Preparing the University Information Architecture for Net-centric E-learning and Research: a case-study

Frederik Truyen, Leen Van Rentergem
ICTO, K.U.Leuven, Leuven, Belgium
Fred.truyen@arts.kuleuven.be
Leen.vanrentergem@cc.kuleuven.be

Abstract: Adjusting to the logic of the knowledge economy might be a natural task for dedicated Online Education Companies, for traditional Universities with a predominant share of regular, daytime students this amounts to a very specific challenge. We will present a case study on the K.U.Leuven, and its association, currently using one of the largest implementations of an LCMS with more than 43000 active users. The transformation of the university's IT infrastructure is an effort spanning over a decade, constructing layer after layer on the new foundations. A net-centric vision and an open architecture with modular approach are the keys to success.

Keywords: LCMS, Campus Management, University ICT

1. Changing requirements for University Information Systems

The Leuven University was founded in 1425. From the beginning, its mission was to promote, divulge and foster knowledge in the - at the time - international but unmistakably Eurocentric world. Besides the preservation of knowledge contained in Latin and Greek texts, educating scholars was of course one of the main goals of the early university. More than 500 years later, this mission has not changed much. This does not mean however that the mission can be called out-dated. Quite on the contrary, in today's knowledge economy, where knowledge is sold as a precious good and is protected by ever refining intellectual rights, the University's century-old mission seems more relevant than ever.

Although the mission of the university remains essentially unchanged (to offer course curricula to students and to engage in research) , the way universities organise themselves to cope with this mission is radically changing, certainly with the advent of Online and Distance Learning technology. We will focus on how the university's information management needs to be adapted to the new environment created by widespread information and communication technologies. In doing so, we will develop some themes already addressed in a short presentation at EADTU 2004 (Truyen 2004).

In what follows, we will limit ourselves to an IT perspective. What needs to be done for the university to have the most suitable IT infrastructure for its mission in today's environment? How can legacy systems evolve and get integrated into a new, more flexible framework? Of course, the main effort of this enterprise resides in the deployment of ERP solutions. Somewhat surprisingly perhaps, we will argue that a mayor contribution to this process comes from unsuspected contenders: Learning Content Management Systems. We will see that E-Learning provides some key concepts that give guidance to the way we should look at University ERP.

As a guide when developing the architecture of the information systems needed to support the university, it can be an eye-opener to look at Virtual Learning Environments (VLE's), and in particular their core, the E-Learning Management Systems, not only as mere information systems in the classic sense of the word, but really as *production* support tools that help to create the added value the university is pursuing.

The rapid evolving internet technologies have reduced the concept of knowledge to information sharing, rapid exchange of messages and just-in-time delivery of missing pieces of information. Not only traditionalists however might find that, like beauty is in the eye of the beholder, science is in the mind of the researcher. We could be wrong, but we still have the impression that sharing the

passion, the know-how, the observational skills and sense for accuracy, in other words the education of young researchers is what motivates a lot of colleagues, much more than the mere sharing of information about their subject. Those who ever deployed a VLE know that this is the main appeal for its rapid adoption.

The strange thing is that before we started with the implementation of a VLE, the university didn't have information systems that supported its *core* activities. Of course, departments and research groups ran the systems they needed for their research and the university mainframe was used for calculations, but the university itself, as an organisation, had no systems specifically designed for its business. We did have an accountancy system, just as we did have a payroll application and a database for our Real Estate, but these are systems you would find in any company, not something specific for a university. There were however some legacy systems based on procedural IMS databases that handled student enrolment and exams administration. Anything that remotely could be considered as helping to attain business intelligence (e.g.: monitoring of student curricula, determination of the market position in the educational space, performance in academic output, etc.) was still to be developed. The reason why we can so openly admit this, is that it always helps when you feel you are not alone in the dark!

What was badly needed was a paradigm shift: information systems needed to seen as the tools to do our business (education and research), and not as mere registration systems.

It is reassuring to know that this mental shift is not taking place in the K.U.Leuven ICT context as a result of mere abstract philosophising. We are actually forced to change gear by 2 factors, one more generic, and one very specific to the Leuven University.
Firstly, there is an urgent need to provide more flexibility in the students' curriculum. Students need to be able to choose an individual course traject. This puts a strong burden on our E-Courses, since they mostly are used in a blended learning context and often lack sufficient meta-data to be correctly assessed out of context. Here, inspiration from the distance learning community will be very welcome.
Secondly, Leuven University is now associated with 12 other institutes for higher education, in the K.U.Leuven Association (which also works closely together with the Katholieke Universiteit Brussel). Since this is a cross-regional, non-geographic association (in contrast to the competition in the Flemish higher education space), the "virtual campus" will be the preferred place to yield structural scale advantages.

In what follows, we will describe the different layers currently in development at Leuven University. It is important to understand that this is not only a technical endeavour, but for a large part also an organisational challenge: building the right support staff and structure for each of the layers, encouraging their development at an autonomous pace and at the same time keeping everything together in a general framework.

1.1 Some history …

University information systems have come a long way since the introduction of mainframe technology in the seventies. In those days these systems accounted for 3 main information-processing goals:

- To provide brute calculating power for scientific applications
- Administration: accounting, student registrations and payroll
- Library automation

The advent of mini-computer systems and UNIX workstations meant a first wave of scientific applications and obliged the central infrastructure to move to decentralized units that would soon be merged by a local IP network. This even led to some attempts in decentralized administrative

computing: the first Plessey mini-computer for the Faculty of Arts administration in Leuven university was a gift from the engineering faculty!

