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Subject:	Chapter in ADL NATO TT Handbook on ADL/SCORM
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1 STANDARDS AND ARCHITECTURES

1.1 Introduction

The development and management of educational media / learning content for Computer-Based Training (CBT) and e-Learning is a complex and difficult process. Learning technology standards can be useful, since they better accessibility, exchangeability and reuse of learning content. This memorandum describes the current state of learning technology standards. The memo will be the basis for a chapter in a handbook on learning technology standards in general, and Advanced Distributed Learning/Sharable Content Object Reference Model (ADL/SCORM) in particular.

SCORM is a technical framework for computer and web-based learning that should foster the creation of reusable learning content as "instructional objects" in multiple applications and environments regardless of the tools used to create them (ADL/SCORM, 2001a, 2001b, 2001c). The handbook will be written in the context of the ADL NATO Technical Team (NATO TT), currently presided by the Royal Netherlands Army (RNA).

1.1.1 Goals of standards

The benefits of having a standards-based integrated teaching and learning system include:

- Interoperability: operate across a wide variety of hardware, operating systems and browsers
- Portability: allow software to work on different systems (e.g. JAVA)
- Data exchange: allow systems to communicate with each other, allow data to be transferred to different systems, provide the availability of comprehensive library of training materials in one repository and the resources to mix and match off-the-shelf content with custom content
- Accessibility: learning objects can be indexed and found when needed
- Usability: consistent behavior of systems, no constraints in data exchange
- Reusability: courseware can be modified and reused

1.1.2 Considerations in choosing standards

- Durability: will the technology evolve with the standards to avoid obsolescence?
- Versatility / convertibility: do not require modification as versions of system software change
- Cost: reduction of the costs associated with the implementation of multiple systems
- Scope: consider the range of use

1.1.3 Types of standards

There are two types of standards:

- *de jure standard*: By right; by law; often opposed to “de facto”. The designation of a specification’s status by an accredited body such as IEEE LTSC, ISO/IEC—JTC1/SC36 or CEN/ISSS (European).
- *de facto standard*: Existing in fact whether with lawful authority or not. Typically, when a critical mass or majority choose to adopt and use a specification. For example, TCP/IP, HTTP, VHS etc., are all “de facto” standards.

The ideal state is when a *de jure* standard is also *de facto* (i.e., HTTP).

There are several initiatives that develop and promote instructional technology standards. Many organizations all around the world have been working diligently to create specifications for learning-related technologies and needs such as meta-data, learner profiling, content sequencing, web-based courseware, and computer managed instruction. At first, these groups focussed on different areas of the standards, working simultaneously but not in coordination. Today, these various specification and standards bodies are working together and collaborating on SCORM.

1.1.3.1 Process of standardization

Standardization initiatives develop specifications with the goal to become a standard. A specification is a documented description. Some specifications become a standard, which means they have received the stamp of accreditation after having proceeded through the four stages; Research & development, Specification development, Testing/profiling, and Standard status.

Examples of initiatives that develop specifications are AICC, IMS and ARIADNE. The ADL/SCORM co-labs put the specifications into use either in test situations or pilots to determine what works, what doesn’t, what is missing, etc. (the testing and piloting phase). At the final Standard status, the standard has become widely adapted and is *de facto*, e.g. IEEE LTSC and ISO/IEC JTC1/SC36.

1.1.3.2 Web technology standards

XML is a mark-up language for documents containing structured information. Structured information contains both content (words, pictures, etc.) and some indication of what role that content plays (for example, content in a section heading has a different meaning from content in a footnote, which means something different than content in a figure caption or content in a database table, etc.). A mark-up language is a mechanism to identify structures in a document. The XML specification defines a standard way to add mark up to documents.

In the e-Learning domain, XML allows a structured representation of learning content. The meta-data in XML specify the content structure. The XML-file contains links to the learning material, the lesson content. The XML converts the raw media in sharable content objects and describes how the content objects are used (XML, 2002).

1.1.3.3 ADL or e-Learning standards

ADL is launched in 1997 as an initiative of the US government’s Department of Defence (DoD). The goal was to support time and place independent learning and therewith to increase the learning capabilities of the US government and society. The vision underlying this project is to afford all Americans access to learning anywhere, anytime.

In the traditional educational situation, learning and instruction was aimed at reaching large groups by means of grouping learners into classrooms, develop general curricula and courses, and transmit large chunks of information. One does and can only adapt little towards the prior knowledge and other characteristics of individual learners. This may sometimes be the most efficient method, but mostly it is just firing one large shot of bullets to hit a small, moving target, and hoping some bullets will reach their goal! So effectiveness is probably not high, which may also be the case with respect to efficiency.

E-Learning promises a new situation: individualized, flexible, adaptive, just enough, just for me, just in time, just when needed. So better results are excepted, without travel costs, and less time off work. However, the current applications for e-Learning still reflect the traditional educational systems of learning, just enhancing current models of (school)learning. Also, there are some bottlenecks in making e-Learning really innovative and fulfil its efficiency promises:

- The current generation of e-Learning systems is not ready. Courses often are the smallest approachable units for Learning Management Systems (LMS): the systems that are responsible for delivery and administration of content to the user. There are Learning Content Management Systems (LCMS) that are able to deal with smaller units, but they are still in their infancy.

- Infrastructure is not ready: Most organizations have some kind of IT infrastructure by means of workstations, networks and intranet. But e-Learning pushes the infrastructure to the limit: it often requires considerable amounts of bandwidth, but more important it requires good solutions for security problems (most systems have difficulties with firewalls) and distance learning (how is the situation at home or at the workplace/office).

- Content development is too expensive: Both internal and external development or customization is expensive, time-consuming and requires specific expertise. Content development requires high investments, which are only cost-effective if large target groups can be reached. But this contrasts with the promise of individual, adaptive learning interventions. Moreover, most e-Learning is a simple abstraction of rich, real world problem solving, mostly aimed at the reproduction of factual knowledge (retention). In order to enhance the effectiveness of e-Learning by means of transfer of what is learned into the workplace, the learning intervention requires also rich learning environments with simulation, micro worlds, animations etc. However, this increases the costs considerably.

- Blended learning: The promises of e-Learning to provide flexibility; learning anytime/anyplace, and asynchronously cannot be fulfilled. The experiences are disappointing. Consequently there is a trend towards Blended learning: a mix of classroom sessions with synchronous and asynchronous learning. However, this lowers flexibility considerable, as fixed groups should meet at fixed times at fixed places.

