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

- **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

- **DMAS and Formulas, Geometry, and other fields**
  - DMAS and Mathematical formula handling
  - DMAS and geometrical graphing

- **Conclusions and Future Work**

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 <u>copied</u> 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.

•**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 Structure

04/11/2007

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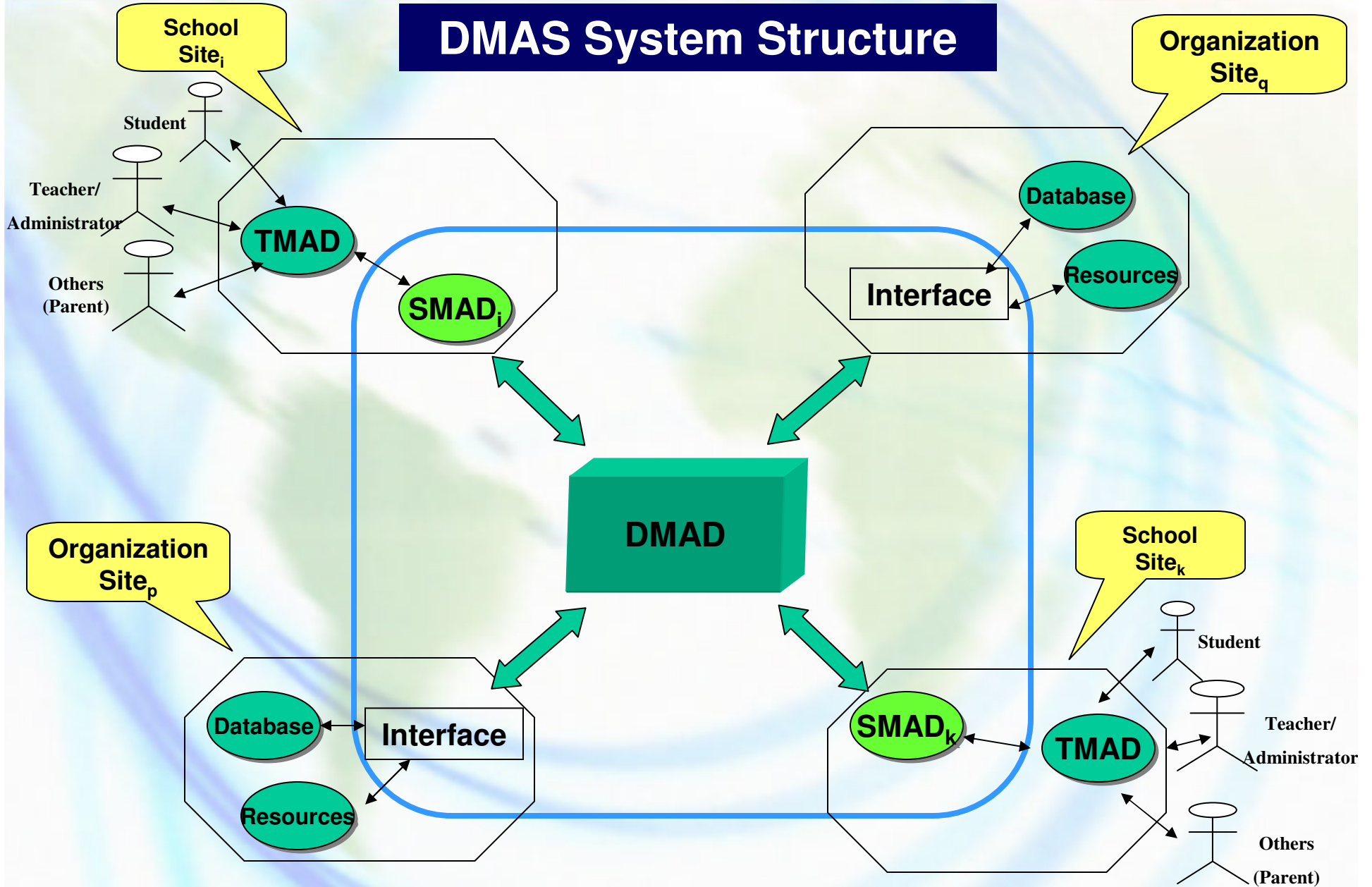
DMAS Search Engine (DMASEngin)

- First version of the DMASEngine has been produced.