The PC came in a tidal wave submerging the university at a very fast pace. Starting with some delay around '84 – the first PC hitting ground at the arts Faculty in '87 –, ARCNET-based LAN technology (Banyan Vines) meant that a lot of local administrative processes where moved out of the mainframe. Proprietary, LAN-based email systems started to challenge traditional corporate communication.

In 1990, the general transition of the traditional LANs (LAN Manager, Banyan Vines, Novell Netware) towards a generic IP network came to fruition with KULeuvenNet. With the first browsers and Internet email, a totally new functionality came within the reach of the university information systems: it was now possible to manage the University's communication through these networks.

For research communication, FTP and SMTP functionality added to LAN-based mail where the most used protocols.

Table 1 Ground zero: information systems before the web

Corporate email, FTP, telnet …				
Faculty Adm. Scientific reporting	Scientific Apps	Central Administration	Library LIBIS	SAS Supercomputing
PC-LANs	Unix networks	Mainframe		

1.2 World Wide Web and Broadband

With some delay – we altogether skipped the "gopher"-era - two innovations laid the first foundation of the new university information environment:

- The Campus Wide Information System (since 1994)
- City Campus Broadband network "KOTNET" (since 1997)

In fact, both were a real "student revolution" at the university. Web-technology was very "aggressively" adopted and embraced by the student community, leading to the founding of *Ulissys*[1], the first computer-oriented student movement on Campus.
It also meant that the University Calculation Centre saw its user base radically shift: alongside the high-level specialized research community a totally new group of "customers" placed unforeseen demands on the facilities.

This led to a transformation of the Calculation Centre (URC) into a *service*-oriented organisation, 'LUDIT' or *Leuvens Universitair Dienstencentrum voor Informatica en Telematica* in 1997.

Table 2 CWIS WWW front-end dominates application interfaces

Campus Wide Information System		
SAS, supercomputing, Faculties, Research, Scientific apps.	Central Administration	Library LIBIS

[1] http://www.ulyssis.org/

KOTNET	KULeuvenNet	Mainframe

From that point on, the evolution went very fast, totally transfiguring the IT infrastructure at the University. We show in the next tables how the structure evolved.

1.3 Network-oriented computing

The importance of the network infrastructure is steadily growing, it has superseded and integrated the faculty LAN's and is generally accepted as a core service requiring proper staff and expertise. Most investments are directed to new network architecture, which acts as a force multiplier for existing PC's and server systems. The typical client-server architecture also encourages the use of centralized databases on dedicated servers. Legacy IMS databases show to be insufficiently flexible and are perceived as hampering a more distributed workflow in the administrative processes, necessitating unwanted centralisation. Already in a very early stage more than 5000 PC's where connected to the intranet (KULeuvenNet), tens of thousands would follow on the city broadband student network (KOTNET).

Table 3 Consolidation of broadband network services

Campus Wide Information System			
SAS, supercomputing, Faculties, Research, Scientific apps.	SAP Central Administration	Central administration	Library LIBIS
Oracle, SQL-Server, MySQL, Access	Oracle		
Platform : PC LAN's, Unix/Linux, SP2		Mainframe	
Network services: KOTNET KULeuvenNet			

1.4 Finding the right management structure for innovation

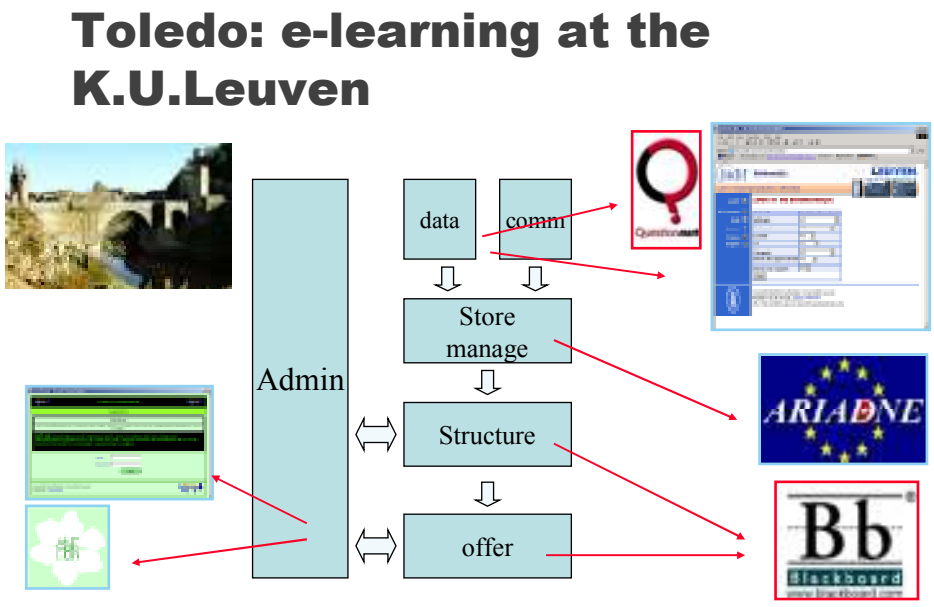
When the university got the opportunity to spend specific funds for educational innovation, the coordinator of educational affairs realized that there was a need for a specific counsil to follow-up on educational ICT. Normally, however, ICT falls within the authority of the general manager, so a mixed committee was set up, the "ICTO Advisory Board". In this committee, ICT managers from the ICTS directorate paired with people from the educational sector, both management and support. It proved to be the right formula (Elen 2003).

