Abstract: One of the most relevant activities in the EU TENCompetence project is directed at the development of models and tools to stimulate the sharing and management of knowledge resources. Knowledge resources are the containers that store the explicit knowledge for sharing purposes. Examples are learning objects, articles, books, software programs, informal messages, etc. From the technical perspective the main outcome of this part of the research in TENCompetence is to develop an infrastructure suitable to provide users with functionalities for the creation, storage in distributed, federated digital repositories, search, support, retrieval, packaging, reuse, sharing and quality rating of knowledge resources. Moreover, in order to guarantee a high degree of interoperability, each knowledge resource must be both packaged according to existing specifications (e.g. IMS-CP and SCORM) and uniquely identifiable using worldwide unique identifiers and metadata descriptors (e.g. LOM or Dublin Core format). This paper is an overview on the objectives, issues and potential technical solutions identified in the initial phase of the project.

Keywords: Content management, knowledge management, knowledge modeling, knowledge sharing.

I. INTRODUCTION

From a general perspective, not necessarily related to a learning process, some of the specific business and organizational factors justifying KM adoption include the need for increasing competitiveness and rising the innovation rate [1]. Furthermore, more and more informal knowledge has to be replaced with formal methods, in order to deal with increasing competitive pressure by reducing the amount of people that holds valuable knowledge and limiting the effects of a loss of knowledge due to early retirements and increasing mobility of workers.

Another aspect that has to be considered is the possible loss of knowledge in specific areas due to quick changes, which are normal in the modern society as well as in market’s strategic directions. This, combined with a limited time availability for experiencing and acquiring new knowledge, is rising a need for solutions suitable to manage increasing complexity.

Besides the previous considerations it is worth noting that most of human activities, as well as many aspects affecting normal life, are heavily information and knowledge-consuming. For instance, organizations compete on the basis of knowledge, products and services are increasingly complex and endowed with a significant information component. This means that life-long learning is more and more an inescapable real and urgent need.

It can be said that knowledge and information domains have become a relevant space in which problems occur, from everyday life issues to learning/training and business processes. As a result, managing and appropriately sharing knowledge represents the primary opportunity for achieving substantial savings, significant improvements in human performance, and competitive advantage.

Within this context the TENCompetence project aims at investigating aspects of knowledge resources management and sharing (KRMS) from the perspective of learning processes and scenarios. The final objective is to develop an infrastructure for managing and sharing whatever kind of knowledge resources and suitably support innovative knowledge exchange paradigms and models within learning activities. This will be achieved through some consistent and correlated tasks.

As a first step liaisons with other initiatives in the KRMS area are needed to both avoiding reinventing the wheel and promoting the adoption of open standards and protocols. Furthermore, components should access and use existing libraries of knowledge resources were possible.

The following step is the selection and adaptation of existing tools is considered, to create a set of KRMS components that can be integrated as services within an integrated complex system that will be evaluated in terms of efficiency, effectiveness and usability.

Outcomes from the assessment activity will allow defining a roadmap for further research and development in the field of KRMS.

With respect to these objectives and activities, the following sections are devoted to a description of the main issues that need to be dealt with and a preliminary proposal for a conceptual and technological framework that could be adopted in TENCompetence for providing KRMS features.
II. WHAT IS KNOWLEDGE RESOURCES MANAGEMENT?

When dealing with knowledge management the first issue is to define the concept of knowledge itself, as this definition will directly impact the whole discussion eventually even preventing a real in-depth understanding on what is exposed. Therefore, as usual in any multidisciplinary environment like TENCompetence, it is necessary to agree on used terms in order to fully avoid misleading assumptions.

Unfortunately, there's no universal definition of knowledge management, just as there is no agreement as to what constitutes knowledge in the first place [2]. Over the millennia, philosophers and scientists of each age have added their own definition of knowledge to the list. For instance according to Plato, as emerging from his Dialogues, and other ancient Greek philosophers we could say that:

- knowledge is what is true. What is true represents reality as it is and therefore knowledge represents reality as it is (Socrates)
- conceptual knowledge is truly knowledge for us (psychological fact), so conceptual knowledge represents reality as it is
- conceptual knowledge represents reality as static, eternal and necessary. (Parmenides)
- the phenomenal world (becoming) is not static, eternal and necessary. (Heraclites)
- the phenomenal world is not reality. Therefore conceptual knowledge doesn’t represent the phenomenal world.

From what just stated is apparent that the concept of knowledge can be split in what is absolutely true (maybe also unknowable) and what is perceivable. In the latter, knowledge is specific to the cognitive system that created it, not residing outside the cognitive system.

Moving from the pure concept of knowledge to a reasonable and applicable definition of knowledge management, also in this case several attempts have been made and can be found in the related literature. Starting from this and taking into account the specific objectives and constraints in the TENCompetence project with respect to knowledge resources management and sharing features, we could say that the main high-level requirement for the KRMS components is to contribute to the logical and practical flow that goes from basic knowledge resources to complex learning activities support.