- The search covers the local SMAD and all participating DMASs of other sites the rest of DMAD – All that is transparent to the user.

- A teacher (user) can easily *search for assessment questions* on particular subjects and at specific grade levels.

- The search can be narrowed by subjects, topics (for example, fractions, algebra, geometry, and measurement), keywords, grade levels, question type and author.

- The search engine will also look for geometrical graphs, questions with formulas, and those containing images (gif, jpeg, etc.).

DMAD Search Engine (cont.)

Browser window showing DMAD Search Results:

Address bar: http://wme.cs.kent.edu/kimpton/assessment/search_dmad.php?txtSearch=&btn_search=Se

Tab: DMAD - Search DMAD Res...

Total number of questions found (12)

DMAD Search Results

choose?	Question	Type	Action	Author
☐	On the ruler below, what value lies at each labeled point A-D? (Dr. M - can a ruler have the points shown but no intervals identified except one half? the ruler should be broken into 16ths and point A would be at 1 and 1/4, point B at 5/8, point C at 2 and 7/16 and point D at 2 and 3/4) at point A _____ at point B. _____ at point C. _____ at point D. _____	SH	[view] [edit] [del] [import]	Anonymous
☐	On the ruler below, what value lies at each labeled point A-D? (Dr. M - can a ruler have the points shown but no intervals identified except one half? the ruler should be broken into 16ths and point A would be at 1 and 1/4, point B at 5/8, point C at 2 and 7/16 and point D at 2 and 3/4) at point A _____ at point B. _____ at point C. _____ at point D. _____	SH	[view] [edit] [del] [import]	Anonymous
☐	Wal-mart is having a contest. They filled a large jar with peanuts and whoever guesses closest to the number of peanuts in the jar wins a $50 gift certificate at Wal-mart. Carolyn made a guess of 655 peanuts, which was 135 off. Carl guessed 480 peanuts, which was only 40 off. How many peanuts are in the jar? Explain in detail how you found your answer using words, number, and/or pictures.	SH	[view] [edit] [del] [import]	WASL
☐	Today Connie is three times as old as Grace. Six years from now, Connie will be twice as old as Grace. How old is Connie today? Explain in detail how you found your answer using words, number, and/or pictures.	SH	[view] [edit] [del] [import]	WASL
☐	The new movie, Return to Monkey Island, opened on Monday, March 1st. On the first day, 50 people attended the show. On the second day, there were 78 people in attendance. On the third day, 106 people were there. If the pattern continues, what is the first day on which there will be at least 200 people in the audience? Explain in detail how you found your answer using words, number, and/or pictures.	SH	[view] [edit] [del] [import]	WASL
	On the quiz show "What Do You Know?" each question is worth four		[view]	

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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

DMAD

export   Import

SMADs

TMADs
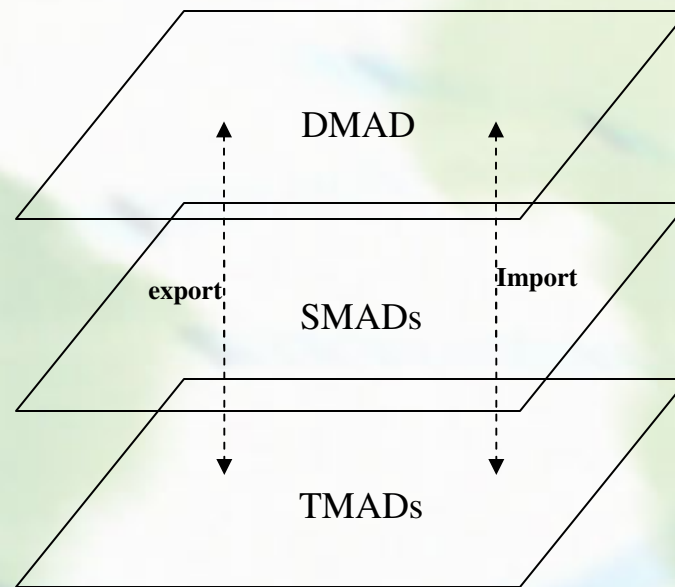
DMAS System Levels

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 teacher.

- **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.
- <u>Two new types introduced: two-columns matching and fill-the-blank.</u>

- 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.