After two years of preparatory study a choice was made to introduce a Learning Management System, Blackboard, and an assessment system, QuestionMark Perception. In a second fase this was complemented by a Knowledge Pool, Ariadne, for resource management and re-use (see Duval e.a. 2001).

2. E-Learning implementation: TOLEDO

2.1 Toledo as an E-Learning service

Figure 1 Toledo E-Learning



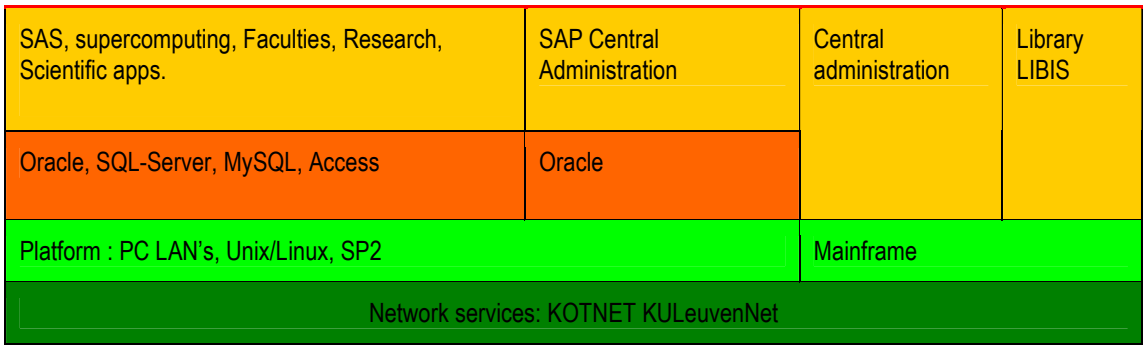
We can consider the current implementations of e-learning platforms in universities to support daytime classes in *blended learning* as a second generation in the use of web-applications for education. This started ten years ago with large investments and partnerships for broadband connectivity on the Campus and the region. Today, Leuven University has more than 30.000 students and staff connected to its *KOTNET*, offering broadband off-campus. The E-Learning platform *TOLEDO* was the next step, involving now more than 40.000 students, more than 5.500 online courses on a system with projected 24 hours a day uptime and more than 6000 concurrent users each minute of the day.

Actually, we did not as such deploy Blackboard and QuestionMark Perception, but bundled them into a *service*, with an institution-specific "brand name": Toledo. Toledo, or in Dutch "Toetsen en Leren Doeltreffend Ondersteunen", is an acronym for a service that supports academic staff in their teaching activities. The Toledo-team is a hybrid team composed of developers, end-user support staff and people from the university's pedagogical support service DUO (Dienst Universitair Onderwijs).

The idea to have a mixed team with engineers and education experts proved very valuable. Instead of focussing on the software development, the team rapidly focused on the service as such: the required functionality, the support cost, maintenance issues and sustainability. Also, a very huge campaign was set up to enlist the largest possible group of professors to actually use the platform. To that end, temporary support staff was hired in the Faculties.

Table 4 introduction of Toledo E-Learning layer

Campus Wide Information System
TOLEDO E-Learning



The introduction of the E-learning platform, a combination of Blackboard for course material and Question Mark Perception for on-line tests, enjoyed an exponential adoption rate. It forced us to redefine the role of the general CWIS, which was conceived on the basis of first-generation web-technology (Dreamweaver combined with FTP on a distributed network of servers). Instead of adopting generic CMS software for our web, as we did for specific sites like KULAK (Zope) and UZLeuven (ColdFusion), we are starting to use Toledo for a lot of internal communication, using the limited portal functionality it already offers to have a modern day web environment. To us, LCMS solutions on the market proved more mature than generic CMS systems. A possible reason is the heavy constraints put on an LCMS regarding availability and useability. Another factor is that CMS is mostly deployed tightly integrated with corporate systems, whereas the LCMS market has grown primarily in smaller to midsize higher education institutes where in-house development resources are limited and administrative systems are often not fully integrated. This has certainly improved the packaging and usability of LCMS systems.

There was also another reason why we put investments in corporate CMS on hold: the very large and resource-intensive project involving our new administrative systems based on SAP was in full expansion. From the beginning, a choice was made to have a lot of the SAP functionality through web interfaces. To that end, a so called "E-Univ" team is working to make specific portals for the SAP software, which, taken together in the later stages of the project will offer a very solid CMS for most of the administrative information in the master databases.

These combined factors contributed to the fact that the LCMS was effectively the largest investment in web technology outside the basket of administrative applications. More important, its cost-effectiveness and rapid growth would force us to rethink the basic administrative processes that we were automating in a SAP R/3 context.

The advent of a learning space actually alters administrative processes, in the sense that a lot of these procedures become obsolete or superseded by a more participative, collaborative way of working. We are very surprised how the more direct but structured communication with students in the E-Learning environment has a profound impact on our traditional, face-to-face education organisation.

