[SGSt01] *Achim Steinacker, Amir Ghavam, Ralf Steinmetz;* **Metadata Standards for Web-based Resources;** IEEE Multimedia, 8(1), January 2001, S: 70-76,.

Abstract
To overcome the information overload on the web, different communities are currently developing metadata schemes, to structure and describe the available information. These metadata descriptions can be used to describe what is actually inside a web based multimedia resource, for what it is good for, who can or should use it and why. In this article we describe two of the most widely used metadata approaches, Dublin Core and the Learning Object Metadata (LOM) approach by the IEEE.
Furthermore, corresponding standardisation efforts of the W3C, like the Resource Description Framework (RDF), are introduced to show how a net of metadata descriptions can be established , to form a Semantic Net on top of the existing WWW.

Introduction

One of the main reasons for the success of the Web has been, that it is very easy to provide information for millions of people. Furthermore, additional information already available somewhere on the Web can be integrated into the own pages, by just adding a simple link. On the other hand, finding the relevant information becomes more and more difficult as the amount of information on the Web grows to unbelievable dimensions. Search engines usually offer thousands of hits to a user as a result of a query, if the keywords the user provided are popular or generic. The problem is that it is still not possible to describe the content of HTML pages, or multimedia content in an adequate way. There is the necessity for information about the information included in a resource, also called metadata – labelling, cataloguing and descriptive information structured in such a way that allows for web pages being properly searched and processed [15]. Metadata shifts the description of the content from a string matching level, where you can hardly make decisions about the relevance of a resource, to a conceptual level, where a user can semantically describe what she/he is actually looking for, much more easier.
"A multimedia system is characterised by computer–controlled, integrated production, manipulation, presentation storage and communication of independent information which is encoded at least through a continuous and a discrete medium" [13] is an example for a definition of multimedia. This definition is sufficient from a technical point of view and helps people to understand how to define and build a multimedia system. What is missing, is the ability how people can describe what is actually inside a of a multimedia resource, for what it is good for, who can or should use it and why. What is needed is a description about the content of multimedia resources available on the Web, tailored to specific needs of different users. As an example for a specific metadata scheme to describe multimedia resources we will describe in this article the Dublin Core which is a simple metadata element set for web resources and the Learning Object Metadata Scheme by the IEEE Working Group P1484.12. [9]

Metadata

Metadata can be defined as information about information or simply data about data. It has been used by librarians for hundreds of years. In fact a library catalogue is a very popular example of the usage of metadata. It helps librarians to manage their books and journals. Using this catalogues the readers can search for material about a particular subject and find them through the library shelves. Search Engines like Yahoo are using catalogues for structuring the content of web pages. If there is no more information available, besides the resource itself, there is no other possibility to classify the resource, than reviewing the resource by some person, to decide where to list it in the catalogue.

With information about the content, the author or the legal conditions, it is easier to classify a resource not also for humans, but also for computers. The main areas where the usage of metadata could be helpful are[6]:

–to summarise the meaning of the data
–to allow users to search for the data
–to allow users to determine if the data is what they want
–to give information that affects the use of data (legal conditions, size, age, etc.)
–to indicate relationships with other resources

To use and benefit from metadata in the Internet, a language as a common format for expressing metadata is needed. This format should be designed for being processed by machines, rather than humans. Merging the web of human–readable documents with a network of machine–understandable metadata promises an immense potential [2]. Proxy caches, web–browsers, search engines and other web tools can work better with humans and participate in a much more intelligent way in locating, evaluating, accessing and managing the web resources.

Metadata application and syntax

The first step when describing a resource with metadata, is choosing an appropriate metadata element set and an appropriate vocabulary as values for the elements. Often the vocabulary for a metadata scheme is taken on or derived from an existing ontology to describe knowledge in general like the International Standard ISO/IEC 11179, Information technology – Specification and standardisation of data elements,
Although every element set or scheme is developed for finding and managing resources, choosing a scheme is highly dependent from the target group for the resource. The type and number of metadata descriptions for a librarian who wants to catalogue a video is completely different from the needs of a company managing a web portal to offer videos for self learning, although they are probably both describing the same multimedia resource. Therefore different metadata descriptions for the same resource will exist. A simple metadata scheme – conceived for author generated description of web resources – is Dublin Core. Another possible metadata scheme, especially for videos is MPEG7 and described in [12]. Dublin Core is designed to facilitate the discovery of online resources in a networked environment. The current metadata set consists of 15 elements. It is completely text–oriented and therefore human readable. Each element is repeatable and optional, and the entire set has been defined as extensible [18]. The fifteen categories of Dublin Core are:

Title
Author or Creator
Subject and Keywords
Description
Publisher
Other Contributors
Date
Resource Type
Format
Resource Identifier
Source
Language

Relation
Coverage
Rights Management

Depending on the element set, there are different ways how metadata could be applied to a resource. It can occur within the resource itself. An example are digital watermarks included in pictures or videos. They can be seen as metadata for pictures or videos with the purpose of protecting the integrity or to ensure the authorship of a resource. Another examples for metadata included in the resource is the usage of HTML meta tags. Metadata can also be stored in a separate description file, it can be transferred accompanying the resource and finally also combinations are possible.
In case of including the metadata description within the resource, the syntax and encoding for the metadata is given by the syntax of the according resource. The usage of the HTML meta tags is a very simple way to apply metadata to a web based document. An example of encoding Dublin Core at the beginning of an HTML page using META tags is shown below. In this case, the metadata describes a Java Applet used for visualisation of communication protocols in an Ethernet LAN.

```
<META NAME="DC.Title" CONTENT="Ethernet Applet">
<META NAME="DC.Description" CONTENT="Visualization of Carrier Sense Multiple Access Protocol
with Collision Detection (CSMA/CD) IEEE 802.3 (Ethernet)">
<META NAME="DC.Type" CONTENT="Learning Material">
<META NAME="DC.Format" CONTENT="Java Applet">
<META NAME="DC.Relation.References" CONTENT="http://www.multibook.de/ethernet.htm">
```

The disadvantage of this approach is that it is not possible to change parts of the metadata description without having access to the resource itself. The other problem is the duplication of information. The value of the "DC.Title" attribute in the above example will most likely appear again in the HTML "Title" tag. Using semantic annotation languages like HTMLa to include metadata within the resource, overcomes this problem but have other drawbacks [4]. Another example with the same information, but this time stored separately from the resource, is described in the RDF section.

When the description is stored and delivered separately from the resource, there is the question of encoding the descriptions. Although there are almost as much possibilities for encoding metadata as there are metadata schemes, usually every metadata scheme can be stored as an XML description. The problem with using XML and a DTD to describe a metadata scheme is that it is only possible to check the syntactical correctness of a description. It can not be used to specify what is meant by description elements. One approach to get closer to the meaning of descriptions is the Resource Description Framework (RDF) developed by the W3C [16].

RDF
RDF is a framework that makes it possible to encode, exchange and reuse structured metadata. It provides especially the basic requirements for metadata interoperability across different resource description communities and applications. RDF is based on the XML syntax and imposes needed structural constraints to provide methods of expressing semantics. RDF additionally provides means for publishing both human–readable and machine–processable vocabularies designed to encourage the reuse and extension of metadata semantics among disparate information communities.

RDF is based on a concrete formal model utilising directed graphs that represent the semantics of metadata. The basic concept is that a resource is described by a collection of "properties" known as an RDF "description". Each of these properties has a property type and value. The RDF model is based mainly on the triple relation of "resource"–"property"–"value" or in other words "subjects"–"predicate"–"object". As an example the above mentioned Ethernet Applet could be considered. In this model the Applet itself is the resource, "DC.Type" is a property of this resource, and "Learning Material" is the value of this property. The corresponding RDF–XML syntax for this example is:

```
<?xml version = "1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:DC="http://metadata.net/dstc/DC-10-EN/#"
<rdf:Description xml:lang="en" about=" http://www.multibook.de/EthernetApplet.html ">
<DC:Title>Ethernet Applet</DC:Title>
<DC:Description>Visualization of Carrier Sense Multiple Access Protocol with Collision Detection
(CSMA/CD) IEEE 802.3 (Ethernet)</DC:Description>
<DC:Type>Learning Material</DC:Typer>
<DC:Format>Java Applet</DC:Format>
<DC.Relation.References>http://www.multibook.de/ethernet.htm</DC:Relation.References>
</rdf:Description>
</rdf:RDF>
```

RDF uses the W3C's namespace convention. In this example, both the RDF and Dublin Core schemes are declared as namespaces and abbreviated as "RDF" and "DC" respectively. The URIs associated to these namespaces refer to the related schemes. Using them, the necessary vocabularies for each data model can be accessed. The element <rdf:RDF> is a simple wrapper that marks the boundaries in an XML document where the content is explicitly intended to be mapped into an RDF data model instance. The element <rdf:Description> contains the URI of the resource in its about statement. The element <DC:Type> in the context of the description represents a property–type DC:Type and a value of "Learning Material".