Two-columns matching

http://wme.cs.kent.edu/kimpton/assessment/insert_upload.php

Please Type your Question:

Match the following options:

B | I | Link | Ext. Link | IMG | UL | OL | LI | B-QUOTE | Close Tags | Dict

« | H1 | H2 | H3 | H4 | P | CODE | PRE | DL | DT | DD | TABLE | TR | TD | U | S | NOBR | Footnote

| add (infix) formula | Use MathEdit | add image (upload) | add flash file | add geometric graph |

add left-column item

Please enter your left-column text:

1. match1 — formula
2. match2 — formula

add right-column item

Please enter your right-column info:

2 option1 — formula
1 option2 — formula

SUBMIT   RESET

[Back]

Error on page.   Internet   100%

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Fill-the-blank

MagicMath - Teacher New Question - Windows Internet Explorer

http://wme.cs.kent.edu/kimpton/assessment/insert_upload.php

Fill the blank:
12 is an _____ number and 7 is an _____ number?

View Question

Please Type your Question:

Fill the blank:
12 is an _____ number and 7 is an _____ number?

B I Link Ext. Link IMG UL OL LI B-QUOTE Close Tags Dict
« H1 H2 H3 H4 P CODE PRE DL DT DD TABLE TR TD U S NOBR Footnote

add (infix) formula   Use MathEdit   add image (upload)   add flash file   add geometric graph

add blank

Error on page.   Internet   100%

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.)

Edit Question

Solve the following <u>formula</u>:
<formula>sqrt(x)/2=3</formula>

and find x?

add (infix) formula

B | I | Link | Ext. Link | IMG | UL | OL | LI | B-QUOTE | Close Tags | Dict

« | H1 | H2 | H3 | H4 | P | CODE | PRE | DL | DT | DD | TABLE | TR | TD | U | S | NOBR | Footnote

A:

36

Commit Changes | Cancel & Close

Authoring Tool (cont.)

http://wme.cs.kent.edu/kimpton/assessment/insert_upload.php

New Question: Short Answer

Solve the following <u>formula</u>:

$$\frac{\sqrt{x}}{2} = 3$$

and find x?

View Question

Please Type your Question:

```
Solve the following <u>formula</u>:<br />
<formula>sqrt(x)/2=3</formula>
<br />and find x?
```

B | I | Link | Ext. Link | IMG | UL | OL | LI | B-QUOTE | Close Tags | Dict

« | H1 | H2 | H3 | H4 | P | CODE | PRE | DL | DT | DD | TABLE | TR | TD | U | S | NOBR | Footnote

add (infix) formula | Use MathEdit | add image (upload) | add flash file | add geometric graph

Done | Internet | 100%

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DMAS and Geometrical Graphing

- DMAS system now can 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.

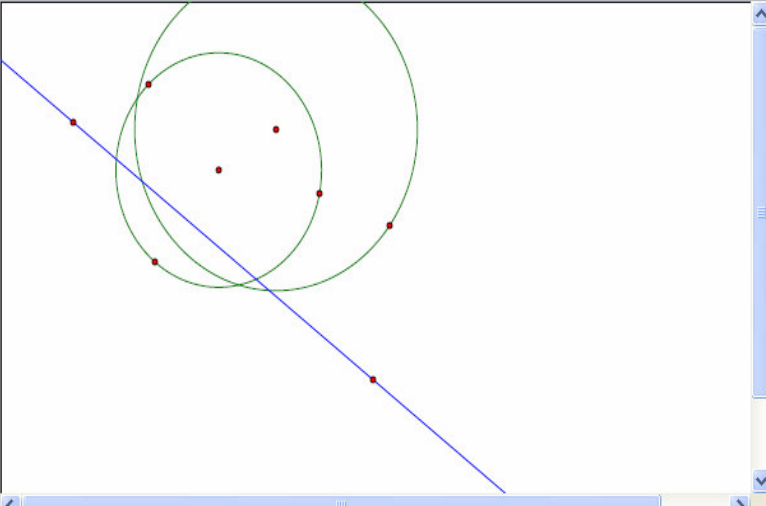- All interactions and communications between DMAS system and geoSVG will be hidden from the users.

DMAS and Geometrical Graphing (cont.)

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).

- I either case, DMAS system interface will handles all different calls in proper way.