2.2 Current developments

There are 4 specific developments regarding Toledo currently in the works. They amount to the transformation of not only the TOLEDO E-Learning platform but also of large parts of the traditional administrative information systems and library information systems of both K.U.Leuven and its association partners into one Virtual E-Learning Campus. First, we are in the process of inserting a "layer 1" *below* the E-Learning platform, where we will organise **resource management** for course materials. Second, we are working together with the schools for higher education in the association context on a layer superimposed on the E-Learning platform, which will provide in a knowledge pool stimulating reuse of finished course material components, together with **e-portfolio** facilities for the students. Third, the second phase of our Campus Management software will integrate tightly

with the E-Learning platform through a **common portal** and direct access to master data. Fourth, we **will integrate our new Library system** into this portal and provide direct links with the E-Learning space.

The importance of a **layered approach** needs to be stressed: it is still often the case that E-Learning people maintain E-learning systems whereas other system engineers maintain the corporate database applications, without structural integration. Although we are using software from different vendors, we did a major effort to split system maintenance from application maintenance. For this, it was vital to have a pool of Oracle specialists whose only focus is to maintain the Oracle databases as such, whether they are serving the SAP administrative systems or the Blackboard services.

On the other hand, we elaborate Service Level Agreements for the higher levels where the E-Learning service is servicing the end-users. We see this evolution going in two directions:

With the Association partners, an agreement has been regarding the level of service we offer to the community. In return, a board has been created to monitor the contract and to follow-up the future requirements to our common e-learning platform. We highly formalised this procedure through "requests for change" that have to be submitted, prioritized and evaluated in due form. For each major request a cost calculation is detailed.

On the other hand, we feel that the more we are organising the service, the more difficult it is to stay competitive on the aspect of innovation. People expect from us, more and more through contracts, a reliable, 24/7 service that makes E-Learning essentially a trivial reality. To keep up with newer technologies, a certain amount of risk management is involved and it is evident that, if resources are scarce, choices have to be made.

We are also developing more extensive technical documentation in order to make it easy for research units who want to try something new to hook up to the central e-learning platform. On the other hand, technical specifications are handed out to assure the required quality level. At the moment, we are working with several research groups on web service standards to enable them to smoothly interface their systems with the central e-learning platform. Besides the interfacing with the QuestionMark Perception assessment server, we have a web service link to the Ariadne Knowledge Pool and are working on a life connection with the IDIO-MATIC language test service.

3. Upscaling to the association level: GDLO

Figure 2 K.U.Leuven Association

On February, 20th 2004 The Board of Management of the K.U.Leuven Association approved the startup of a “Common Digital E-Learning Platform” (GDLO) at the level of the association. A choice was made for the most comprehensive form of integration achievable. In a first fase, a contract was signed to use the Blackboard LMS system from Toledo. In subsequent fases, it was projected that a steering group would look at joint efforts for LCMS and Portfolio.

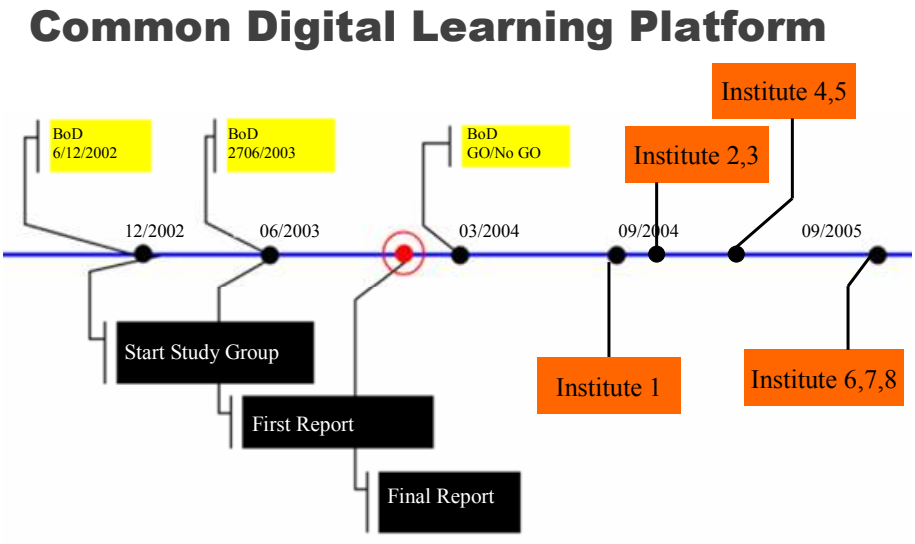
The Leuven University and its association currently represent:

- 70.050 students, in 23 Flemish cities
- 49.336 in 12 institutes for Higher Education
- 20.714 in the university

A decisive factor in bringing on board the association partners was the fact that we had a very precise cost calculation to join the consortium. Maturity for E-Learning services means that an organisation can plan the investment needed to run the desired functionality at a determined quality level.

Under pressure of the co-operation of the university with 12 institutions of higher education in the “K.U.Leuven Association”, a net-centric approach will be inevitable. Data are doomed to travel around a large network of very different institutions. We want to keep data-integrity at the one hand, and maximize flexibility on the other.

Figure 3 Timetable Common Digital Learning Platform



The challenges facing the GDLO or Common Digital Learning Platform are many:

- Organizing the support across different institutions
- Coping with association politics in a big, federated organization
- Administration:
  - Coupling Toledo with 12 different administration systems, considering the fact that:
    - we do not have unique course id’s over the institute boundaries;
    - we do not have a single system for unique userid’s
- Organization:
  - users must only see courses and users of their institution by default;

- users want to see institutional information in the Community System;
- users can be student or staff and/or administrator in their institution.