The old ‘content’ model based upon curricula, courses, lessons etc. is not able to fulfill the demands of e-Learning. Hence, for a real improvement of training a new model is required in which (combined) learning objects can be retrieved, assembled and delivered in order to facilitate the needed, short, customized learning interventions. This new model requires a radical new look to learning interventions. The processes need to be transformed:

- There should be more emphasis on the learner (learner-centered), considering what the learner really wants and needs.

- There should be more emphasis on problem solving (instructional design for competences), considering which competences the learner should require. Accordingly, one should use modern Instructional Design (ID) models geared towards competence based learning instead of traditional models that emphasis only transmission of factual information.

- There should be more support for ‘learning organizations’ and ‘organizational leaning’. And formal training should be only provided when needed. In the case of learning organizations the emphasis should be on the integration of work and learning, informal learning, leaning from experts, learning by cases, worked examples, learning from co-workers, cognitive apprenticeships, etc. In the case of organizational learning, one needs to increase the focus on performance support, knowledge management, communities of practice and smart Electronic Performance Support System (EPSS) solutions.

In order to enable efficient and effective transformation of the processes, all these aspects need to be related to a model that describes the creation and management of learning objects, the “Learning Object Economy”.

1.2 Standardization efforts

The Learning Object Economy (LEO) is framed by standardization efforts. This enables finding, assembling, delivering, tracking and evaluating learning objects, independent of systems and infrastructure. The process of creation and management of learning objects can be described along four phases.

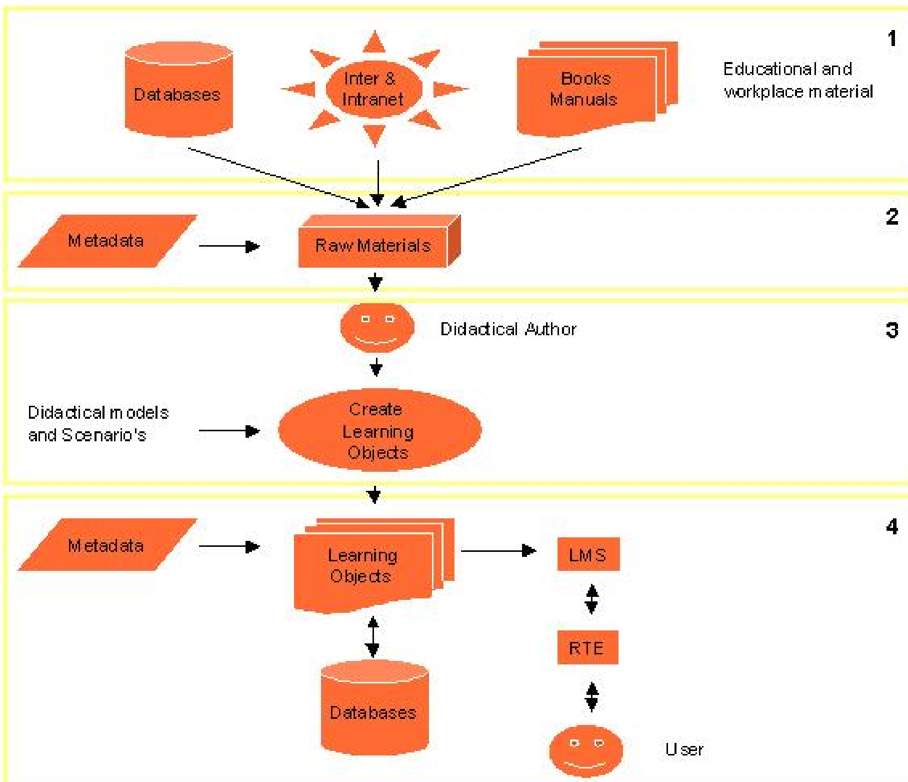

Figure 1 Content creation and management in the Learning Object Economy model.

1 Content is seldom created from scratch, basic material is often available from multiple resources.
2 From these resources, low level learning objects (assets or information objects) can be retrieved and combined, and labeled by means of meta-data.
3 A didactical author (like an educational media developer, a CBT developer, or even a SME) translates the raw materials into (higher level) learning objects. Ideally this is based upon didactical models and an instruction scenario that prescribes the structure and presentation of the learning object (information presentation, practice, assessment, feedback, guidance, sequence etc.).
4 Finally, the learning objects can be labeled by meta-data and stored in databases from where they can be delivered to the user’s Run-Time Environment (RTE) by means of a LMS. A RTE can be viewed as a browser.

Each phase has a specific application of particular standardization guidelines. Also, in each phase, particular problems and bottlenecks appear.

Ad 1) The bottleneck in the retrieval of content from multiple resources is time, effort and costs involved in the retrieval of correct information from a domain or organization. A possible solution is to use tools for semi-automatic segmentation and indexing of fragments of materials, adding meta-data based upon instructional and domain ontologies[1]. However, ontologies cost a lot of effort to create. Another solution may be to use tools that support semantic searches. Examples of standards in this area: MPEG4 (troublesome) and XML (only meta-data).

Ad 2) The bottleneck in the retrieval of learning material is time and costs involved in searching inside meta-data or content. Firstly, the databases often are very large and not supplied with meta-data. Secondly, it is very difficult to define keywords or meta-data for new databases. Finally, ontologies could provide a solution but cost a lot of effort to create. Someone needs to invest in this first. A possible solution is the indexing of resources within the content to use for automatic generation of context specific meta-data. Examples of initiatives in this area are DCMI and IEEE LOM.

Ad 3) Learning content generation is expensive, time-consuming, and requires specific expertise, like dealing with programming and authoring languages and template-based tools. Considering the various types of learning objects according to pedagogical stances, it can be very beneficial to use ontologies to relate learning objects to particular applications and instructional strategies, describing didactical aspects that allow a coupling between didactic scenarios and fragments in the database. These object types and relations could also be described by the meta-model[2].

Ad 4) The bottleneck in the final phase where the learning objects are delivered to the user[3] is how to create, store, manage, and reuse learning objects efficiently across courses, curricula etc. Regardless whether it concerns computer-based, EPSS-based, paper-based training material and courses, one needs to find a way to support (large) teams working on learning objects. A possible solution can be found in the application of a Learning Content Management System (LCMS), to manage content and learning objects. By means of a LCMS, the LMS is capable to retrieve the right content from the database (considering the learner's progress) and deliver it to the learners. An example of a standardization initiative that is active in this area is the IMS repositories (see the section about IMS).