DMAS System Interface to WME
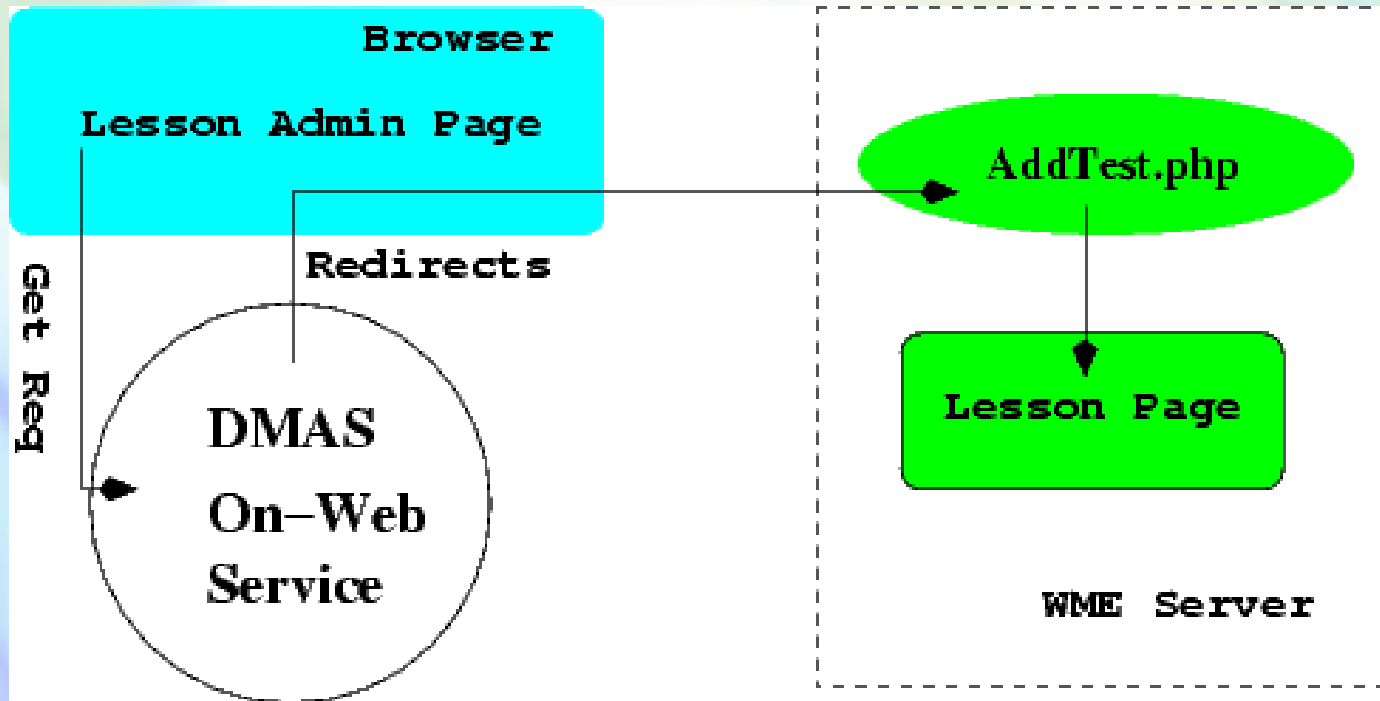
Integrating DMAD with WME (cont.)

➢ **Procedures:**

✓ DMAS system (DMASEngine) is invoked via a URL to search/import questions from DMAD bank. This URL will receive POST or GET data including a "callback URL".

✓ The user can search for (or import) questions in from the DMAD bank databases.

✓ When 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 data returned and display it or records it in the database for the WME page involved.

(Current) DMAS-WME Interface Implementation

**DMAS System
(DMASEngine)**

**WME
System**

MeML/ HTML
Page

DMAS Search
Page

(or search DMAD bank for questions to import)

Request

HTTP Request and parameters (http://.......)

PreTest

1. source = 'WME'

Reply

2. Mode='Teacher'

3. Ref_page_url='…/…/wme_page.php'

Done

4. Action= 'newTest'

MeML
Page

Search results (questions)

HTTP Response and parameters (http://.......)

