

Implementation of Object Approach to Design Integrated Learning Environment based on Java Technology and Oracle

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Abstract

This work is dedicated to the design and development of the multi-user Integrated Information Learning Environment (IILE) intended for the distributed learning model. The distributed education model can be used both in traditional learning systems and in distance learning to increase quality of education. Internet technology, Java¹, and Oracle² are the technological bases of the developed IILE. The characteristic of the work is the use of the object-oriented approach to the design and development of IILE.

1. Introduction

Recently the basic tendency of education is the active use of the progressive information technology [1]. Informatization of education is the objective and well-formed process. The positive influence of the process on the society informatization is difficult to be overrated.

¹ Java is trademark of Sun Microsystems, Inc.

² Oracle is trademark of Oracle Corporation.

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This work is dedicated to the creation of the multi functions Integrated Information Learning Environment (IILE) intended for the education support.

A part of education or the whole education can be described with the distributed learning model. According to the model the students and the teachers are remote from each other but they must interact with each other. Sometimes they must do it in real-time mode.

Resources and services of the developed IILE are available through the dedicated Web-site using information network services, Internet technology and Java. Oracle Data Base Management System (DBMS) carries out storage and management of IILE data.

The basic engineering solutions obtained during IILE developed information and functional models are described in the paper. The use of the object-oriented approach to design the environment and the preliminary results of IILE deployment are discussed too.

2. Integrated Learning System

The design and development of IILE are the main project purposes. The system implements Web-based training. The information and functional system models are directed to following trainee categories:

- ◆ the students of University including conventional form of education and distance learning;
- ◆ raising the level of employee's skills;
- ◆ dedicated programs for the school-teachers and scholars.

Supply and service accesses have to be fulfilled using the customary Internet browsers through the dedicated Web-

site, information network services, Internet technology, Java and DBMS.

2.1 The basic functions of IILE

The basic operational opportunities supported with IILE are:

- ◆ multi-user distributed publishing, modification, review, deletion of information, educational, methodic, and demonstration material of the courses;
- ◆ multi-user distributed creation, modification, review, deletion of the user data, the education results data, and the department data;
- ◆ visualization of all course materials using the only Internet browser;
- ◆ maintenance of access to centralized data using the information network services, the Internet services, Java technology, and DBMS;
- ◆ support of communications between instructors and students through e-mail, off-line conference, and on-line seminar;
- ◆ support of student communications with each other using e-mail and off-line conference;
- ◆ support of automatic control of knowledge level using testing;
- ◆ support delivery of the assignments and receiving student reports;
- ◆ support of the course export to study without Internet;
- ◆ support of the interactivity and high level of the all management modes integration into united IILE.

2.2 The architecture of IILE

The basic system architecture consists of the servers and personal computers located in the logical segments of the internal network of University [1]. The internal network of the University must be connected to Internet.

The standard open Internet protocols are used to support access to IILE. In addition to TCP/IP, the other protocols are used: HTTP, NFS file service, mail service IMAP4/SMTP, DNS naming service, remote access (RAS), FTP-server. Web-navigation eases information search and analysis for IILE users.

IILE was designed tacking into account portability. But at present IILE has been developed and debugged on Sun, Solaris, Apache Web-server, and Oracle DBMS. HTML, Java, JavaScript, and Perl were used to develop IILE.

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2.3. The use of Java-technology

The basic demands taken into account to design IILE are the portability, scalability, and high performance.

At present the most of web-servers support servlets. Servlets being Java-applications are run on any hardware-software platform. Servlets use JDBC drivers supplied with DBMS (for example, Oracle thin driver) or servlets can use JDBC-ODBC bridge included into Visual J++.

Servlets are modules that extend request/response-oriented servers, such as Java-enabled web servers. Servlets are an effective replacement for CGI scripts. Servlets can perform the application processing assigned to the middle tier. Servlets can work as the application servers for the applets.

The most of the IILE tasks are implemented based on the servlets. Java servlets and Java Data Base Connection (JDBC) allocated on the server-side and HTML, JavaScript, and Java-applets allocated on the client-side are used to meet the above demands.

A light thread is begun for every request as opposed to CGI as process is run. The servlets have one more important advantage compared to CGI: servlet thread does not exit as soon as it responses client. Therefore servlet load is not necessary.

The servlet encapsulates task logic, parses HTML form, and generates SQL queries to database server. Database server returns the query results to the servlet. The servlet processes the results and generates HTML page for user.

The system work consists of the following steps (fig.1.).