The basic assumption behind such a requirement is that any piece of knowledge, whatever it is from e.g. a simple image up to a complex learning path, can be looked at as a self-consistent object with common rules for storage, retrieval, indexing, etc. at least with respect to low-level management and sharing. This doesn’t mean that the KRMS will provide features as, e.g., a units of learning editor, as these will be offered by upper layers in the TENCompetence system. On the other hand, at the infrastructural level a unit of learning will be looked at as a knowledge resource.

To fulfill such a macro-requirement it is necessary to supply a complete and consistent infrastructure suitable to be used for managing and sharing any kind of information produced and exchanged within the integrated TENCompetence system. Actually this top-level goal implies two different sub-objectives, which will be deepened afterwards:

- on the methodological side, defining innovative models and approaches for stimulating the active creation and sharing of knowledge resources
- on the technical side, providing knowledge resources storage, retrieval, rating and many other related functionalities, throughout a federated set of repositories, for any relevant piece of knowledge (knowledge object) processed and exchanged within the system (basic knowledge resources, units of learning, learning activities, learning paths, etc.).

III. CATEGORIES OF KNOWLEDGE RESOURCES

This section aims at offering some insight into the different categories of knowledge resources that the KRMS subsystem should be able to manage. Two main categories can be identified: material and immaterial.

A. Material knowledge resources

In this category the most traditional kinds of multimedia resources can be listed, like e.g. text and hypertext, images, 2D/3D graphics, audio files, videos and animations.

Additionally, also some more heterogeneous objects can be collected under the category of material knowledge resources. Some examples are: planning and design documents, resources descriptors and references, executable programmes and libraries, source code and scripting languages.

Furthermore, specifically for e-learning in general and for TENCompetence in particular, as already highlighted previously we shall also consider the following:

- metadata and related vocabularies
- learning objects
- units of learning
- learning activities
- learning paths
- learning networks

Archiving formats have not been considered on purpose since the related compression tools do not alter the properties of the processed resources.

B. Immaterial knowledge resources

Within this category some resources can be grouped that are normally underestimated and will require a specific effort to be properly modeled:

- human resources (i.e. a projection of personal skills, acquired competencies, personal abilities, natural capabilities, personal field expertise)
- Human Area Network (HAN) resources, i.e. communities of connected human beings and mobile terminals and devices (e.g RedTacton)
- “environmental” resources (e.g. organizational know-how, training and lifelong learning policies at
In the next paragraph some considerations on human resources are provided in order to better focus on the added value represented by their usually unexpressed potentialities in terms of effective ‘(re)resources’ of knowledge.

C. People as knowledge resources

Most of the existing Knowledge Management Systems (KMSs) apply the traditional document-centered methodology for managing knowledge. Such classic approaches have some advantages, such as providing users with a powerful means to access and manipulate a huge amount of formalized and formalizable domain-dependent knowledge [3]. On the other hand, they also show some major limitations.

In general tacit and implicit knowledge (i.e. knowledge that is not available in existing documents but mainly present in people’s heads) are not taken sufficiently into account [4], [5]. Moreover, the delivered knowledge is static, frequently not properly represented, often obsolete, incomplete and disconnected from the specific context of use. Finally, both supplied knowledge and delivery mode normally are not contextualized and do not take into account current activity, existing user’s competencies and working/learning style [6], [7].

These limitations are particularly frustrating in the context of modern professional fields, which need to be flexible and adaptable and for which a large amount of knowledge (experiences, social knowledge, or know-how) is not formalized in repositories but is present in people’s heads. As a consequence, Knowledge Management Systems have to be defined to support these new settings and in particular, the knowledge-related activities of knowledge workers which have considerably evolved in this last decade. To this end in TENCompetence the design of the KRMS functionalities will consider at least two fundamental factors: the users (learners) - with their targets, intentions, attitudes (e.g. towards competency development and/or using a CMS), motivation, etc. – and the social network, which provides the context in which competency development takes place and encompasses many different types of relationships users have and develop with other individuals both in specific communities as well as in broader social contexts.

From this perspective, the KRMS subsystem will rely on a new vision that requires a fundamental shift from current content-oriented e-learning solutions towards a more user-centered, interactive and collaborative model of learning. In the new model, the learner is no longer considered as a simple passive recipient of data and information, but is seen as a participant that is actively engaged through a rich set of interactions (e.g. learning by doing, educational games, simulation environments, problem-based learning, learning by discussing, knowledge discovery, etc) [2], [9].

This set of processes plays an important role not only for the delivery of the knowledge, but also in the knowledge selection process, the stimulation of the learner, the construction and the internalization of this knowledge, the validation of this knowledge, its situating in a social context, and its application in real world situations.