**WME Callback
Page**

1. source = 'DMAS'

2. unitID=161

3. Ref_page_url='…/…/wme_page.php'

Question Structure

Question Types

MC | TF | SH

ES | 2C | FB

JS Infix Convertor

geoSVG

MathEdit

Question contents

Formula | Text | Image

Flash file | Svg Graph

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.
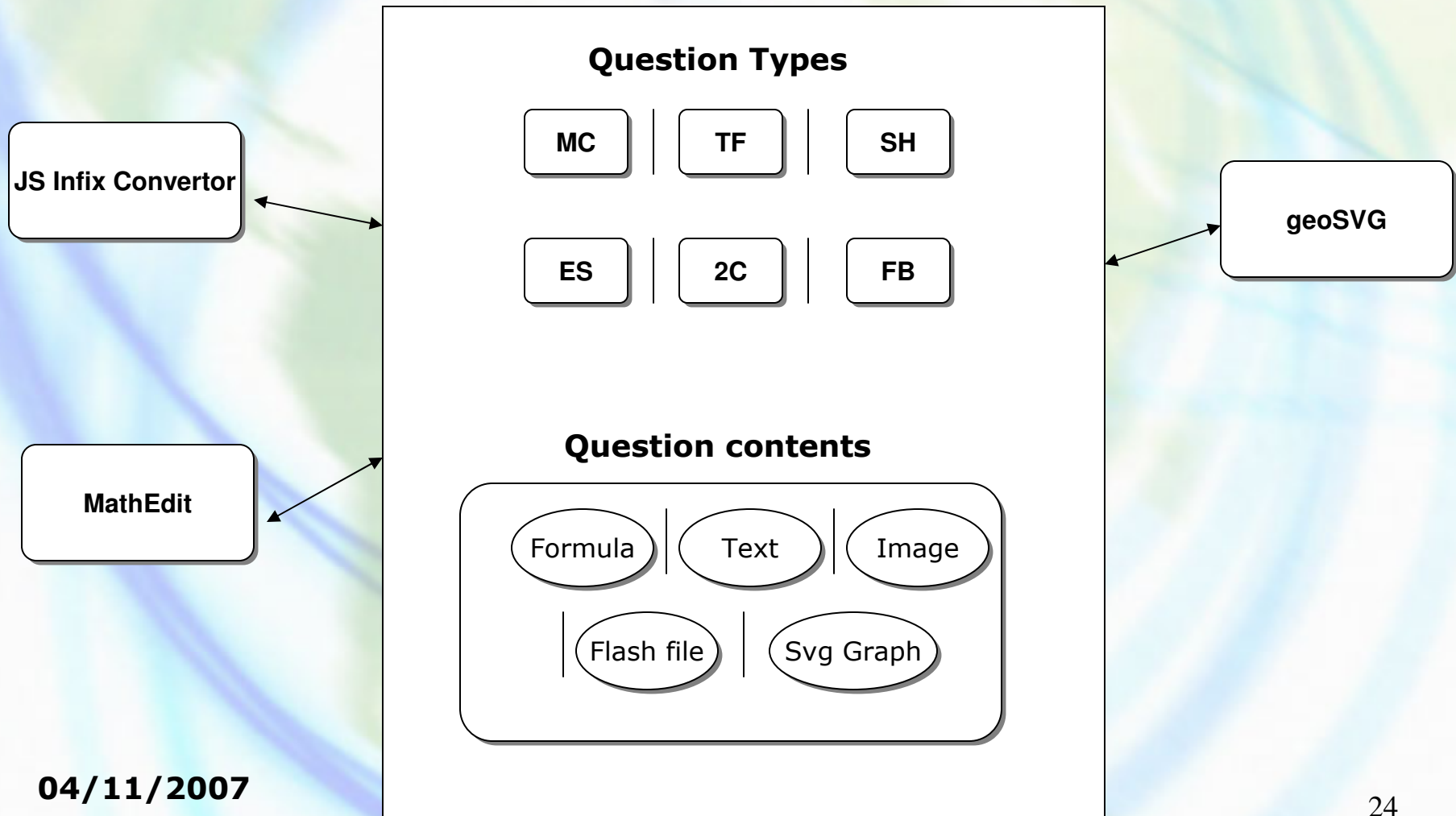
Assessment Test Giving

- 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

DMAD
Question Bank

Export Questions

Search/Import
Questions

| Export
Assessm. questions | Save/Edit
Assessment Test | Add/Import
Assessm. questions | Create New
Assessment Test |