There are multiple standardization initiatives that address the standardization issues in this model. Some of them are already mentioned above. Most of the standardization efforts are focused on development, delivery, administration and evaluation of content. They only provide little information on how to create content, how to deal with learners, how to adapt didactical models and how to interact with other learning systems.

In the next section, an overview is given of the most important standardization initiatives and the relations between them. The standards are discussed upon their role in the Learning Object Economy.

1.2.1 DCMI

The Dublin Core Meta-data Initiative exists since 1995 and is the oldest standard. It organizes an open forum engaged in the development of interoperable online meta-data standards that support a broad range of purposes and business models. DCMI is dedicated to promoting the widespread adoption development of specialized meta-data vocabularies for describing resources that enable more intelligent information discovery systems.

[1] An ontology is a conceptual description of structured information.
[2] One of the rare initiatives in this area is the Educational Mark-up Language (EML). EML originates from the Open University of the Netherlands and constitutes the basis for the Learning Design specification of IMS (see the section about IMS).
[3] The user is not always the learner; it can be an administrator as well.

The general applicability of the meta-data makes it a strong candidate to bridge disciplines and sectors to provide users with a common discovery model that will work throughout the Internet Commons. The DCMI initiative is very active in developing domain specific application profiles in the library domain. It however lacks experience in other domains.

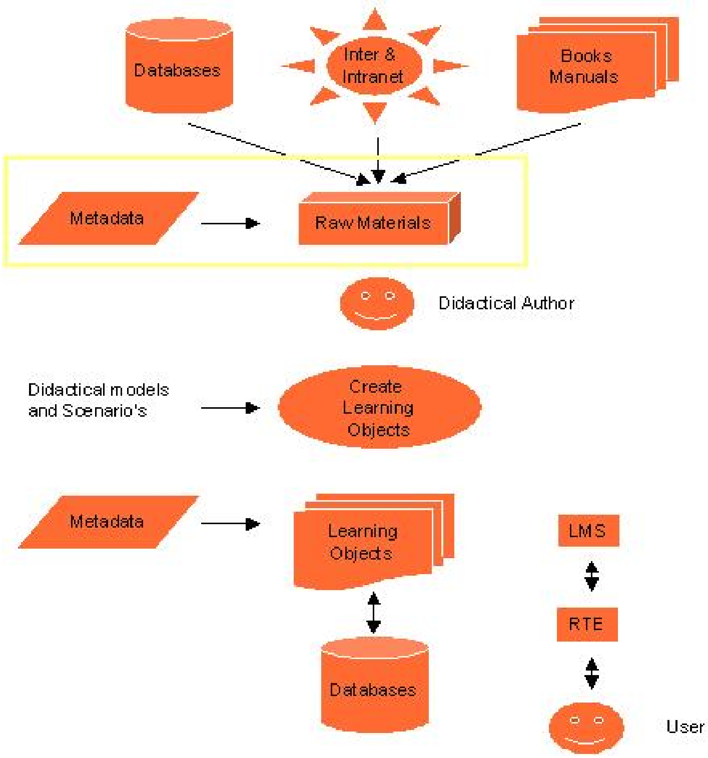

Figure 2 Focus of DCMI in the Learning Object Economy model.

The purpose the DCMI is to support retrieving, assembling and delivering raw materials. It supports standardization of meta-data to label raw material.

The DCMI data elements map directly to the data elements defined in the IEEE LOM standard (see next section).

Conclusion
DCMI is active in labeling raw material through meta-data. Its mission is to make it easier to find resources using the Internet through the development of meta-data standards for across domain applicability.
The approach of DCMI is to index material within the content and to define a standardized set of meta-data for across domain applicability. Though it is very successful in the library domain, it lacks experience in other domains (DCMI, 2002).

1.2.2 IEEE LTSC / LOM

The mission of IEEE LTSC working groups is to develop technical standards, recommended practices, and guides for software components, tools, technologies and design methods that facilitate the development, deployment, maintenance and interoperation of computer implementations of education and training components and systems.

IEEE specifications are already widely adopted and becoming international standards. Within the IEEE, the Learning Technology Standards Committee (LTSC) provides specifications that address best practices, which can be tested for performance. The most widely acknowledged IEEE LTSC specification is Learning Object Meta-data (LOM).

The LOM standard defines a structure for Learning Object Meta-data; element (groups) that describe learning resources. The data elements in the basic meta-data structure (Base scheme) describe a learning object. The learning objects describe features related to the history and current state, technical requirements, intellectual property rights, comments about the educational use, etc.

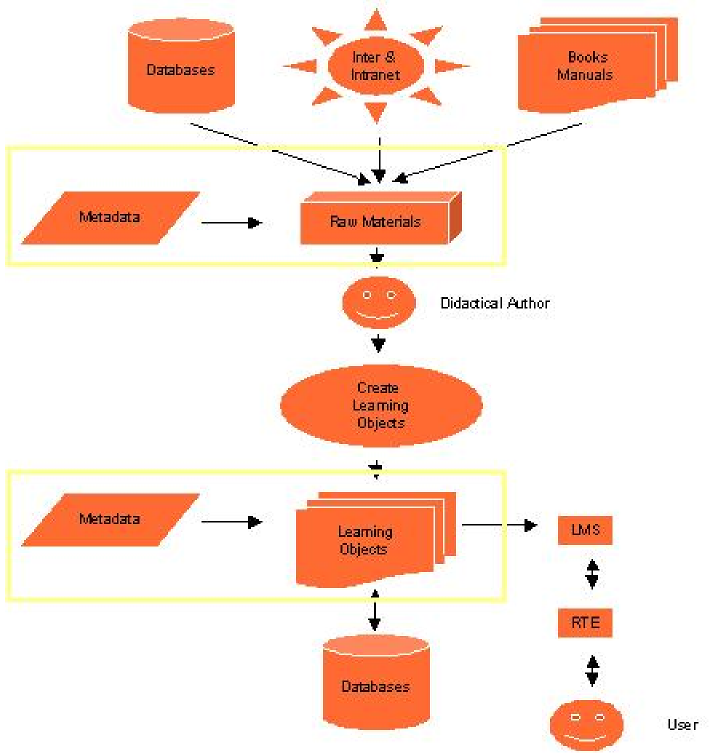

Figure 3 Focus of IEEE LOM in the Learning Object Economy model

A LOM instance strictly adopts the Base scheme plus some optional and/or conditional elements. These provisions for extensions to the base scheme can be introduced without breaking the interoperability between systems that may support different extensions.
In practice, problems with semantic interoperability exist when data elements are abused, e.g. using the title data element to describe the fonts used in the document. This decreases the likelihood that other end users will understand such meta-data sufficiently.