Within the context of the TENCompetence project, extending the concept of knowledge resource to people is a key research objective, which has been addressed from the very beginning but will require thoughtful analysis and, in the medium/long term the design of suitable and innovative knowledge resources management models. Results from this process will be presented in future publications.

IV. PROPOSAL FOR A TECHNOLOGICAL FRAMEWORK

A proposal for a technological framework suitable to support knowledge resources management and sharing according to the previously discussed requirements, criteria and constraints has been drafted, for further discussion and refinement.

Ideally, the functionalities identified during the design phase can be collected under a so-called KRMS Component. This will be smoothly integrated into the TENCompetence infrastructure in order to provide other modules and services in the system with functionalities for creating, processing, indexing, publishing, retrieving and properly sharing any typology of knowledge resources.

A direct consequence of such a definition is that in other to give support to specific searches some semantic has to be associated to each different kind of knowledge object: basic knowledge resources (KR), units of learning (UoL), learning activities (LA), learning paths (LP), etc. This can be achieved by allowing at each level users of the KRMS Component to provide proper metadata they consider as relevant (see Figure 1).

![Figure 1: Structure of a knowledge object.](image-url)
• Knowledge Resources Personalization Service
• Knowledge Resources Customization Service
• Knowledge Resources Search Service
• Digital Repository Management Service
• Workflow Management Service
• Metadata Exchange Protocol Service
• Taxonomy Management Service
• Ontology Management Service

In other words, also following the project philosophy of using available open source for the implementation, the idea is to design an abstract architecture for the KRMS Component and then to match as far as possible the identified services to already existing components.

The KRMS Component and its functionalities will be then accessed by external service consumers (e.g. users through the TENCompetence Client, the UoL&LA Component, etc.) through a limited number of well specified and described interfaces. Figure 2 represents the dependencies amongst a sub-set of the KRMS services (in blue) and the communication with the TENCompetence Client (in yellow).

**Figure 2: A view on the KRMS Component.**

To get a high level of flexibility and extensibility, at the infrastructural level the KRMS Component will refer to three basic assumptions:

- the services provided by the KRMS Component will sit on top of an extended federation of CMSs and KMSs, i.e. a large, reconfigurable, open and interoperable network of heterogeneous content and knowledge management systems
- the architecture for knowledge resource sharing will be based on a peer-to-peer (P2P) network. The clients of this network could be any kind of existing digital repositories, content and knowledge management systems.
- every client will be connected to the P2P network by means of open, standardized and abstract interfaces. This will allow the integration of new heterogeneous clients within the federation by simply implementing a specialized version of these interfaces.

Innovative P2P applications and services are enabling interactive communication with almost any device on the expanded Internet, thus helping the delivery of the right information and services anywhere on the network and providing better access to network resources while maintaining uncompromised security. For instance, if a P2P configuration is considered with a central index server, this does not contain files physically and only maintains the information about users who are logged on to the network, the IP address of the client and the list of files shared at any given moment by a user.

A proposal for a P2P-based technological framework suitable to support knowledge resources management and sharing has been drafted, for further discussion and refinement. This would be based on two existing infrastructures: LionShare [10] and the OKI-OSIDS [11].

The LionShare P2P project is an effort to facilitate robust and secure file-sharing among individuals and educational institutions around the world. In the role of provider, LionShare offers an implementation of the OSID Digital Repository (OSID-DR) interface that provides access to resources on their Peer-to-Peer (P2P) server network. This allows many applications accessing knowledge resources on the server network for no additional development effort beyond the initial adoption of the OSID specification.

In the role of consumer, LionShare’s desktop client application can include any OSID-DR implementation as part of a federated search. In other words, by embracing the OSID specification applications gain access to more resources and knowledge resources providers (either knowledge management systems, which can manage advanced search functionalities and also optionally share knowledge resources, or generic digital repositories that can only share resources) could address a wider market at a low marginal cost.

V. CONCLUSIONS

One of the most challenging objectives in the TENCompetence project is the design and development of an innovative knowledge resources management and sharing infrastructure. The paper provides an overview of the issues that need to be dealt with and also offers a preliminary proposal for a technological framework able to support innovative - more user-centered - models for promoting the use, creation and sharing of knowledge.

Next steps will be aiming at both the detailed specification of the described architecture and the definition of a robust approach for capturing and representing domain-dependent knowledge spaces. The latter point will be very relevant, as without a model of the knowledge space corresponding to a specific application domain it is very difficult to support effective and efficient learning processes in that domain. This means trying to understand which kind of knowledge resources are relevant for a specific learning domain (e.g. videos for digital cinema vs. text in literature), what criteria need to be applied for sharing, which are the major knowledge sources in that domain, etc.

These aspects, as many others in the paper, will require
further in-depth research. Considering also that the TENCompetence project is at its early stages, more achievements and results will be presented and discussed in future publications.

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