The CITO Examination System

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Abstract

Dutch schools all are online, which opens possibilities for a fully web based assessment system. But what is online? Cito has to deal with a wide variety in bandwidths, intranet systems, firewalls, and proxy servers. Furthermore, schools use a mix of Operation Systems, Media Players, and Browser applications. Under these circumstances Cito has to deliver multimedia examinations with video fragments and sound tracks simultaneously to 200.000 candidates. How can this be done?

Cito managed to develop an Assessment system for a range of Microsoft Operation Systems (W95 to XP) for both stand-alone situations and local area networks. The Cito Examination System does not need third party applications for browsing or multimedia presentation. Distribution of multimedia test packages and data return of test results can be handled by installing and returning files or by automated synchronization techniques with the central Cito Data Server. The test content is readable only during test taking by a candidate. Test packages and test data are encrypted, and transmission of files over the Internet is secured by the Secure Sockets Layer (SSL) protocol.

The Cito Examination System

Introduction

The Dutch Government commissioned Cito to construct the national final examinations for secondary education, some 600 in total each year. Approximately 200,000 candidates take them. Cito analyses the results and reports on them within four weeks. Final examinations can be either paper-and-pencil tests, or computer tests. A new form of national examination has recently been developed. It is part of the examinations set at the lowest vocational level. The examinations combine practical assignments with questions on related theoretical knowledge.
Cito develops exams for nearly all school subjects. Exams are held at least twice a year and take place within the schools. Marking is done by two teachers, one of whom is the students' own teacher. To enable for Cito to produce a test and item analysis, teachers send a random sample of the students' scores to Cito.
For the final examinations Cito has to deal with the production of both paper-and-pencil tests and computer tests, and delivering of computer tests in a wide variety of equipment and computer skills in schools. This paper describes the choice we made for a hybrid system, by combining online production with test delivery and collection of test results via the Internet, and local test administration. Cito has built two related systems, CitoBank for managing, processing and compiling items and tests and CitoTester for test administration. Together they form the Cito Examination System.

Production of examinations

The examinations are not only the work of Cito employees. Teachers who are part of a test-construction team chaired by a Cito expert assist them. They work on a contractual basis with Cito, or on the basis of being a teacher on secondment. The teachers contribute their know-how in the field of what can be expected of the students' level of knowledge and skills; the Cito expert is the one with the technical testing know-how. Cito can therefore guarantee that its examinations are in touch with educational reality and are developed in accordance with test-related requirements.
Developing, administering, assessing and managing tests are labour-intensive activities that require considerable time and effort. CitoBank is an item-bank system for storage, management and re-use of large quantities of test questions. To support the work of teacher in de test-construction teams, CitoBank offers this functionality via the Internet. The item-bank is able to support the construction of various types of questions including multi-media item types for digital tests. CitoBank arranges the series of test assignments in test banks. Each bank contains its own characteristics, assignments and tests. The system bank manager determines the structure of the item bank. Users with different authorisations receive personalised access entitlements.
Medium-neutral storage enables test materials to be exported in the IMS Question and Test Interoperability format (Q&TI version 1.2 [1]) and therefore transmitted to third party administration systems and eLearning systems.

CitoBank is based on Microsoft's .NET development tool. The web application runs on a web server with operating system Microsoft Windows Server. Storage takes place in a Microsoft SQL Server relational database management system. Metadata is stored in relational tables. Content is stored in binary objects and as XML objects in the database.
For special applications, for example formulae, use is made of supplementary tools such as WebEQ (Design Science). In the editor freely available plug-ins are implemented.
Communication, import and export with CitoBank take place via Extensible Markup Language, XML, a simple, very flexible text format derived from SGML (ISO 8879)[2]. Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and

elsewhere. The content of the assignments is then exchanged in accordance with the IMS-Q&TI specification. The actual content in W3C-HXTML format is established in this structure, with W3C-MathML for formulae. Microsoft Office Word 2003 is used for output generation from XML to paper tests.