LOM is especially directed at the practical aspects of meta-data. The didactical aspects are restricted to issues such as target group for particular learning material and the time needed for a course. It offers no real support for coupling didactic scenarios to fragments in the database. To achieve that, a more extensive didactic implementation is needed than LOM can offer.
LOM does have an element for indexation through ontologies called ‘TaxonPath’. This element focuses on general classification schemas, e.g. the Dewey indexes, which are less relevant in the context of learning technology. This probably is the reason why SCORM did not adopt this element.

As LOM specifications are very practical, they are widely adopted, used and tested on performance amongst domains. IMS and ADL both use the LOM elements and structures in their specifications. The SCORM meta-data specifications directly reference the meta-data specifications of LOM as the generic specification.

Conclusion
IEEE LOM describes the structure and presentation of learning objects by means of meta-data. It describes a common overall structure of objects within the context of a unit of study (texts, tasks, tests, and assignments). It does not describe the semantic relations between different types of objects.

IEEE LOM supports interoperability between systems as well as usability for specific domains and user groups. Context specific indexing of content can be achieved by specifying optional and/or conditional meta-data elements, a specific set of descriptors for a specific user group or industry. These extensions to the Base scheme can be introduced without breaking the interoperability between systems that may support different extensions (LTSC/LOM, 2001).

1.2.3 EML

The creation of learning objects from raw material should ideally be based upon didactical models and scenarios. One of the rare standardization initiatives in this area is the Educational Modeling Language (EML).

The EML initiative originates from the Open University of the Netherlands (OUNL) and forms the basis for the Learning Design specifications of IMS. The EML started in December 2000, being the first notational system that describes not just the content of a unit of study (texts, tasks, tests, and assignments) but also the roles, relations, interactions and activities of students and teachers.

In e-Learning the focus is often on the knowledge resources, while the ‘learning’ part is forgotten. However, a lot of learning does not come from knowledge resources at all, but stems from the activities of learners solving problems, interacting with real devices, interaction in their social and work situation. EML is one of the spare initiations that claim that knowledge objects are not the key things in effective learning processes. It focuses on the pedagogical design of learning experiences.

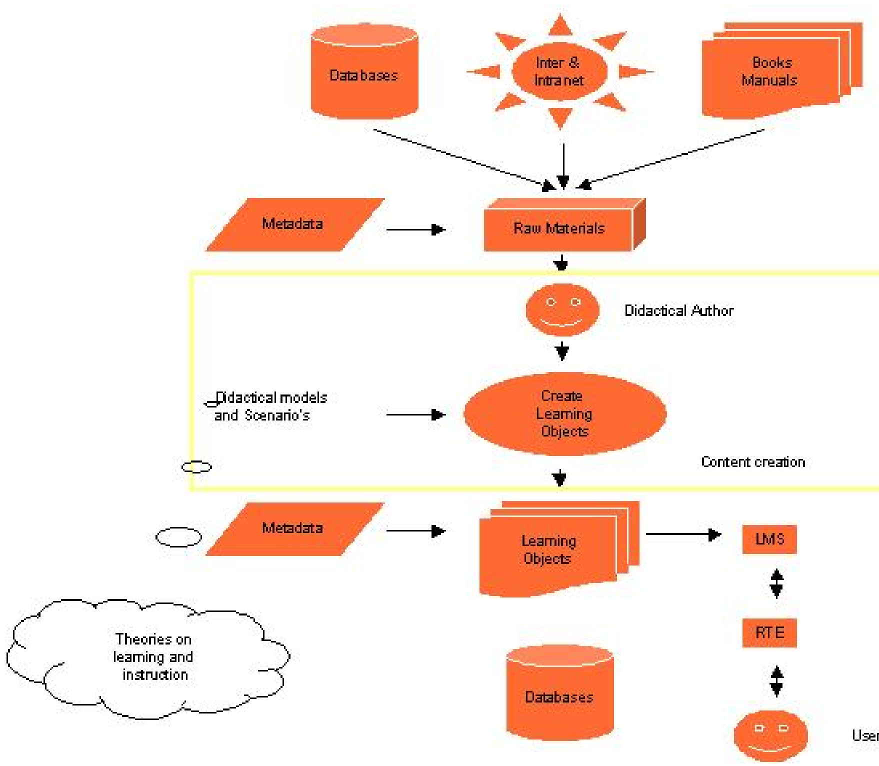

Figure 4 Focus of EML in the Learning Object Economy model.

In their approach, the EML starts from the didactical demands in modeling learning material; it defines 'Roles' and 'Activity environments that can have properties and will be sequenced by play'. The pedagogical model expresses semantic relationships between pedagogical entities. It merely records the way in which the various elements of a particular educational setting are related. The basic idea is:

- to classify, or type, the learning objects in a semantic network, derived from a pedagogical meta-model;
- to build a containing framework expressing the relationship between the typed learning objects;
- to define the structure for the content and behavior of the different types of learning objects.

Expressing all possible relationships sounds ambitious, but the educational domain is a restricted domain with a lot of commonalties in its instances. These commonalties are the focus of the meta-model; the differences (that still exist) are made by parameterization of the meta-model.

EML describes units of study. A unit must meet some general requirements including the ability to describe personalization aspects. The content and the activities within units of study can be adapted to the preferences, prior knowledge, educational needs, and situational circumstances of users.

The unit of study is neutral with respect to the pedagogy and mode of delivery used. One may use EML to model for instance a competence-based pedagogy, problem based learning, performance support, self-study packages or even traditional face-to-face teaching. It allows one to deliver learning materials on paper, on CD-ROM, via the Internet, or via e-books.

Conclusion
EML is the first notational system with a meta-model that describes relationships between different learning objects, considering different pedagogical stance, roles, relations, interactions and activities of students and teachers. In contrast to other modeling languages, like LOM, EML focuses on pedagogical design of learning experiences and meets many of the learning interventions as aimed at in new reference model for e-Learning like adaptation of the learning objects to the competences, preferences and needs of the learner (EML, 2001).

1.2.4 ADL/SCORM

The ADL initiative is central to the development of the SCORM standard. The ADL/SCORM initiative unites different models for standardization into one and translates them into a usable specification frame. It continues to evolve and extent alongside the other standard developments. It is hoped that ultimately, SCORM will integrate and supersede most of current standardization efforts.