**Generate
Test Code**

Review
Assessment Test

TMAD
Database

Login

Teacher

| Show/Hide
Assessment Test | Start/Re-take
Assessment Test | Submit/Store
Student answers | Display Test
Grade/Statistics |
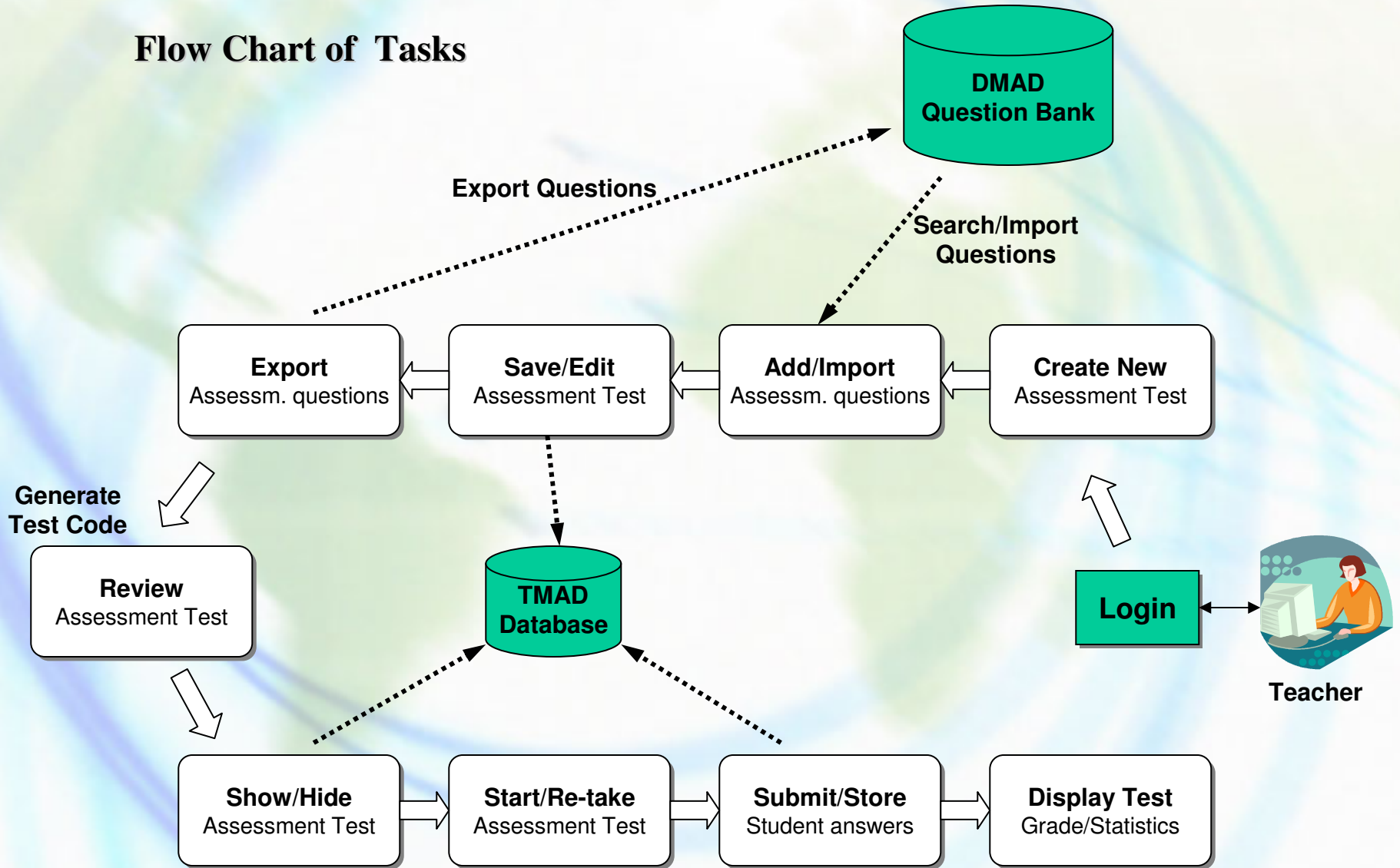
Assessment Test Giving (cont.)

- **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 heir 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.