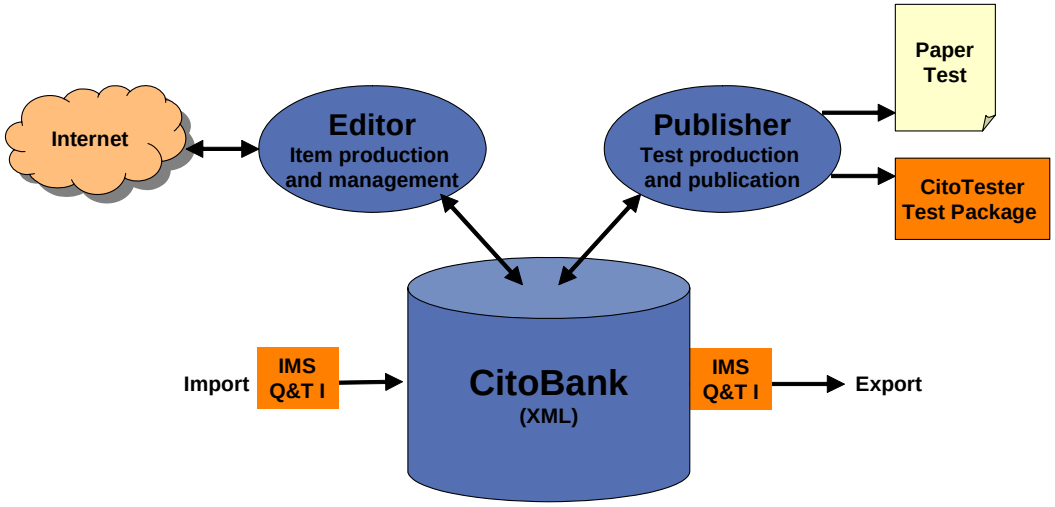


Figure 1. Overall scheme of the CitoBank item-bank system.

Item banking provides the means for composing examinations at any time and for any purpose. It will make the examination process more flexible, as in the future examinations will no longer take place simultaneously. Flexibility is high on the agenda of Dutch schools and Education authorities.

Test delivery and administration

To prevent problems with upgrades and different versions of third party applications, Cito decided to develop an administration system without needs for a complementary browser, a media player of database. The application CitoTester only uses own components, including a rendering-engine for presentation on the screen. Because of the fact that many schools in 2003 were equipped with old operation systems as Windows 95 or 97/98, Cito chose Virtual Basic (VB6) as development environment. As soon as possible future versions will be developed in VB.NET. Data are imported, stored and exported in XML format. A hard requisite of the authorities involved was double storage of test results, for example on the hard disk of the workstation plus the network server.

The test packages constructed with CitoBank publish tools can be distributed on cd-rom or via the Internet. The content of test packages is encrypted and can only be unlocked by the administration system CitoTester. The CitoTester application has to be installed on a stand-alone pc or workstations in a network within the school organisation. After installation of the CitoTester application, the tests packages can be downloaded via the Internet or imported from cd-rom. This makes the system stabile and secure. During test taking the system is independent of failures or availability of the Internet: all tests are downloaded and installed on local networks, inclusive images, sound track, Flash animations and video fragments.

CitoTester consists of a management environment, and an administration environment. The test manager of the school determines the location and time that test administration takes place with TestManager, the management environment of CitoTester. In TestManager authorised persons can implement management activities such as entering the data of examinees, groups, and test supervisors, installing tests and planning test administration. After a test has been administered, TestManager can generate various reports. TestManager should be installed on at least one computer in the network. Below is the main menu of TestManager.

Figure 2. TestManager Main Menu

TestCenter is the test-administration environment of CitoTester. TestCenter is installed on the workstations where tests are administered. Examinees can choose from three optional menus. With *Planned Test* examinees may take a scheduled test. This test administration should be scheduled in TestManager. The test data will be saved. *Practice test* allows examinees to take a practice test for training purposes. The test data will not be saved. If one or more examinees who are not included in the schedule wish to take a test, they can still be added to the schedule with the option *Ad hoc Test.*