ADL/SCORM is a reference model that serves to test the effectiveness and real-life application of a collection of individual specifications and standards. It applies a mapping of standardized meta-data definitions from IMS and IEEE for labeling and indexing of the content, courses and raw media (multimedia) material. IMS is a major collaborative ADL partner and the ADL/SCORM meta-data specification directly references to the Meta-data specification of IEEE-LOM as the generic specification.
Consequently, the implementation of didactical aspects is very limited in ADL/SCORM (just like in LOM). The content structure does not use any didactical guidelines that determine the rational behind the sequence. The focus is on the content, development, delivery, administration and evaluation of content. However, there are more aspects involved in e-Learning, like 'how to create content', 'how to deal with learners', 'didactical models', 'other learning systems', 'LMSs' etc.

The goal of the SCORM model is to provide guidance for describing object-based learning content in a consistent fashion such that they can be searched for and discovered within and across systems to further facilitate sharing and reuse over distance (connected via a network).

In short, it exists of three components:

- The specification of the meta-data model; enabling the description of information about content and courses in order to retrieve and apply this in many different settings.
- The specification of the Content Structure Format (CSF); enabling the description of the structure of courses and lessons in order to retrieve and apply these also in many different ways and settings.
- The specification of the Run Time Environment (RTE); a browser that enables the user to run the courses and content.

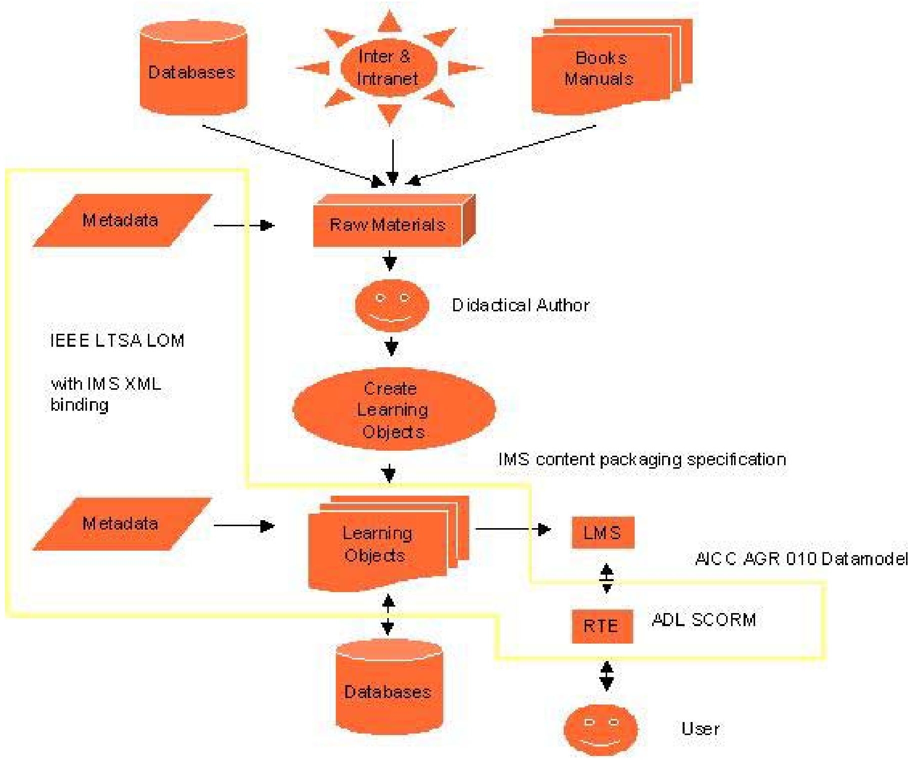

Figure 5 Focus of ADL/SCORM in the Learning Object Economy model.

ADL has established a prototype network with the Co-labs and the Learning Objects Network (LON), of digital asset repositories. It is pursuing the development of a prototype repository that will be used to stimulate requirements for three types of repositories: the asset Repositories, the SCO Repositories and the aggregated Content Repositories. The prototype repository will implement all three types with emphasis on storing (importing), searching (search services) and retrieving (exporting).

The development of a prototype SCORM repository is intended to stimulate feedback on repository concepts and feed the development of an ADL/SCORM Repository Requirement specification. It should facilitate the development of new search engines designed to find and make learning content available. Developers can take their content and aggregate it with repository learning content. In some cases, this might even be done real-time, at the point of use.

The SCORM Content Aggregation Model identifies the building blocks of the content structure format on three aggregation levels and meta-levels:

The first level identifies assets, which represent the learning content in its most basic form; media, text, images, sound, web pages, chat session, assessment objects or other pieces of data that can be delivered to a Web client.

The second level identifies Sharable Content Objects (SCOs), which represent the lowest level of granularity of learning resources that can be tracked by a LMS using the SCORM Run-Time Environment. It represents a collection of one or more assets and/or sharable resources. To be reusable, a SCO itself should be independent of learning context.
The third level identifies the content aggregation (content structure), which is a map that can be used to aggregate learning resources into a cohesive unit of instruction (e.g. course, chapter, module, etc.), apply structure and associate learning taxonomies. It defines the sequence of the learning resources that is presented to the user (ADL/SCORM, 2001b).

Basically, the content structure is an XML-file with meta-data, containing links to the learning material, the lesson content. The links convert raw media in sharable content objects (SCOs) consisting of “executable” content, which delivers small reusable learning objects.

Conclusion
The ADL/SCORM initiative unites different models for standardization into one and adds value to existing standards by providing examples, best practices, and clarifications that help suppliers and content developers to implement e-Learning specifications in a consistent and reusable way.

Basically, ADL/SCORM cuts the course into small chunks, supporting the collaboration of SCORM compliant learning objects in modular training material. However, the meta-data in SCORM only describes how a SCO is used and does not describe the content and structure of a course, e.g. typical scenarios in the structure (ADL/SCORM, 2001a; 2001b).

1.2.5 ARIADNE

The Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE) is a research and technology development (RTD) project pertaining to the "Telematics for Education and Training" sector of the 4th Framework Program for R&D of the European Union. The project focuses on the development of tools and methodologies for producing, managing and reusing computer-based pedagogical elements and telematics supported training curricula.

For the production of pedagogical documents, ARIADNE partners have developed a number of authoring tools for specific types of documents (simulations, questionnaires and self-evaluations). Moreover, segmentation tools have been developed for segmenting existing hypertext or video documents down to smaller and more homogeneous and thus more reusable segments.
In order to support the process of sharing and reusing content across organizational boundaries, ARIADNE has set up a distributed Knowledge Pool System of reusable educational components and has become active in global standardization activities to support an interoperable infrastructure for good quality material.