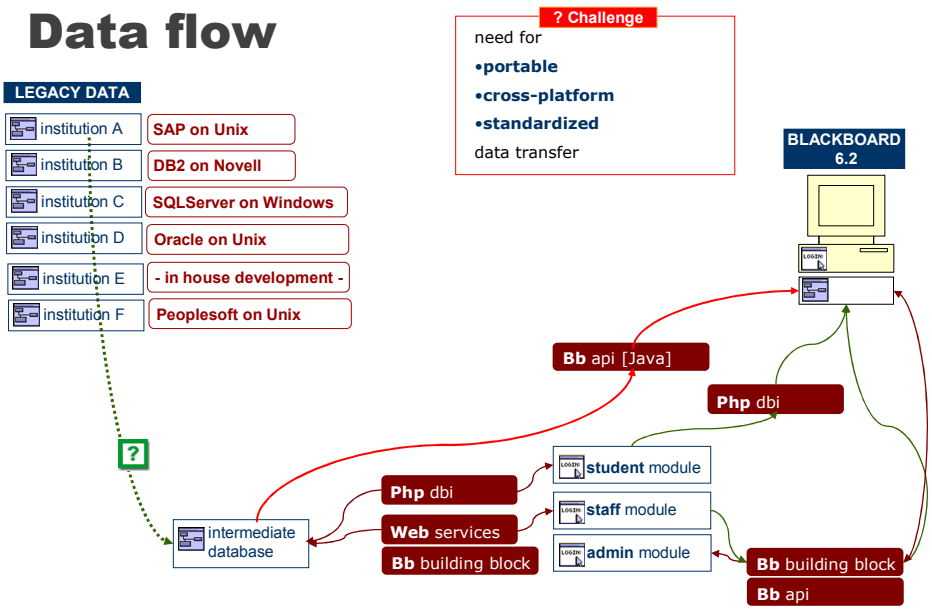
The GDLO is meant to be used primarely in support of education. But different institutes want to offer bridges to other e-learning systems, e.g. QMP, FirstClass, … Also, the institutes and their respective departments have different educational needs (e.g. competence based education versus guided independent learning).

The **community system** will be used for specific types of information that go beyond the course-related announcements: information for all users of the system, for all members of an institute, for all students/teachers/administrators of the system, or for students/teachers/administrators of certain institutes only.

Besides the communities the **portal roles** will be used for *branding* and *tab pages* of each institute. This will be their primary role. As a secondary role, portals will be used to differentiate between student, staff and administrator of an institute. The departments will be able to define the modules on the tab pages.

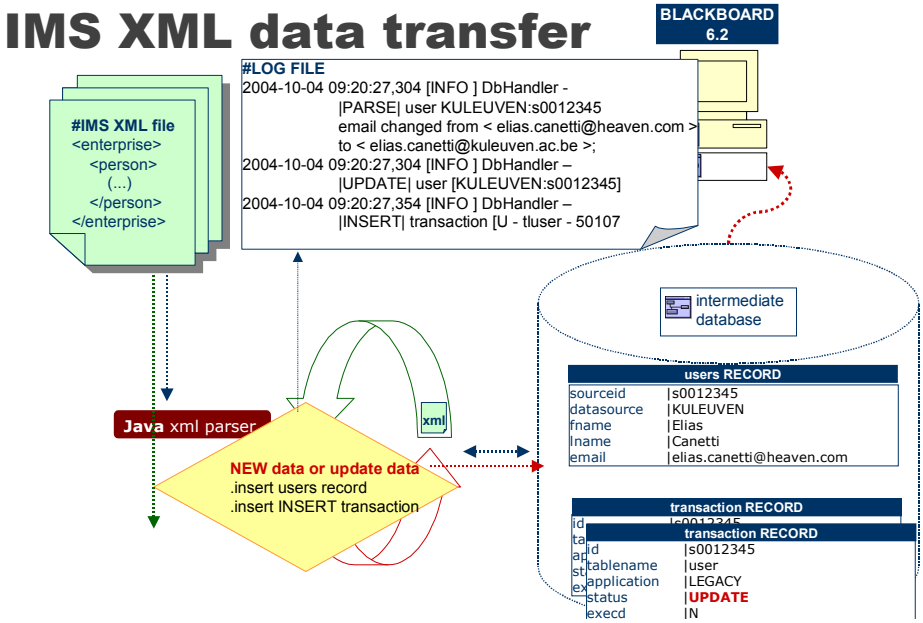
Until now, the main focus has been to make the GDLO system work without hampering the TOLEDO service for the K.U.Leuven users. A common login portal has been introduced, and much work has been done to streamline the procedures to automatically register the students of the different institutions to the right courses. For this aspect, the technical issues where daunting, and required a lot of development effort. Figure 4 shows how data from very different origin needs to be integrated into one system.

Figure 4 Feeding administrative data from several institutions



To meet the challenge of allowing the different institutes to continue to use their own legacy administration systems where students are enrolled in specific courses, a complex, transaction-oriented and robust data-interchange system has been setup. Perl scripts are passed to the institutions. These scripts generate IMS enterprise compliant XML wrapping of data (see http://www.imsglobal.org). The XML-files are retrieved on site overnight via a tunneled secure ssh connection. The XML files are then parsed and SQL statements are generated: new records generate an insert transaction, existing data are compared and may generate an update transaction.