1. A user inputs information into HTML form or selects URL. The form (or URL) is sent to web-server.
2. Web-server begins Java-servlet thread. The request from the user is processed, form (or URL parameters) is parsed, and SQL queries are generated using JDBC.
3. Database server processes SQL queries and returns the results to the servlet.
4. The servlets generates HTML page based on the results.

Some tasks of IILE are implemented using applets. These tasks need more interactivity than usually or demand the graphic opportunities. The tasks are implemented as client-server applications.

Server side is Java servlet and its child threads. Java servlet creates the first child thread if the thread is

absent. The creation of the first child thread has to be synchronized to run the only first child thread. The first child thread is one that waits for the client connections. As soon as the server accepts a client the new thread is begun to interact with the client. The first thread is waiting for other clients.

Client is Java applet. It is loaded from Web-server and it is executed on the local user's computer. The applet

connects using server socket to the first child thread. The number of the server socket port is sent as the applet parameter. The dedicated thread, in which server and client communicate data, lives until applet window is closed or connection is broken. This thread generates SQL queries to database server. The received results are sent to the applet using sockets. The data received through the sockets from applets the server thread stores into the database (fig.2).

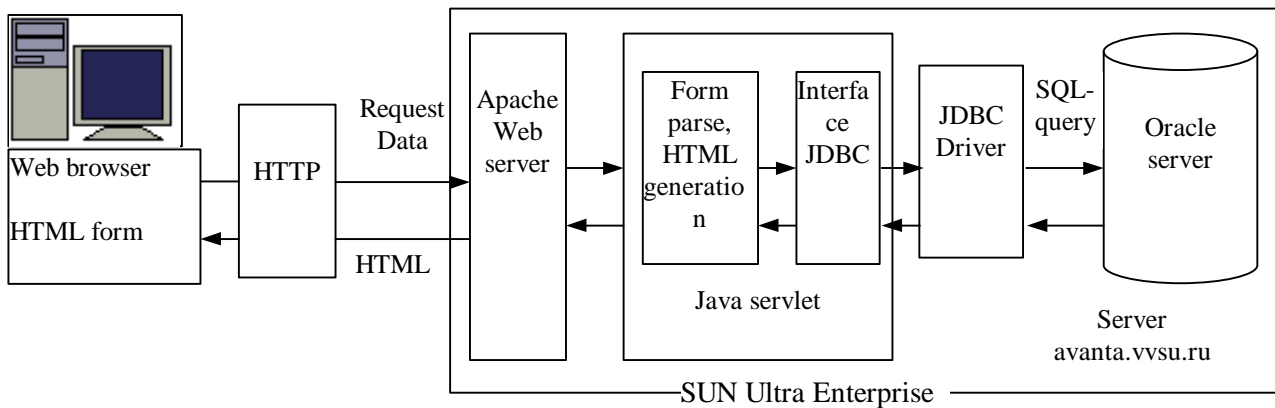


Figure 1. Client-Server interaction in the IILE

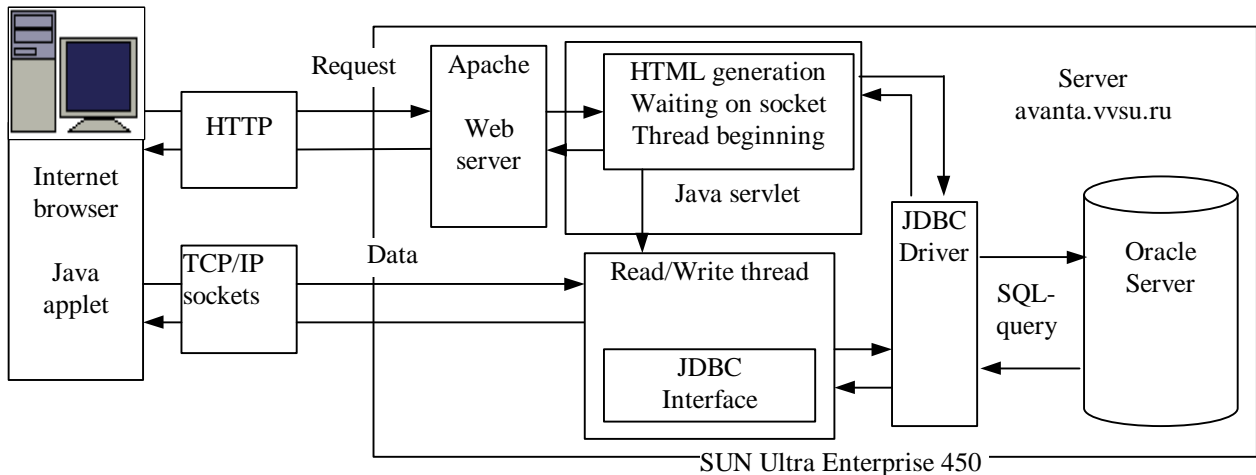


Figure 2. Multi-tier IILE architecture using applets

2.3.1. The use of Java applets

Why some tasks of IILE are implemented as client-server applications using applets?