The goal of ARIADNE is to realize that different descriptions (i.e. meta-data instances) can be associated within one and the same learning object, as there is a degree of subjectivity in the description of the educational use that can be made of a learning object.

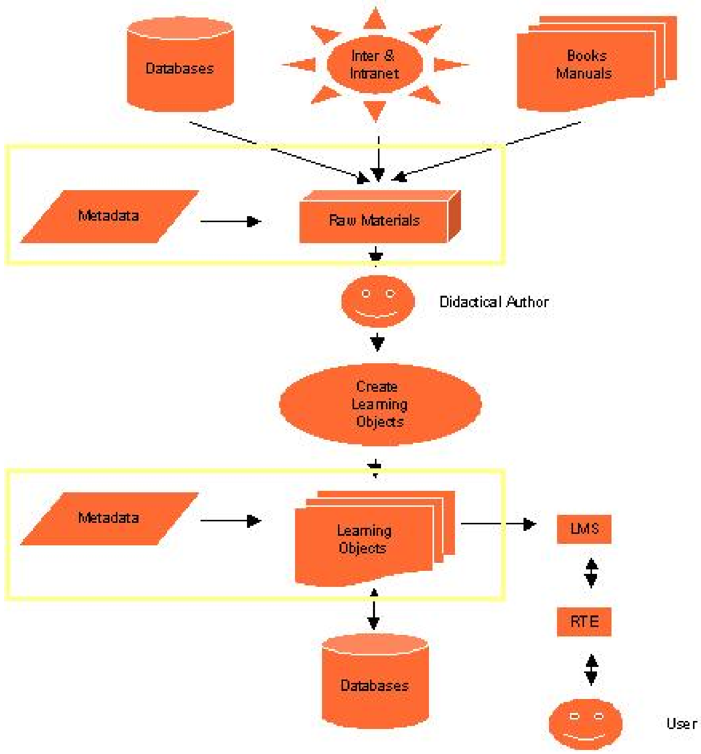

Figure 6 Focus of ARIADNE in the Learning Object Economy model.

To zoom in on relevant material for educational purposes, from a large pool of reusable components, ARIADNE developed so-called “pedagogical headers” that describe general, technical, semantic, and, above all, pedagogical characteristics of the documents involved.

The specifications of ARIADNE and IMS have been used as the basis for the LOM specification. The LOM specification with its Base scheme and extension elements allows a particular community of users (like the ARIADNE user group, or one of its subgroups, for instance in a particular industry) to have its own set of compatible descriptors.

Conclusion

ARIADNE focuses on the development of tools and methodologies for producing, managing and reusing computer-based pedagogical elements and telematics supported training curricula. The goal of ARIADNE is to realize that different descriptions (i.e. meta-data instances) can be associated with one and the same learning object, as there is a degree of subjectivity in the description of the educational use that can be made of a learning object (ARIADNE, 2002).

1.2.6 IMS

While other ADL activities are focused on instructional content development and delivery by the use of current and emerging technologies, the IMS project focuses on next-generation open architecture for online learning. It defines and delivers interoperable, XML-based specifications for exchanging learning content and information about learners amongst learning system components. The XML specifications describe the key characteristics of courses, lessons, assessments, learners and groups.

The most widely acknowledged IMS specifications are the IMS meta-data, IMS content packaging, and the IMS Questions and Test Interchange. These specifications provide a structure for representing e-Learning meta-data. IMS is based on a data model that describes those characteristics of a learner needed for the general purposes of recording an managing learning-related history, goals and accomplishments; engaging a learner in a learning experience and discovering learning opportunities for learners. The specifications support the exchange of learner information among learning management systems, human resource systems, student information systems, enterprise e-Learning systems, knowledge management systems, resume repositories, and other systems used in the learning process.

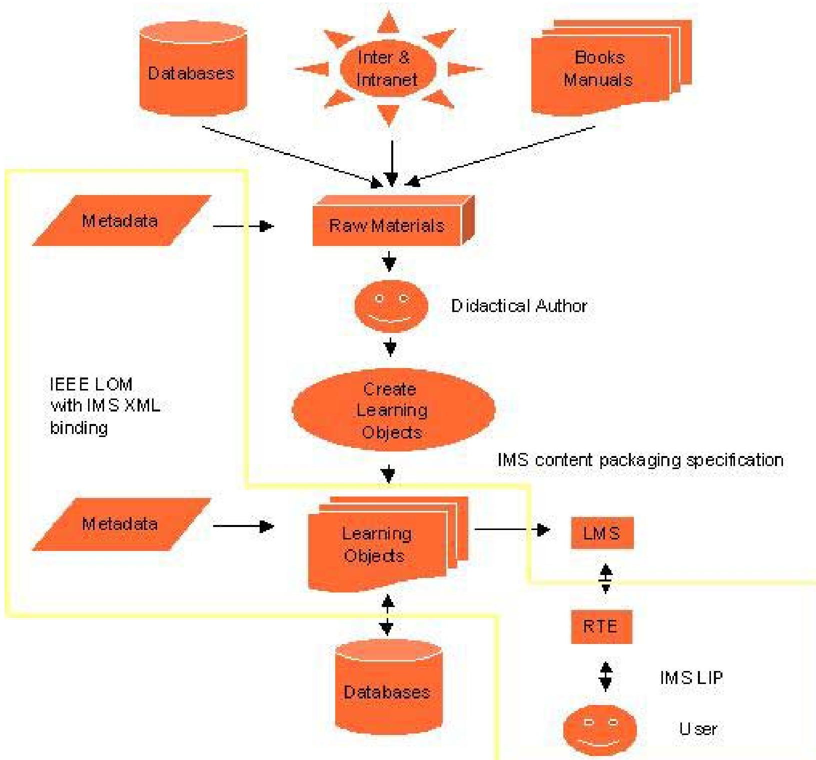

Figure 7 Focus of IMS in the Learning Object Economy model.

Technically, IMS defines a structured information model with the intention to define a set of packages that can be used to import data into- and extract data from an IMS compliant Learner Information server. It defines fields into the data can be placed and the type of data that may be put into these fields. Typical data might be the name of a learner, a course or training completed, a learning objective, a preference for a particular type of technology, and so on.

Practical examples of the exchange of learner information amongst systems are: HRM systems tracking skills and competencies and defining eligibility for training programs, student Administration Systems supporting the functions of course catalogue management and library Management Systems tracking library patrons, managing collections of physical and electronic learning objects and managing and tracking access to these materials.