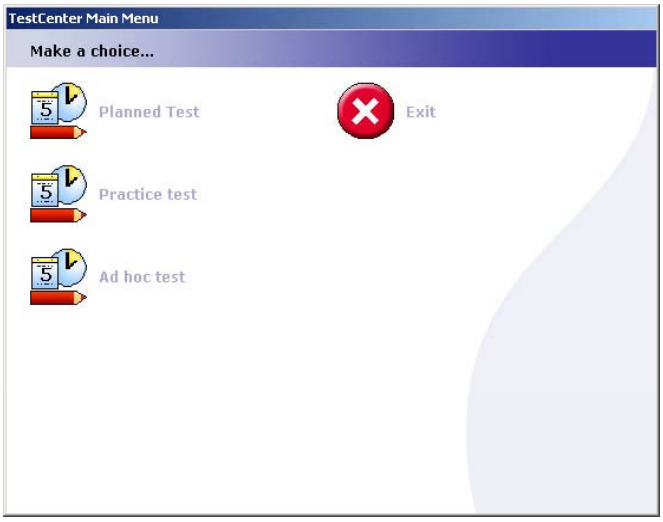


Figure 3. TestCenter Main Menu

A computer-based examination is aimed to test the content of an examination program and not to test computer skills. Therefore Cito researches the interaction between candidates and computer and proposes directions for the interface of digital products.

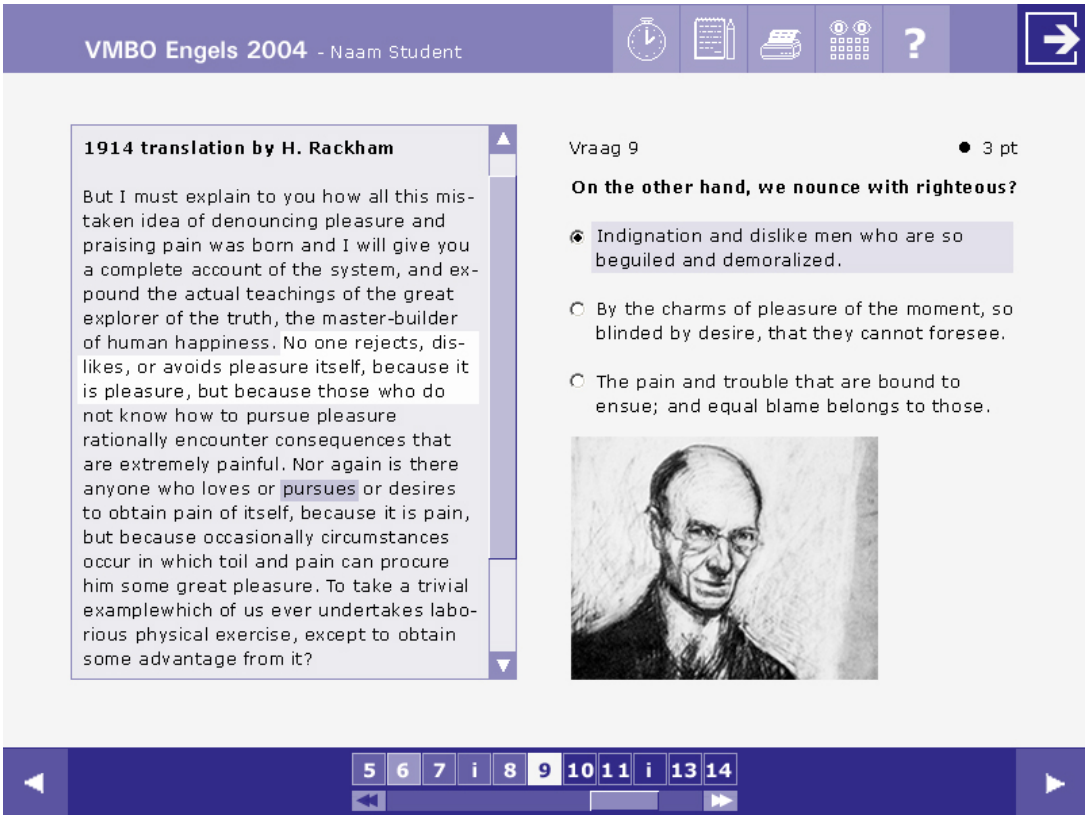
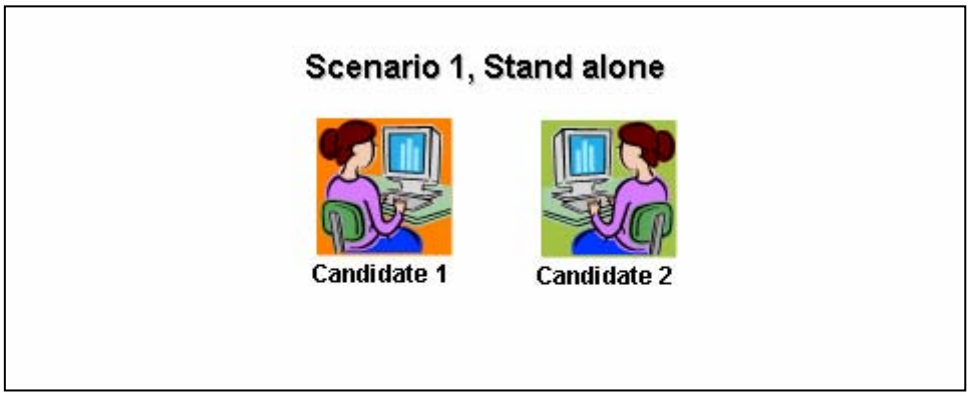