Figure 5 insert/update statements are processed



4. Personalized portal: merger of TOLEDO and Campus Management

Parallel to the introduction of Toledo, our enterprise management software, based on SAP R/3, is also evolving to cope with the changing workflows in the education environment. This has led to new portal software, completely integrated with the master databases. This portal, KULoket, is being released gradually into the staff community, the first student applications are hitting ground and will be fully deployed at the beginning of the next academic year.

At the moment, each Faculty member has his own administrative portal, with personalized access to finances, HR, even including course syllabi and project administration.

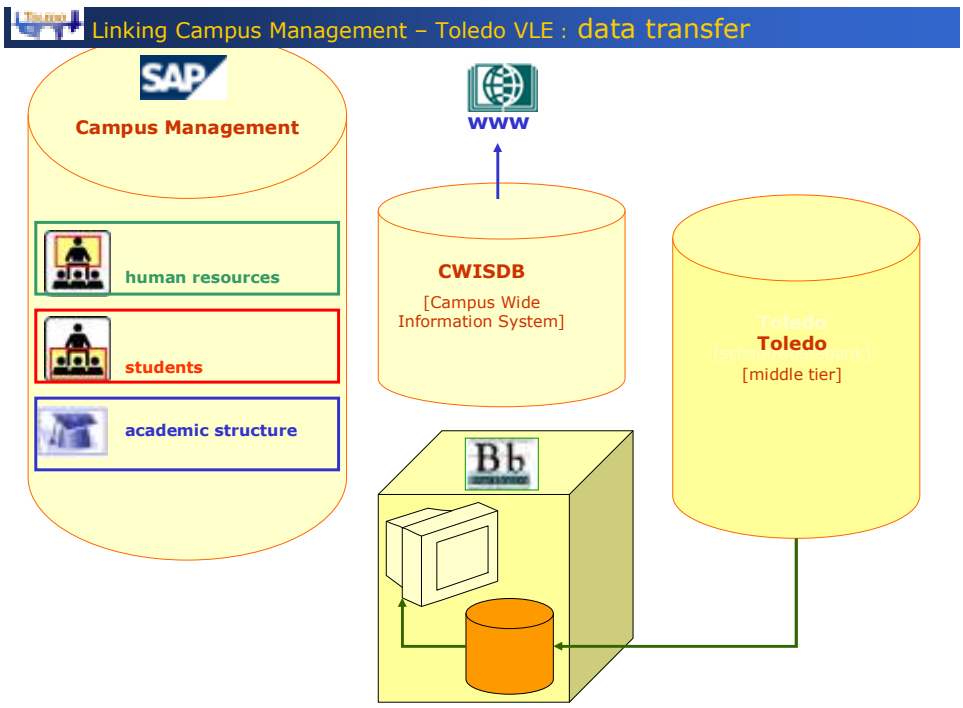
Table 5 Campus Management

<table>
<tr><td>WWW</td><td>E-Desk</td><td>Blackboard Portal</td><td colspan="2">KULoket</td></tr>
<tr><td colspan="2">Public Website University</td><td>TOLEDO E-Learning
Communities
Assessment tools</td><td colspan="2">Campus Management
KU Loket
E-University</td></tr>
<tr><td colspan="2">SAS, supercomputing, Faculties, Research, Scientific apps.</td><td>SAP Central Administration</td><td>LIBIS-NG Aleph</td><td rowspan="2">Obsolete administrative systems</td></tr>
<tr><td colspan="2">Oracle, SQL-Server, MySQL, Access</td><td>Oracle</td><td>Oracle</td></tr>
<tr><td colspan="4">Platform : PC LAN's, Unix/Linux, SP2</td><td>Mainframe</td></tr>
<tr><td colspan="5">Network services : KOTNET KULeuvenNet</td></tr>
</table>

The main focus of the Anemoon SAP implementation project is to provide a coherent layer of databases, replacing all mainframe applications, of which some are still based on IMS. But also our Library systems, long-time adherents of mainframe philosophy, are following the newest trends by adopting, in this case, the Aleph solution from Ex-Libris.

In 2004, the decision was made to integrate the SAP portal with the Toledo portal environment for the academic year 2005-2006. Students register their official study program through this portal, which automatically registers them for the Blackboard courses available.

Figure 6 Integration of CM and TOLEDO



The most promising aspect is already a reality: the portal is the common interface, not only for the students of K.U.Leuven, but also for 6 other association partners. This way, we can offer the same information to all students of Spanish language courses in the whole of the association by using the portal roles and communities. Since bachelor students are possible candidates of master curricula in the same association, this portal interface offers many possibilities to provide the students personalized information throughout their curriculum. This “profiling” of students has tremendous educational potential.

4.1 Open architecture and standards

The large scale and federated nature of the K.U.Leuven Association – where institutions each have their own ICT history and existing legacy databases - means that it is not possible to embrace an overall “open source” doctrine. Of course, the Leuven University has a lot of resources for programming and developing software. A common argument is that many scientific collaborators at university faculties are skilled programmers, and that an open source approach would enable to integrate these resources for the development of university administrative systems.