As mentioned above, IMS is a major collaborative ADL partner. The meta-data specification of SCORM 1.3 directly references the meta-data specification of IMS as a XML binding of LOM.

Conclusion
IMS offers a disciplined approach for describing the various resources and provides a common set of elements that can be exchanged between multiple systems and products. It defines and delivers interoperable, XML-based specifications for exchanging learning content and information about learners

amongst learning system components. ADL/SCORM fully adheres to the IMS specifications (IMS project, 2002).

1.2.7 AICC

AICC is an international association of technology-based training professionals. It develops guidelines for aviation industry in the development, delivery, and evaluation of CBT and related training technologies. Their goal to achieve is more cost-effective, efficient and sustainable training.

The AICC initiative has the longest standing experience from the consortia in the field of education and training. It grew out of the obvious problems caused by the simple fact that, whereas the active life of an aircraft easily spans 30 years, the computer-based training materials that come with the aircraft become obsolete when the next generation of computer technology arrives, which takes only a couple of years (or less).

The AICC published a variety of recommendations, including hardware and software configurations. The greatest impact of AICC has been the development of computer-managed instruction guidelines. The SCORM Run-Time Environment is a deviation of the AICC's CMI001 "Guidelines for Interoperability". It includes guidelines for creating content that communicates both 'communications about the state of the course', i.e., which materials are being presented to the student and 'information about how a student is progressing through a course'.

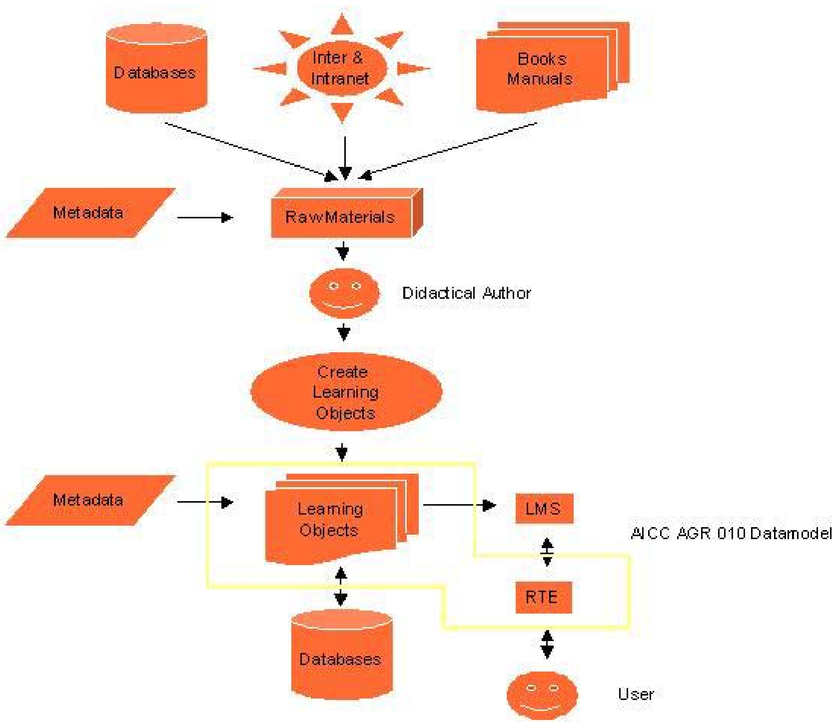

Figure 8 Focus of AICC in the Learning Object Economy model.

Conclusion
The most important input of AICC on ADL/SCORM standard is the CMI guideline. It describes methods for conducting communications between the course and the LMS. AICC's mission thereby is to provide and promote guidelines that result in cost-effective implementation of CBT and WBT (AICC, 2002).

1.3 e-Learning architecture

1.3.1 Management functions

In order to make e-Learning successful, a sufficient investment of the management of a training or educational organization is required. It is recommended to appoint a Learning Manager (see LTSA document of IEEE LTSC) for each learning program or component. This person should be responsible for (a) planning of the course in time and resources, (b) recording of customer details, (c) evaluation of courses, (d) database management, (e) publishing of a catalogue with available courses en possibly previews, and (f) processing of registrations.

1.3.2 Communication and collaboration functions

1.3.2.1 Communication

With one to many real-time discussion applications, instructors can be made available for answering questions that student may have in real-time. The instructor will be provided with a username and password to access an area where he can respond to student queries as they happen. Technologies like email, discussion forums, audio-conferencing and video-conferencing can be very helpful for this purpose.

1.3.2.2 Collaboration

The ideal situation is that blocks of learning content can be used and reused independently of time, place and platform. Developers can take their content and aggregate it with repository learning content. In some cases, this might even be done real-time, at the point of use. That is, learners will be able to create their own, possibly unique, combination of learning content selected to meet their particular needs, just when they need it.

However, considering the fact that standardization development is very technology-driven the didactical issues are often ignored. There are two metaphors that reflect the problems involved in reusing and combining learning objects: the Lego metaphor and the Atom metaphor.

- According to the Lego metaphor *each cube fits another cube* and *by combining cubes each structure* can be built. Combining is seen as easy and accessible.
- According to the Atom metaphor on the other hand, *not every atom fits another atom* and *atoms can only be combined into certain structures*. Combining is seen as something that can *only by done by experienced people and with suitable tools*.

In practice, the Lego metaphor seems not totally fitting the real situation. Not every learning object fits on another learning object. Issues like language, language use and instructional approach play an important role. A collaboration of didactically neutral learning objects does not support the construction of strong learning material.

Moreover, for building strong learning material, training will always be required. Even if the learning objects are very good, it is still possible to build very bad learning material.

1.3.2.3 LMS functionality

The goal of the LMS is to permit a user (learner, instructor, learning manager, or developer) to retrieve learning material in a specified manner, e.g. performing online assessments, offering personalization functionality.

Currently, LMSs are strong on (a) a micro level, considering the progress in learning activities, (b) a meso level, considering the progress in lessons, and (c) on the macro level, with respect to the progress in the course and personal information. There is not much attention to portfolio’s and learning styles, learner’s preferences, etc.