Figure 4. Cito Standard Interface for computer based testing.

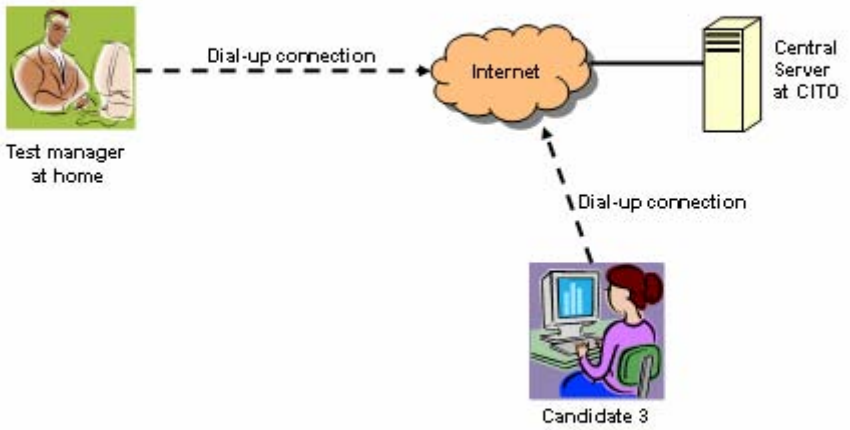
Test results can be gathered on cd-rom and send back to Cito for analyses or automatically been uploaded to the central database server at Cito in Arnhem.

Test scenarios

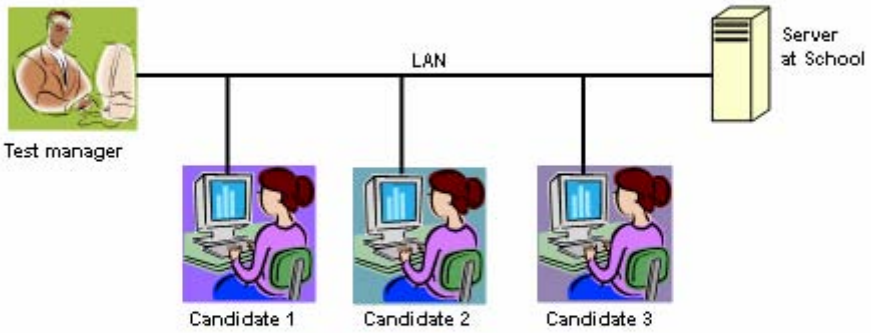
Cito aims to meet most situations of equipment in school organisations. Therefore CitoTester fits in a series of test scenarios, from stand-alone configuration, used in practice classrooms for vocational education, till multiple sites on a campus.