While XML specifies the syntax of a description, RDF tries to structure the meaning of the descriptions elements. An RDF description provides answers to questions like: about what something is said, who says something and where the statement is stored. Like XML it does also not provide answers to the question: What is the meaning of the statement? To answer this question it is still necessary to agree on a shared vocabulary or namespace about the statements. Without using a vocabulary, it is not possible to automatically make decisions about the resource. Therefore the W3C is currently developing RDF Schema [17]. With RDF Schema, a basic vocabulary for the meaning of a statement in a metadata description and for the relation between two metadata descriptions are introduced. Although the vocabulary used in RDF Scheme currently is limited, it builds the bridge between metadata descriptions like Dublin Core and formal semantic descriptions of specific domains called ontologies. Ontologies using description languages like the Ontology Interchange Language (OIL) [5] – where the concepts of the ontology can be encoded with RDF Schema – can be connected with a metadata description of a web based resource also encoded with RDF Schema. The combination of semantic networks or ontologies with descriptions of web based resources will eventually lead to the so called Semantic Web [3].

Metadata for learning resources

An example for the need of specific metadata are universities or any other organisation with the need of managing, finding and especially reusing learning materials or courses. As described in [14] multimedia technology is not simply an add–on service for universities as computers or audio–visual were before – it touches the very substance of the university that is knowledge development and transfer. In Universities, content is generated every day by building their courses and organising seminars. It is probably stored on the faculty webserver for some more time but it is hard to find it again, although it could still be used in many other projects or seminars. The idea of independent modular information resources described with appropriate metadata, which can be combined in a meaningful way, can lead to different ways of creating learning material which can be reused much more easier, than without metadata. Another important aspect for universities is the changing way of knowledge transfer and teaching itself. The main purpose for a course is no longer to provide students with a closed set of existing knowledge (which can soon be obsolete) but to teach them how to find and correlate knowledge [14].

LOM

One of the most promising approach for metadata describing learning resources is currently developed by the IEEE Working Group P1484.12, the "Learning Object Metadata (LOM)" Scheme. It is mainly influenced by the work of the IMS (Educom's Instructional Management Systems) [7] project and the ARIADNE Consortium (Alliance of Remote Instructional Authoring and Distribution Networks for Europe) [1]. There are already editors available [10] and companies like Microsoft have started to offer free software for it [11]. The LOM scheme uses almost every category of Dublin Core and extends it with categories and attributes tailored to the need of learners and authors searching the web for material.

The LOM approach specifies the syntax and semantics of Learning Object Metadata. A Learning Object is defined as any entity, digital or non–digital, which can be used, re–used or referenced during technology–supported learning. Examples of technology–supported learning applications include computer–based training systems, interactive learning environments, intelligent computer–aided instruction systems, distance learning systems, web–based learning systems and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, instructional software and software tools, referenced during technology supported learning. In a wider sense, Learning Objects could even include learning objectives, persons, organisations, or events. The IEEE LOM standard should be conform to, integrate with, or reference to existing open standards and existing work in related areas.

LOM: Purpose

In the LOM specification [8] the following points are mentioned as the purpose of this standard:

"To enable learners or instructors to search, evaluate, acquire, and utilise Learning Objects.

To enable the sharing and exchange of Learning Objects across any technology supported learning system.

To enable the development of learning objects in units that can be combined and decomposed in meaningful ways.
To enable computer agents to automatically and dynamically compose personalised lessons for an individual learner.
To complement the direct work on standards that are focused on enabling multiple Learning Objects to work together within an open distributed learning environment.
To enable, where desired, the documentation and recognition of the completion of existing or new learning & performance objectives associated with Learning Objects.
To enable a strong and growing economy for Learning Objects that supports and sustains all forms of distribution; non–profit, not–for–profit and for profit.
To enable education, training and learning organisations, both government, public and private, to express educational content and performance standards in a format that is independent of the content itself.
To provide researchers with standards that support the collection and sharing of comparable data concerning the applicability and effectiveness of Learning Objects.
To define a standard that is simple yet extensible to multiple domains and jurisdictions so as to be most easily and broadly adopted and applied.
To support necessary security and authentication for the distribution and use of Learning Objects."