We use Java applet for on-line seminar, on-line testing, and creation of the question containing a map.

These tasks can be implemented using the alternative tools: CGI, servlets, Dynamic HTML. The use of servlets is more preferred than CGI. The disadvantages of CGI scripts are low performance and they need more resources than servlets.

The use of servlets for the testing and seminar tasks is not suitable, as a new HTML page will be generated for every next or previous question and every new message in this case. The use of Java applet does not demand new HTML page and allows increasing performance.

If we would use servlets then the intermediate data of seminar and testing have to be sent to server. There are three base approaches to solve this task.

- ◆ The use of the hidden input type in HTML page.
- ◆ The use of cookie.
- ◆ The use of a database or the file system to store both intermediate and final results.

The use of the hidden input type is undesirable, as it needs to transfer the same data from Web-server to browser and visa-versa. Internet browser does not always allow the use of cookie. Besides cookie size is restricted. Complementary recourses of disk space and time are necessary to use of a database or the file system for storing intermediate data.

The use of DynamicHTML based on COM technology is the modern solution. This solution allows using sockets. Authors had developed the trial variant of using COM. This technology is the comfortable tool to develop web-applications. But it has a number of the disadvantages. Client using DynamicHTML is restricted within Windows operating system and Internet Explore 5.0.

The use of the applets only, without server is possible but undesirable. This approach implements the two-tier architecture and has a number of the disadvantages. The database connection parameters are embedded into applet code and they are accessible to view. Secondly SQL database query transmitted through Internet is too heavy construction.

Thus we decide to use servlets to run the server threads and applets to encapsulate business logic of the tasks. The server threads and applets interact through sockets. Only the server threads connect with the database.

This approach has a number of the advantages.

- ◆ The offered solution satisfies the multi-tier client-server architecture. This architecture is the modern approach to design the information systems.
- ◆ Applet provides more interactivity to communicate with user. Since data transfer is carried out in the individual thread then receiving of a new data is fulfilled simultaneously with the processing of a previous data and when the user passes on to a new data, he has the data already.

- ◆ The testing task using the applet has additional advantages. Since the questions of a test allocated into applet memory then return to the previous question is carried out without delay. As time delays can be excepted then time limits of testing can be set. Testing applet transforms the testing results the only time after testing.
- ◆ Java applets provide graphic opportunities, which are necessary to create a map question.
- ◆ The use of server (servlets and child threads) allows applet to know nothing about the database and the connection parameters. It provides more safe work with database.

Nevertheless the offered approach has some disadvantages:

1. applet has to be loaded;
2. Internet browser has to support a virtual Java-machine;
3. Internet browser Netscape Navigator (NN) does not support Russian encoding for applet text fields by default.

How it copes with these problems? Firstly applet is loaded for the first request only. Next time browser loads the applet located on the user's computer. Secondly the most of Internet browsers have Java -machine support. IE and NN support it. Thirdly the Russian encoding can be installed for NN updating NN configuration file.

2.3.2. The use of Java-servlets

The authors considered alternative tools to generate HTML pages. CGI, ASP, Dynamic HTML based on COM technology. The technologies are opposed Java-servlets. As IILE bases on the Oracle server then we could use Java cartridge or PL/SQL cartridge too.

The use of Oracle Java cartridge and PL/SQL cartridge is confined within Oracle Web-server and Oracle database server. As Apache is the base Web-server of IILE then the use of the cartridges is not available. Besides PL/SQL language is not object-oriented programming language (having object opportunities). It restricts developers within the structure approach.

Selection of Sun-Solaris platform and Apache Web-server excepts the use of ASP. The disadvantages of CGI and DynamicHTML based on the COM technology are discussed above.

Thus the use of Java servlets as the main developer tool provides the software portability, web-server independent, high performance, and the database connection tools.

2.4. IILE tasks

IILE consists of several interrelated tasks: registration, course program, schedule, topic, test, assignment, report, off-line conference, on-line seminar, announcement, glossary, e-mail, course export, help, administration, student progress, course copy. These tasks allows to register students, to study of course materials, to get assignments and projects and to send the assignment and project reports, to carry out tests, to take part into a group work and so on.