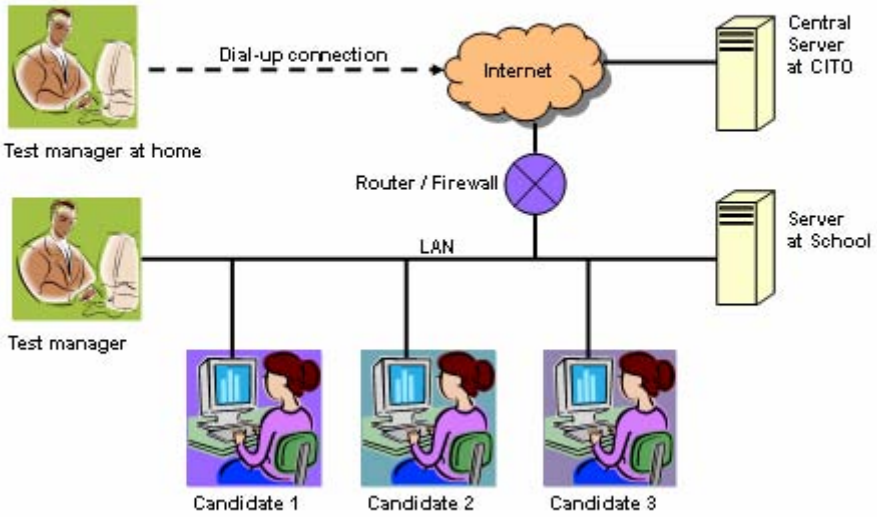
Scenario 2, Stand alone with the Internet