LOM: Structure
The definition of LOM divides the descriptors of a learning object into categories. The actual version of this proposal (5.0) issued on November 11. 2000, introduces 9 such categories [9]:

Category 1: General, regroups all context–independent features of the resource.
Category 2: Lifecycle, regroups the features linked to the lifecycle of the resource.
Category 3: Meta–metadata, regroups the features of the description itself (rather than those of the resource being described).
Category 4: Technical, regroups the technical features of the resource.
Category 5: Educational, regroups the educational and pedagogic features of the resource.
Category 6: Rights, regroups the conditions of use of the resource.
Category 7: Relation, regroups features of the resource that link it to other resources.
Category 8: Annotation, allows for comments on the educational use of the resource.
Category 9: Classifications, allows for description of a characteristic of the resource by entries in classifications

Taken all together, these categories form what is called the "Base Scheme". As an example the detailed structure of the technical and educational categories are presented in the following figures. Some elements like the Description element of the General category allow free text as values, while for other elements the values are restricted to a limited vocabulary.
Following Dublin Core, all categories are optional in the LOM scheme. The reason for this is simple. If someone wants to use all categories and attributes from LOM, she/he has to fill out at least 60 fields. Entries like author, creation date or probably keywords can be filled automatically by an authoring system. But then there are still many entries left, which the author has to fill her–/himself. The time effort to describe all properties of

a resource is considered as a hindrance to a wide distribution and usage of a metadata scheme. Another problem with the use of a general scheme like LOM are special attributes for example the difficulty level (category educational), which should be an integer between 0 and 4. It seems to be almost impossible to find a value for difficulty which is valid in diverse societies and institutions all over the world, even if you can specify a target group with the values of other attributes. Furthermore, the difficulty level of a resource depends on the existing knowledge of the user and especially the context in which the resource is used. There are other examples for the fact that some of the attributes can only be used in closed systems or special cases. The limited possibilities of a single LOM description to make statements about a resource concerning for example the difficulty is, that these are important but also very complex educational statements. Using modular learning resources to build individual lessons automatically, requires more information than the description of a single resource can provide. But also categories with no educational background have this problem. Also the Rights category does not provide enough information to manage a resource within a commercial scenario. The reason is that LOM is reducing the needs from all areas of computer supported learning to a common denominator. It can't and it is not meant to provide all information for every scenario. All categories are optional and the Base scheme can easily be extended to fit particular needs. LOM is just the common starting point of a growing user community including companies and scientific projects, to share and reuse their existing learning materials and knowledge.

References

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[16] W3C, "*Resource Description Framework (RDF) Model and Syntax Specification*", February 1999, http://www.w3.org/TR/REC–rdf–syntax

[17] W3C, "*Resource Description Framework (RDF) Schema Specification 1.0*", March 2000, http://www.w3.org/TR/CR–rdf–schema–20000327

[18] Weibel S., Kunze J., Lagoze C. and Wolf M.; "*Dublin Core: Metadata for Ressource Discovery*"; RFC2413; September 1998

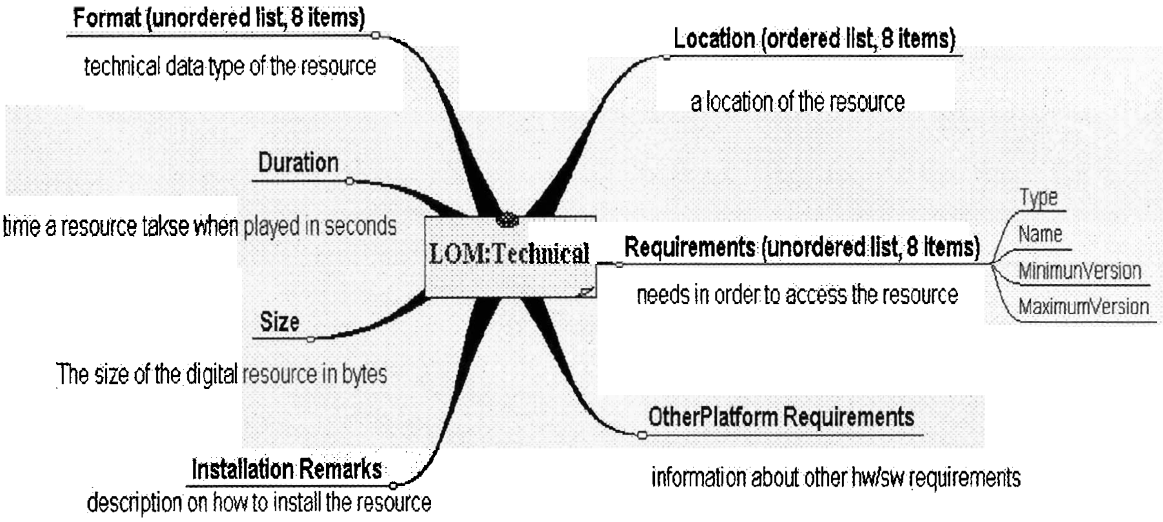
Figure titles:

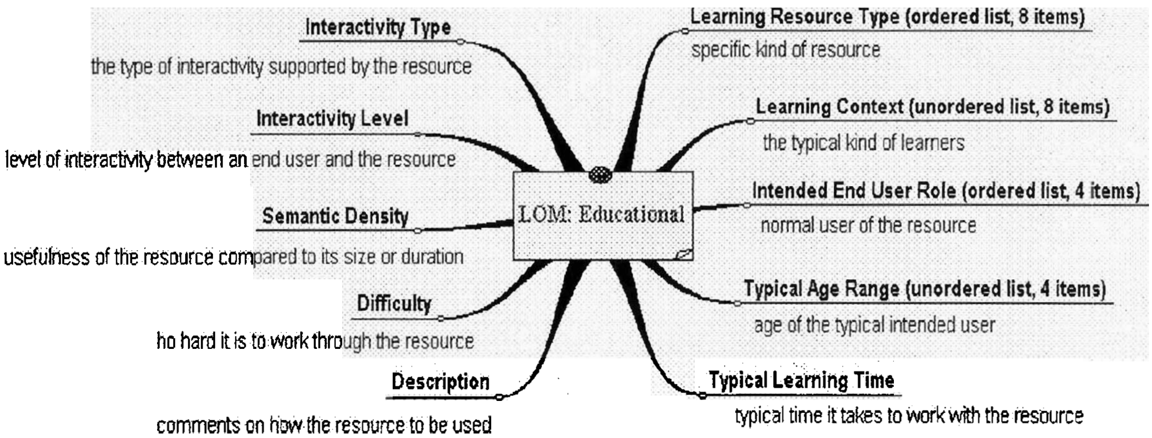
Combination.tif: a modular learning resource its Learning Object Metadata description with RDF and a visualisation of the resource including relations to other resources

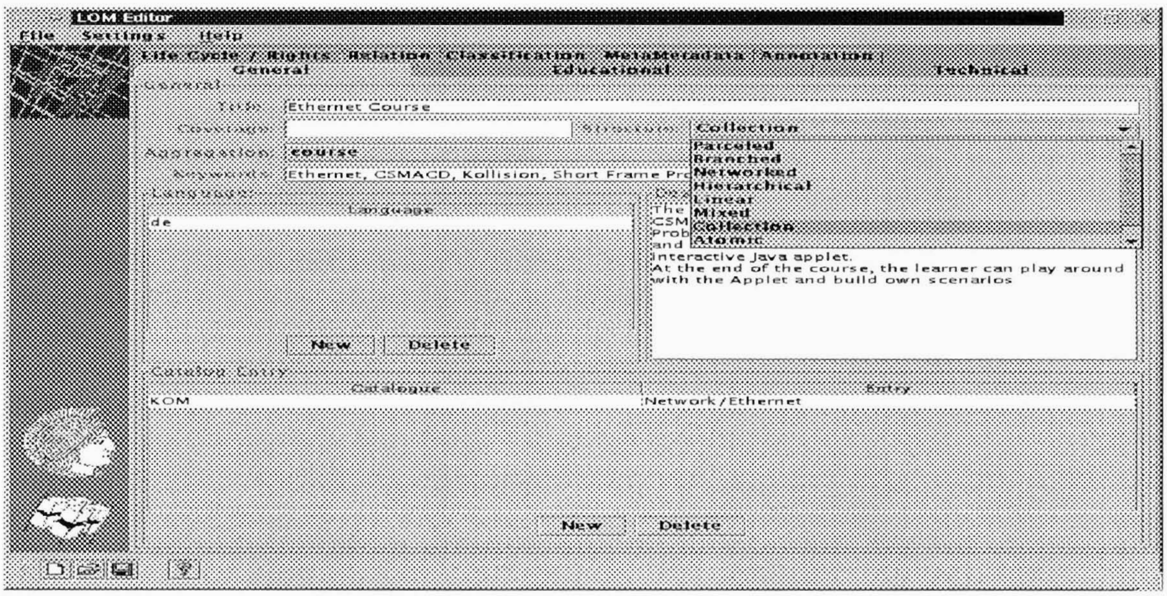
Educational.tif: the educational category of the LOM scheme