Topic, assignment, and test tasks are the central system modules. They allows to study topics and to do exercises and self-testing. The topics are similar to lecture material. The assignment task assumes to cover labs, homework, and practical work. Assignment is a work that a student has to do himself. Every assignment can have several variants. To prepare the assignment report a student uses any software and sends his report to IILE. Instructor entering into IILE may examine the report and evaluate it.

Group work tasks (off-line conference, on-line seminar) provide opportunity to discuss some questions between teachers and students. Discussion of a question can take place as long as the course is taken. These tasks implement the principle of active transmission of knowledge.

E-mail may be used as a customary email and as a tool for the internal message exchange.

Course export mode allows to do course copy for IILE users on their local computers, soft disk or CD-ROM. Exported course may be studied using Internet browser only (without Internet connections). The users can study course, get assignments, carry out testing, but they can not take part into a group work, send or examine report.

There is opportunity to copy course and carry out its modification for another educational form.

Announcement task allows to communicate to students hot news. IILE provides opportunity of frequently asked questions.

The IILE users³ were divided into:

- ◆ course author;
- ◆ group instructor;
- ◆ administrator;
- ◆ student;

- ◆ observer.

Course author is the IILE user who develops course. Course development assumes:

- ◆ to develop course structure and scenario of course study;
- ◆ to prepare the theoretical course material as HTML files according to the course study scenario;
- ◆ to publish these material into IILE by means of IILE;
- ◆ to develop questions and tests, to fill glossary, to assign seminar and conference themes;
- ◆ to publish teaching aids, demo materials, tools into IILE;
- ◆ to compile the course program.

Instructor is IILE user conducting a course, teaching one or several groups. Course conducting assumes:

- ◆ to do a class schedule tacking into account the course program, beginning date of study;
- ◆ to appoint assignment and project variants to the students;
- ◆ to evaluate the assignment and project reports;
- ◆ to evaluate the essays (written answer) of the students;
- ◆ to guide off-line conferences and on-line seminars;
- ◆ to maintain frequently asked questions and to publish announcements;
- ◆ to evaluate a course project and a course work;
- ◆ to control student progress;
- ◆ to carry out course export for the students.

Administrator is an IILE user providing IILE user registration, management of the courses, groups, and users.

Student is an IILE user studying the course material and using the IILE service (fig.3). A student has the right to study course, to take part into a group work, to ask an Instructor by e-mail. A student has to carry out appointed assignments, to make up reports, to send the reports to IILE, and to carry out testing.

The observer is IILE user who is teacher attached to the course but he is not author and he is not instructor. The dean's workers or head of the department can be the observers.

Any part of IILE demanding student active operations has points. Tests (questions), assignments, course projects, conferences, and seminars have points. The

³ IILE users are users having opportunities to connect by Internet browser to web-site where server applications are run (<http://avanta.vvsu.ru>), and registered there.

student's purpose is to get more quantity of the points. An instructor evaluates a knowledge level of a student tacking into account collected points and him own subjective opinion.

The IILE users are situated into one of the four modes: management activity mode, course study mode, creation course mode, and conducting course mode.

Management activity mode is accessed for administrator only. Course study mode is accessed for students and teachers (author, instructor, and observer). Course creation mode is accessed for course author only. Conducting course mode is available for instructor only.

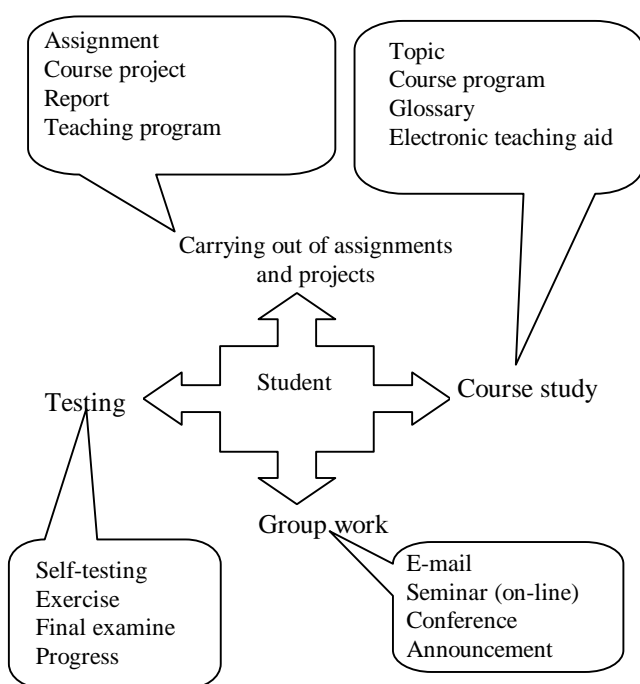


Figure.3. Functions of a IILE student

2.3. Object-oriented approach

Design and development complex system is an iterative process [2]. We were compelled to back to system analysis designing of the system and we designed system while we had to develop the system.

