporting assessment materials can help create an environment in which usage and experience can accumulate and mutually reinforce.
- In fact, I have much work to do and to add features and more improvements to DMAS system to make assessment materials ready to deploy on the Web, to conduct tests online, to provide grading help, to generate performance statistics, to provide diagnostics and to suggest remedial materials, while making tests and scores private and secure, controlling access to tests and results.
- Creating the new assessment language MAML, Assessment Web service, and DMAS interface to other Web applications definitely need more investigations and much work ahead.
- My goal is to put DMAS system under extensive trial in schools and collecting feedback and suggestions from teachers, students, school administrators and education experts to help me evolve DMAS. As more schools adopt WME and DMAS, the distributed nature of DMAS will be demonstrated in realistic situations.



## Demo and Q&A

- **Take a look..**

[http://wme.cs.kent.edu/wme\\_sample\\_page.php](http://wme.cs.kent.edu/wme_sample_page.php)

<http://wme.cs.kent.edu/kimpton/assessment/>

<http://wme.cs.kent.edu/develop/kimpton/>