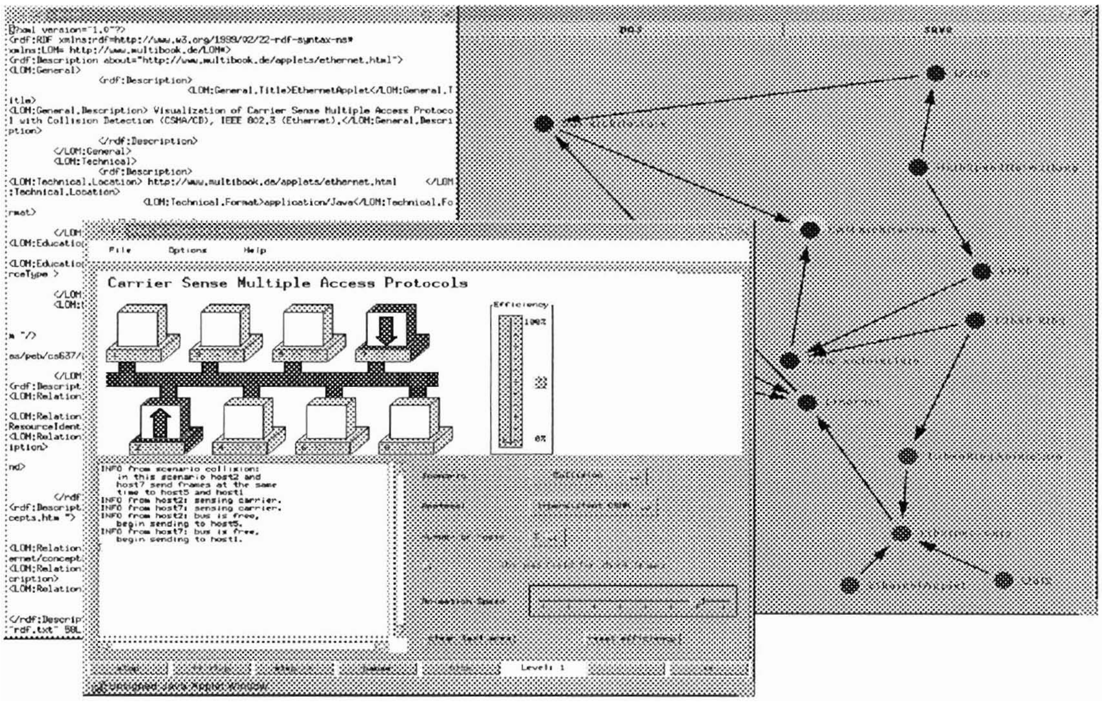
Technical.tif: the technical category of the LOM scheme

Editor.tif: Screenshot of an editor for describing and managing LOM–descriptions.


LOM:Technical
Format (unordered list, 8 items)
technical data type of the resource
Duration
time a resource takse when played in seconds
Size
The size of the digital resource in bytes
Installation Remarks
description on how to install the resource
Location (ordered list, 8 items)
a location of the resource
Requirements (unordered list, 8 items)
needs in order to access the resource
Type
Name
MinimunVersion
MaximumVersion
OtherPlatform Requirements
information about other hw/sw requirements


LOM: Educational
Interactivity Type
the type of interactivity supported by the resource
Interactivity Level
level of interactivity between an end user and the resource
Semantic Density
usefulness of the resource compared to its size or duration
Difficulty
ho hard it is to work through the resource
Description
comments on how the resource to be used
Learning Resource Type (ordered list, 8 items)
specific kind of resource
Learning Context (unordered list, 8 items)
the typical kind of learners
Intended End User Role (ordered list, 4 items)
normal user of the resource
Typical Age Range (unordered list, 4 items)
age of the typical intended user
Typical Learning Time
typical time it takes to work with the resource


LOM Editor
Ethernet Course
Collection
Parceled
Branched
Networked
Hierarchical
Linear
Mixed
Collection
Atomic
course
Ethernet, CSMACD, Kollision, Short Frame Pr
de
Interactive Java applet.
At the end of the course, the learner can play around with the Applet and build own scenarios
New
Delete
KOM
Network / Ethernet
New
Delete



File
Options
Help
Carrier Sense Multiple Access Protocols
Efficiency
100%
0%
Level: 1