04/11/2007

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)
- ○ Alphanumric (Capital letters only)
- ○ Alphanumric (Small letters only)
- ○ Alphanumric (Mix capital and small letters)

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

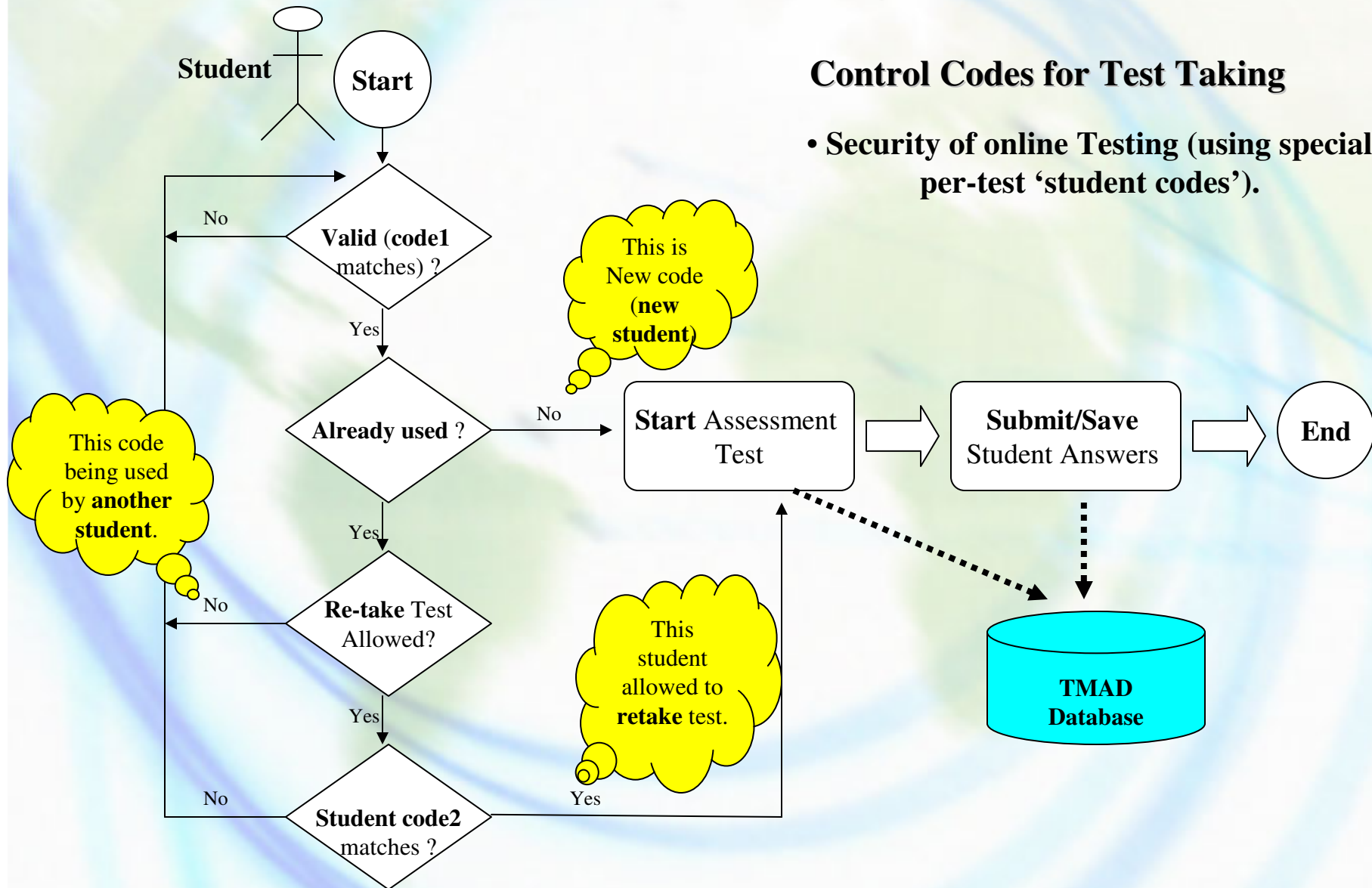**Please enter number of students (no of codes needed), Integer (1 - 99):** [　　　]

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.)

Student

Start

Control Codes for Test Taking

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

Valid (**code1** matches) ?

No

Yes

*This is New code (**new student**)*

Already used ?