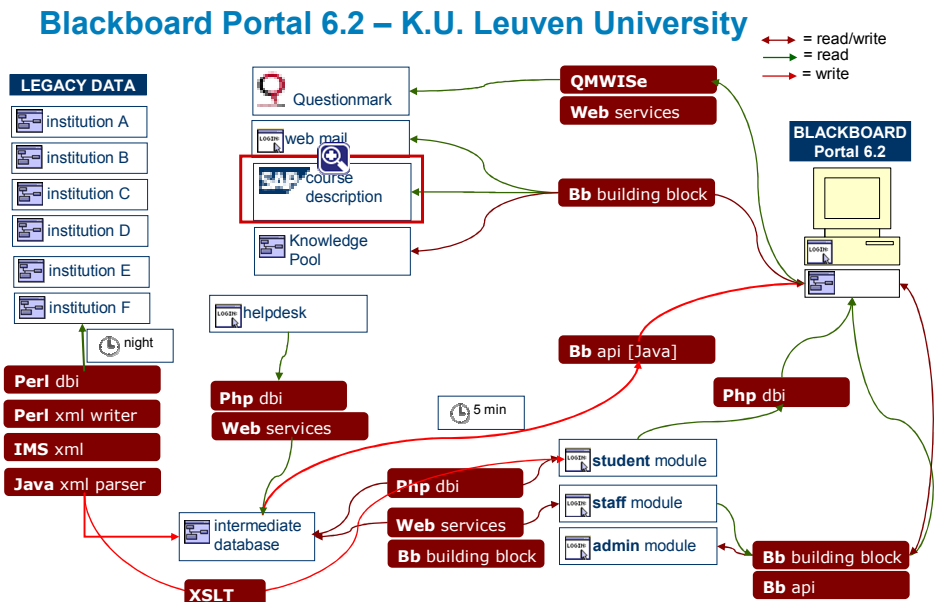
For us, this does not seem a very viable solution. Scientific collaborators are meant to practice science, and they should focus on research rather than solving administrative problems. The argument of the availability of skilled developers is only theoretical and does not take the resource management of the available expertise into account. Most scientific collaborators working on projects have deadlines to meet and researchers have PhD’s to prepare and articles to write! Also,

security concerns make it difficult to give development access to a large group of non-professional collaborators. Moreover, IT-support staff at our institution has a specific deontology, which goes beyond the deontology binding scientific IT-users. Mixing both groups to develop life systems would generate a lot of liabilities. Instead of enlarging software development capacity for administrative systems, the academic's input is preferably directed to steering committees and control organisms, where their expertise can enhance overall quality control.

We see the advantages of open source more in the ease of software maintenance and in the fact that it is sometimes easier to find qualified people for open source solutions than for legacy or proprietary systems. On the other hand, we do organise our services around the concepts of open architecture and open standards.

We find it essential to have an open architecture, which enables to plug-in different software into one, manageable complex information system. This way, component services can develop at their pace or be substituted by more competitive alternatives if required. At the very heart of the TOLEDO/GDLO service are web services and IMS compliant document interchange procedures in Java and Perl. The XML-based information interchange allows for smooth and reliable, transaction-oriented exchange of data between association partner institutes, but also between SAP databases and Blackboard or Blackboard and QMS within the K.U.Leuven context. It also allows new partners to plug in through standardized procedures, and without having to do prohibitive investments.

Figure 7Net-centric approach: interfacing Blackboard with other systems



This is what we call a **net-centric** approach: the highly layered infrastructure is bound together with open standard protocols, which enables a modular design of the support resources throughout the university and association network. Just as, on a deeper level, the Toledo database team can hand off the data storage and security issues to the specialized SAN people, at a much higher level one of our association partners can hand off its course enrolment to our Toledo portal people. In each case, service agreements clarify the expectations and requirements for the service to be delivered.

5. Conclusion: a net-centric approach for growth and flexibitlity

The key factor in this endeavour are the large databases we use for our resource management, starting from financial data to HR and Real Estate, over audio-visual material, course materials, courses, course descriptions, dissertations, usage data etc. Table 6 shows how this rearrangement of the core IT-systems of the universities is the true revolution that is taking place, where behind

the scenes these databases start to model the core activities of a university in the knowledge economy.

By choosing an open architecture, we hope to combine the best of many worlds. On the one hand, the large scale of our organisation urges for solid, industry-class solutions. These are to be found through mayor ERP companies and are not readily available in open source. Being part of a large customer network with the same needs for e.g. legal obligations for accountancy etc. creates a lot of advantages. In the same way, we chose Blackboard as a proven LCMS, avoiding the need for development in basic functionality. Integrating these investments however through a layer of in-house developed, state-of-the art open standard compliant XML data interchange techniques, makes us both more independent from choices made and open to new functionalities and service levels.

On the other hand, this net-centric approach does not lead to a myriad of databases: the master data are consolidated and deeply enshrined as the core engin of this system. This will enable the Leuven university and its association in the near future to extract valuable business intelligence data out of these integrated systems: comparing results for specific course components between associationwide student groups; monitoring and guiding the students course curricula through the personalized portal. And, of course, in the end this should lead to better, more flexible course curricula for specific target groups, enabling the Leuven university association to adapt dynamically to the education market.