In spite of that we have gotten operable version of the system so as we use the object-oriented approach to the analysis and the design of IILE.

Support of system extensibility, i.e. addition of the new functions and modification of the existing opportunities are the main reason of the use of the object-oriented

approach. Java selected as the main programming language of the system promotes this approach.

IILE consists of several modules. The modules are isolated from each other. There is minimum of connections between the modules. The failure of the one module does not affect on the other modules. For example, when testing module failed during the debugging stage of IILE it was not barrier to study a course or to create a test.

The modules consist of classes describing data domain. There are classes such as topic class, subtopic class, assignment class, project class, course class, test class, question class, report class, program class, schedule class, seminar class, conference class and so on.

Let's consider, for example, the one of the most intricate IILE tasks - the knowledge control task based on testing.

At first three types of questions were filled into IILE. The new types of questions were added during development stage. If the module would be designed and developed on the base of the structure approach then it should be redesigned and redeveloped again.

Task was to support easy addition and modification of question or test types. Test is the framework for the questions and the some complementary attributes including test name, back-off permission and other.

There are three types of tests: self-test, exercise, and final examine. Self-test is the simple training test covering subtopic. The correct answers can be seen after self-testing. The number of testing attempt is not restricted.

Exercise is a test according to a subtopic. But the correct answers can not be seen and the number of attempts to test is limited. Exercise allows to evaluate and to fix knowledge of students.

Self-tests and exercises are the same for all students.

The final examine is the test covering the whole course. This test has randomly chosen questions and limited number of testing attempts. The test has predefined points. The number of questions in the test can be different.

The test is implemented using the abstract base class Test. Test class aggregates question list class (ListQuestion). ListQuestion class is sequenced collection of the questions. Beside test class has test name and back-off permission attributes. Test class describes interface and defines partial implementation of fetching test from database, storing test into database, writing test in socket, showing test, deleting test.

Self-test class (Self), exercise class (Exercise), and final examine class (Exam) are derived classes from the abstract class Test (fig.4).

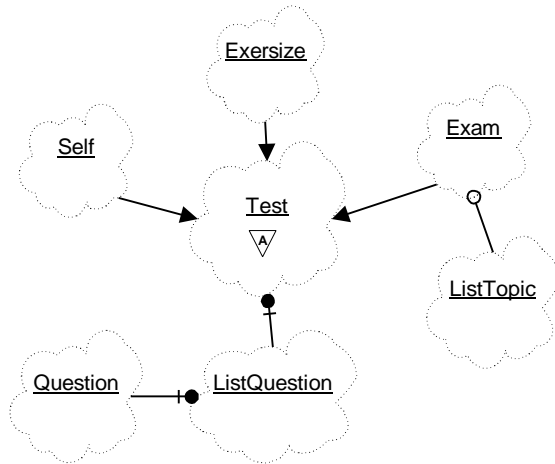


Figure 4. Test classes hierarchy

Self class and Exercise class have the attribute concerned with subtopic. Since a final examination has feedback with subtopic then Exam class uses subtopic class (ListTopic). Exercise and Exam classes have the number of attempts.

Exam class methods of question fetching and storing are different from the methods of exercise and self classes.

To develop a new test type it needs to add new class as derived from abstract Test class. For example, it will be intermediate exam.

IILE question is the framework for the attributes and statements. IILE supports eight question types.

- ◆ A boolean question (TrueFalse) has two statements. The only statement is correct.
- ◆ The single choice question (Single) has several statements and the only statement is correct.

- ◆ The multiply choice question (Multiply) has several statements and some of them may be correct.
- ◆ The matching question (Matching) allows establishing correspondence between two sets of the statements. The one statement of one set can accord with several statements of another set.
- ◆ The essay question (Describe) supposes to write answer. A student writes answer and this answer is stored into database to be checked later.
- ◆ The fill-in-the-blank question (Standard) allows comparing written by student word (or phrase) with standards.
- ◆ The question putting together a sentence from randomly ordered a number of words (Sentence).
- ◆ The image map question is a clickable graphic. It allows marking area of picture (Figure) as correct answers. The areas can have different forms (Polygon, Circle, Ellipse, and Rectangle). The figure consists of points.