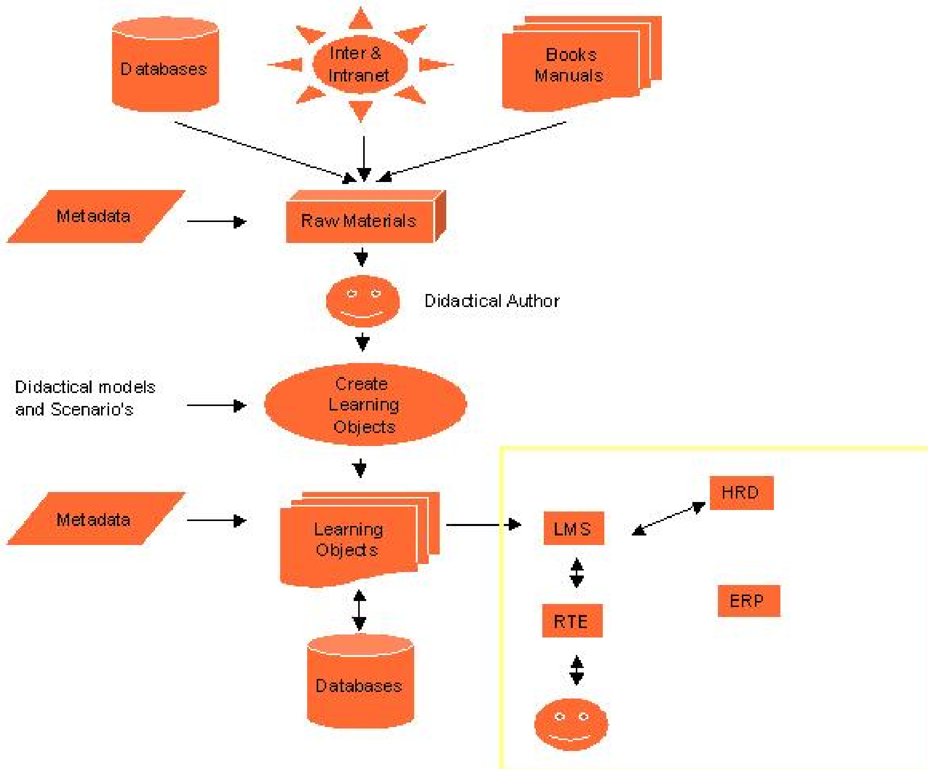

Figure 9 Focus of LMS in the Learning Object Economy model.

The LMS is a software system for the automation and registration of students' learning processes. It exists of a database filled with learner-records, administrative functions and an interface for the presentation of the courses. It delivers a management report.

The LMS is responsible for interpreting the intended sequence described in the content structure (content aggregation) and controlling the actual sequence of the learning resources at run-time. Sequencing/navigation is determined by rules defined within the aggregation and interpreted by the LMS.
The LMS merely processes the externally defined rules and has not necessarily knowledge about how the content is organized except through the importation of rules defined in content packages.

The lowest level of granularity that can be tracked by a LMS is referred to as the SCOs; a collection of one or more assets and/or sharable resources. The SCORM run-time environment overview is a data model that makes sure that a defined set of information about SCOs can be tracked by different LMS environments. It includes both communications about the state of the course, i.e., which materials are being presented to the student, and information about how a student is progressing through a course. If for example, it is determined that tracking a student's score is a general requirement, then it is necessary to establish a common way for content to report scores to LMS environments.

SCORM does not specify the functionality of a LMS. The only specification is that the LMS should be SCORM compliant. This provides the LMS with the responsibility to retrieve the needed Meta-data and control the Run Time Environment through the API (ADLSCORM, 2001c).

1.3.3 LCMS functionality

Whereas the LMS manages learners, their progress and so on, the LCMS manages content and Learning Objects. The LCMS is a system that is used to create, save, assemble and deliver e-Learning objects in the format of learning objects. The system exists of a repository (a database for managing and saving learning objects).

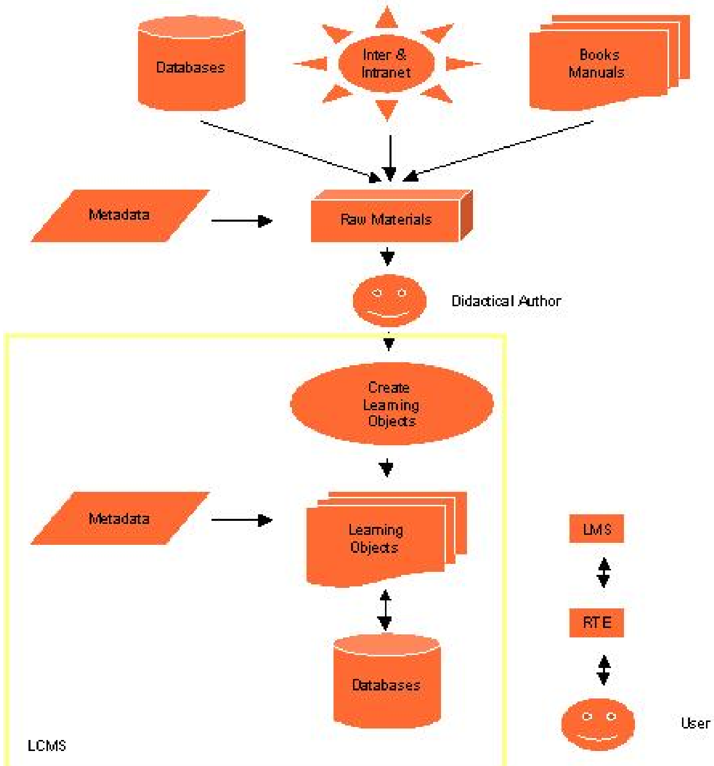

Figure 10 Focus of LCMS in the Learning Object Economy model.

SCORM focuses on key interface points between content and LMS environments. It supports the notion of learning content composed from relatively small, reusable learning resources aggregated together to form units of instruction such as courses, modules, chapters, assignments, etc.

The learning resources have no specific context by themselves. When combined with other learning resources, the aggregation provides the context and allows an LMS to manage the learning experience.
The creation of learning material is based upon a link between multimedia files and the content structure, which define the navigation of information. There are multiple parts of the content structure that each intends to define specific aspects of an authored collection of learning resources. Firstly, the content hierarchy groups learning resources into a logical hierarchical order. Secondly, context specific meta-data describe learning resources, like purpose, description, name (context independent of where the learning resource might be used). Thirdly, issues around sequencing and navigation, describe how to present the choices to the user.

The fact that the LMS is responsible for interpreting the intended sequence described in the content structure and controlling it at run-time represents a major difference from the way courseware has been developed for the use of stand-alone computer-based training and authoring tools. Navigation information was typically imbedded in the data formats. Learning resource reuse cannot happen if the learning resource has embedded information that is context specific to the course. Therefore, it was impossible to share content between different authoring environments.

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