No → **Start** Assessment Test ⟹ **Submit/Save** Student Answers ⟹ **End**

Yes

*This code being used by **another student**.*

No

Re-take Test Allowed?

Yes

*This student allowed to **retake** test.*

No

Student code2 matches ?

Yes

TMAD Database

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.)

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.
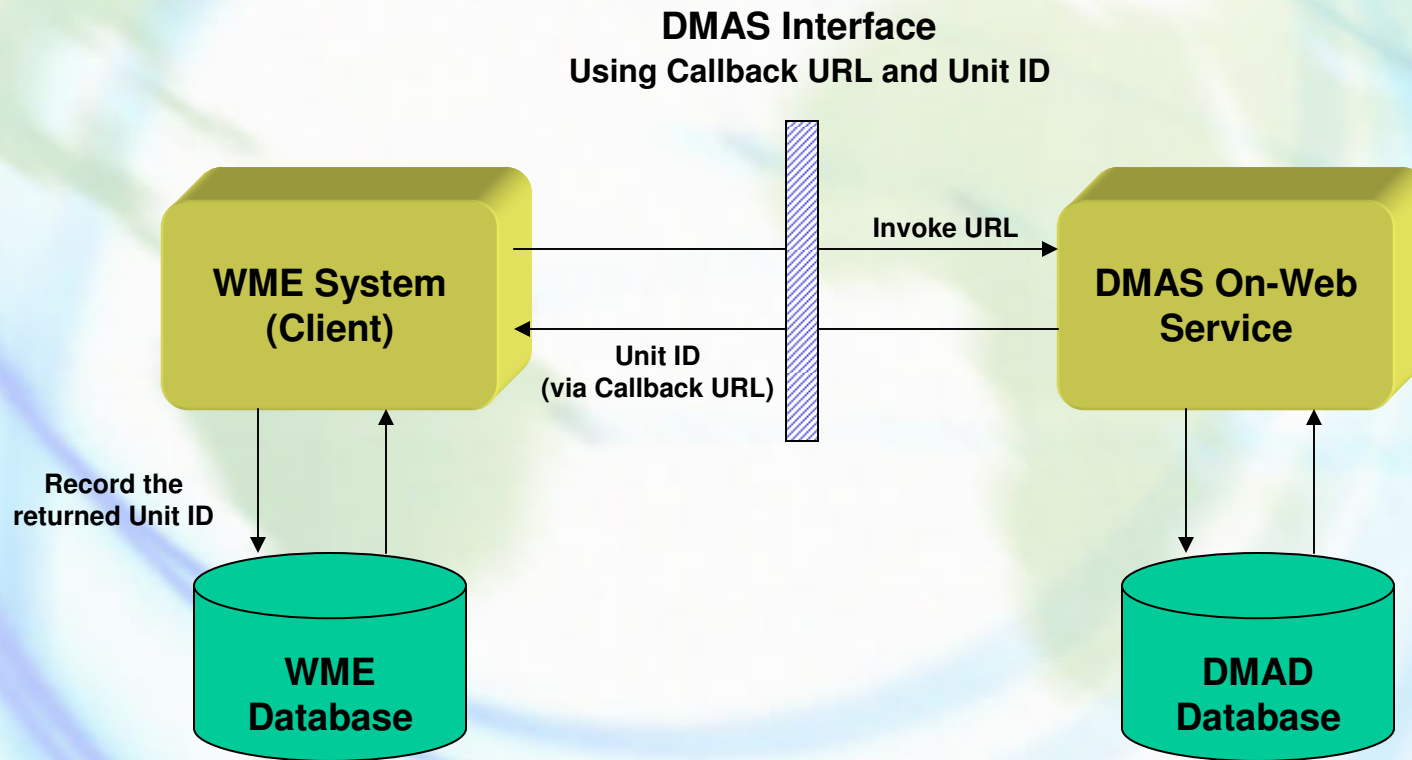
Assessment Markup Language: MAML

✓ 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.

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.

04/11/2007

Integrating DMAS with WME
(DMAS as On-Web Service in WME)

DMAS Interface
Using Callback URL and Unit ID

WME System (Client)

Invoke URL

Unit ID (via Callback URL)

DMAS On-Web Service

Record the returned Unit ID

WME Database

DMAD Database

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 MatML 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.

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/kimpton/assessment/