A question has some attributes: title question, points (from 1 to 10), question formulation (can have a picture), comments (can have a picture), percentages of points decrease if a student saw a comment, statements (can have pictures), statement correctness.

The base attributes and behaviors are encapsulated into abstract base Question class (fig.5). Question class allows to store/fetch question attributes into/from database, to delete a question, to write a question into a socket and so on.

All question types is implemented as derived classes from the abstract base Question class. They implement distinctions of every question types.

ThruFalse, Single, Multiply, and Map questions have correctness vectors. Matching question has correctness matrix but Describe, Sentence, and Standard have not correctness attributes.

To fill into IILE a new question type it needs to derive new class from the base Question class.

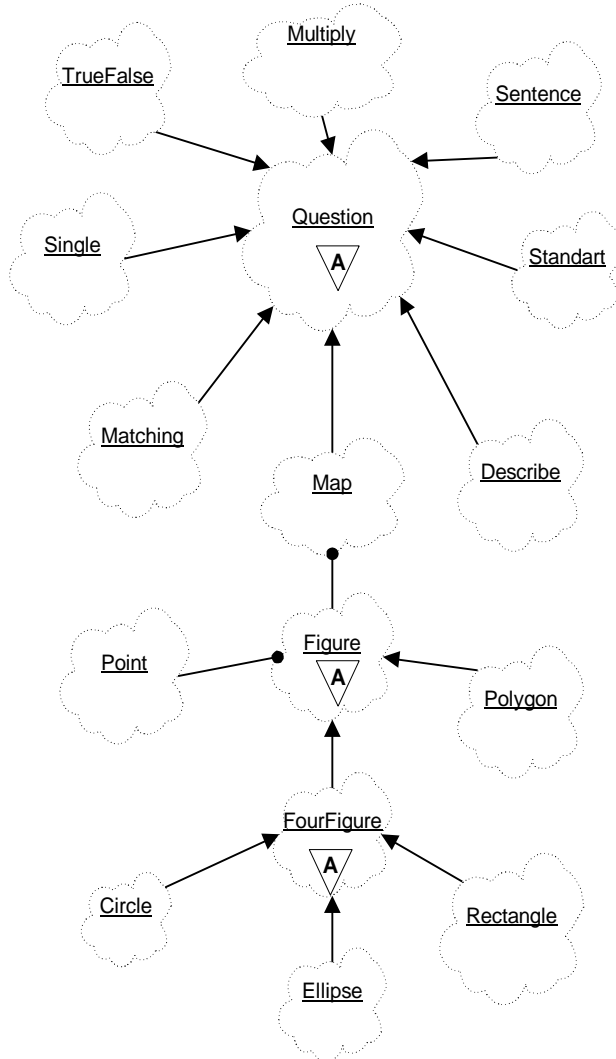


Figure 5. Question classes hierarchy

3. The use of IILE

Internet browser supporting JavaScript and Java-applets, and Internet/Intranet access are needed to work into IILE.

A course author has to be PC user, having skills of IE or NN user, and to be able to work with a text processor to generate HTML pages (MS Word, for example).

A group instructor has to be PC user as a course author at least. But he has to be able to use e-mail and complementary software needed to do assignments.

IILE was deployed since beginning of 2000 year. At present six courses were developed for the students of Computer technology and systems department:

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Algorithmization and programming, Internet technology, Computer network, Object-oriented programming, Digital signal processing, Peripheral devices. And two scholar courses were developed also: Bases of Informatic, Bases of algorithmization and programming. About 110 students of the department are IILE users.

The first experience use of IILE testifies about large interest of the students. IILE allows to develop independent work skill, to develop group work skill, to use time more effective.

The use of IILE sets new problems in front of teachers. The teachers have to revise course matters to develop Web-courses. They have to spend much time to conduct courses especially at first. They have to use new work forms.

4. Conclusion

The use of Java-technology, Oracle DBMS, and the object-oriented approach provides creation Integrated Information Learning Environment. This environment is scalability, extensibility.

The developed IILE allows organizing full education system. The distinctions of the system are great education efficiency, opportunity for a student to get independent work skills and group work skills. Availability of the course creation tools provides easy course updating to maintain the modern level of the course materials.

5. References

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