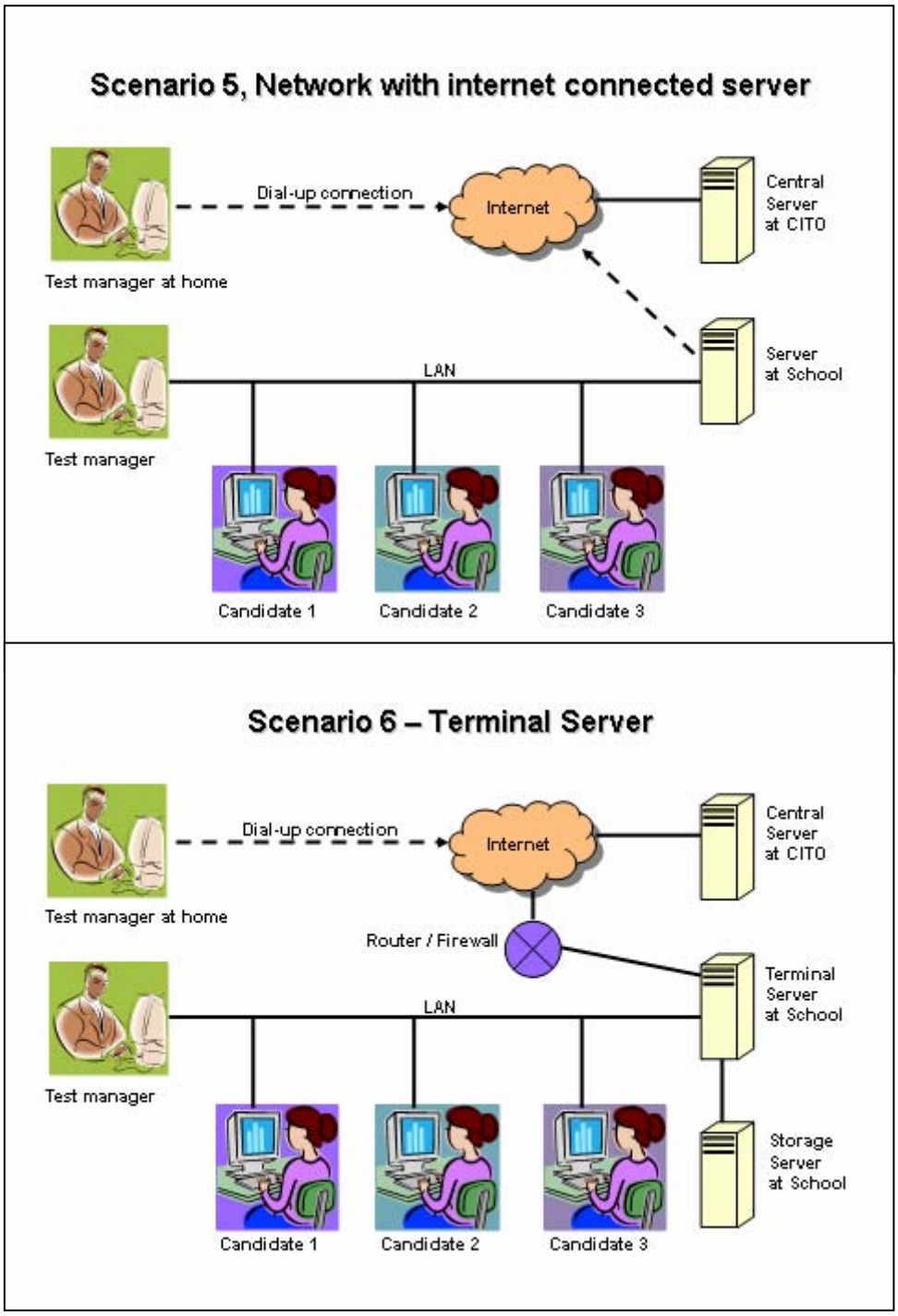


Scenario 3, Local Area Network without the Internet



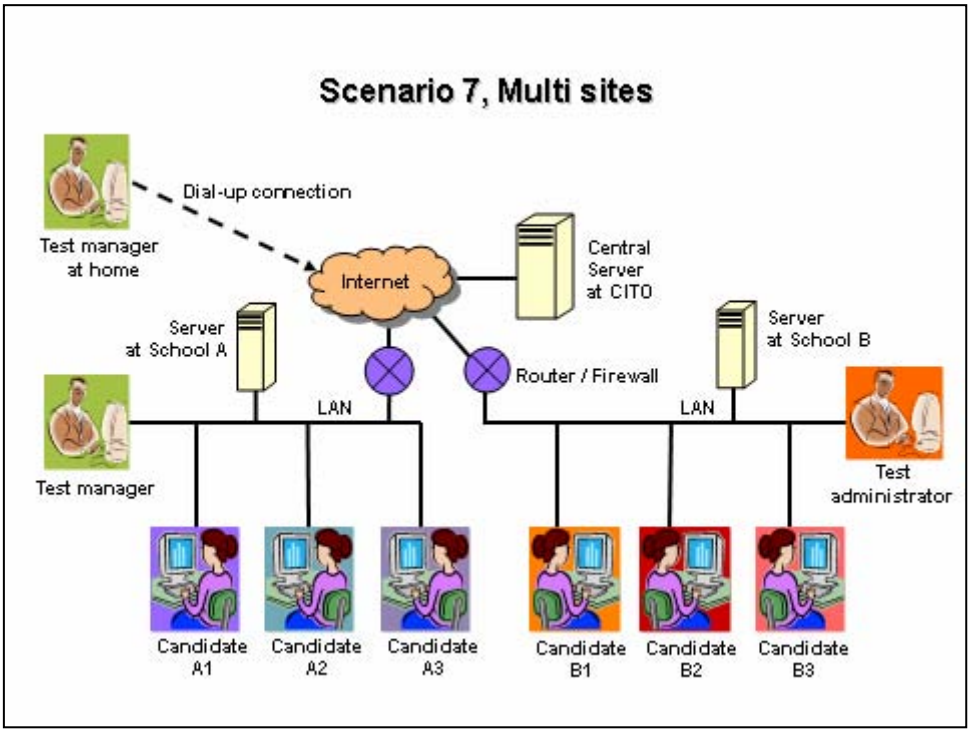
Scenario 4, Local Area Network with the Internet





In all situations the system is off line during test taking and thus independent of Internet connection. In a configuration with a terminal server (scenario 6) CitoTester and test packages are installed on the server and therefore sensitive for delay when multi-media is simultaneously used by a group of candidates.

From a single central location, CitoTester can steer several (sub)locations that are connected to the Internet. As a result, it is also suitable for large institutes with several locations, which is shown in the last scenario with multi sites.



Concluding remarks

Anno 2006 an application should be a browser based, cross platform webservice with a service-oriented architecture. Despite this commonly accepted starting point Cito made a choice for a more traditional hybrid system of local installation combined with synchronisation techniques and a central database.
It was a good choice, since we managed to serve all schools in The Netherlands, despite the large variety of equipment. Now we look forward to the moment we can start with smart client technology, with Visual Studio as development environment.

References

1. IMS/QTI: Final Specification Version 1.2 of the international open standard for Question & Test Interoperability, IMS Global Learning Consortium (2002), available at http://www.imsglobal.org/question/qtiv1p2/imsqti_oviewv1p2.html
2. XML: Technical specifications of extensible Markup Language of the World Wide Web Consortium (W3C) are available at http://www.w3.org/XML/