Table 6 Layered net-centric architecture

WWW	E-Desk	Intranet Portal	E-Portfolio	Knowledge pool
Public Website University IPAC	E-University external services	TOLEDO E-Learning ODL	Campus Management KU Loket E-University BW - EIS	Librisource SFX ETD
SAS, supercomputing, Faculties, Research, Scientific apps.	Authoring environments multimedia IMS SCORM		SAP Central Administration	LIBIS-NG Aleph
Application databases: Oracle, SQL-Server, MySQL, Access, R/3				
Resource Management			DSPACE	
Master data: core databases (Oracle)				
Platform : PC LAN's, Unix/Linux, SP2, Mainframe				
Storage management: NAS – SAN				
User Authentication & authorisation AAI				
Network services: KOTNET KULeuvenNet				

6. Acknowledgements

Special thanks go to Prof. Antoine Van de Capelle, chairman of the ICTO advisory board, René Florizoone and Anne-Marie De Meyer from LUDIT, Prof. Herman Buelens, Director of DUO/ICTO and of course the members of the Toledo-Team K.U.Leuven: Dirk Cosemans, Ilse Depré, Herta Van den Eynde, Pieter Vandepitte, Arnoud Wils (LUDIT) and Natalie Coelmont, Hilde Creten, Nicole Totté (DUO/ICTO). Mariet Vriens (Maerlant Centre) was so kind to revise the English text.

References

Akeroyd, John (2005) “Information management and e-learning: Some perspectives.” *Aslib Proceedings*, Vol. 57 Issue 2, p157-168.

Alvin I. Goldman (1999) *Knowledge in a Social World*, Oxford UP, Oxford

Barker, Philip (2005) “Knowledge management for e-learning” *Innovations in Education & Teaching International*, Vol. 42 Issue 2, pp111-122.

Begeleide Zelfstudie (1999), [online] http://www.kuleuven.ac.be/duo-icto/bz/index.php

Connolly, Michael; Jones, Norah; O'shea, John (2005) “Quality assurance and e-learning: reflections from the front line” Quality in Higher Education; Vol. 11 Issue 1, pp59-68.

Derek Bok (2003) *Universities in the Marketplace. The commercialization of higher education*, Princeton UP, Oxford

Duval, Erik; Forte, E; Cardinaels, Kris; Verhoeven, Bart; Van Durm, Rafael; Hendrikx, Koen; Wentland-Forte, M; Ebel, N; Macowicz, M; Warkentyne, K; Haenni, F. (2001), “The Ariadne knowledge pool system” *Communications of the ACM*, Vol. 44 No.5; pp73-78.

Duval, Erik; Hendrikx, Koen; Cardinaels, Kris; Van Durm, Rafael; Verhoeven, Bart; Cleenewerck, Thomas; Olivié, Hendrik. (2001), “Using Ariadne for real: the Leuven experience” *Proceedings of the Ariadne foundation* / Ed.: E. Forte, Vol.1, pp73-82.

Elen, Jan - Roosels, Walter - Clement, Mieke - Verhesschen, Piet - Waeytens, Kim (2003) “Begeleide zelfstudie aan de K.U.Leuven: een stand van zaken” *Dynamiek in het hoger onderwijs : uitdagingen voor onderwijsondersteuning* / onder red. van N. Druine, M. Clement en K. Waeytens. - Leuven: Universitaire pers Leuven, pp31-43.

Elen, Jan (2003) “Fostering quality in higher education: digital media and guided independent learning at the university of Leuven” *Wirkungen und Wirksamkeit: neue Medien in der Bildung* / Eds.: R. Keil-Slawik, M. Kerres. - Münster: Waxmann, 2003. - pp275-293.

GDLO (2005), [online] http://associatie.kuleuven.be/bezoeker/digitale_leeromgeving.htm

Hellemans, Mariette; Simons, Maarten; Braeckman, T.; Elen, Jan (2004) “The relation research-education in the self-understanding of universities: an exploration of ambivalence” paper presented at the Third Global Conference: the idea of education (http://www.inter-disciplinary.net/ati/education/ioe/ioe3/s6.htm) - Prague, Czekia

John S. Brown & Paul Duguid (2000) *The Social Life of Information*, Harvard Business school Press, Boston

Jon Mason and Paul Lefrere, “Trust, collaboration, e-learning and organisational transformation”, *International Journal of Training and Development* 7:4

Joseph O. Chan, “Enterprise Information Systems Strategy and Planning”, *The Journal of American Academy of Business*, Cambridge, Nr.2 March 2005

Michael Meire, Erik Duval, Joris Klerkx, Stefaan Ternier, Jan Van Looy, Frederik Truyen, Sara Roegiers (2004) "Authoring on top of a Learning Object Repository: the GALATEA-ARIADNE case", published in the proceedings of "ECEL 2004: 3rd European Conference on eLearning" at the Université Paris Dauphine (France, 25-26 November 2004)

Modupe E. Irele (2005) [online] ”Can Distance Education be Mainstreamed?” *Online Journal of Distance Learning Administration,* Volume VIII, Number II http://www.westga.edu/%7Edistance/ojdla/summer82/irele82.htm

Quinsee, Susannah; Sumner, Neal (2005) “How to manage the big bang: evolution or revolution in the introduction of an MLE?” *Aslib Proceedings*, Vol. 57 Issue 2, pp146-156.

TOLEDO (2005), [online] http://toledo.kuleuven.be

Truyen, Frederik (2004) “Total ReUse. Towards a Virtual E-Learning Campus for Sustainable Knowledge Development”, in: EADTU Conference 2004, Heerlen, 21-23 october 2004, Mass-individualisation of higher education for the knowledge-based society: on-line conference proceedings http://www.eadtu.nl/proceedings/

William H Dutton, Pauline Hope Cheong & Namkee Park (2004) “The Social Shaping of a Virtual Learning Environment: The Case of a University-wide Course Management System” *Electronic Journal of e-Learning* Volume 2 Issue 1, pp69-80.