METOKIS - Methodology and Tools Infrastructure for the Creation of Knowledge Units

FINAL PUBLIC REPORT AND SOFTWARE SHOWCASES
Deliverable D27

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**Change History**

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1 Executive Summary

The METOKIS project (1.1.2004 - 31.10.2005) investigated the use of semantic web technologies for electronic publishing in knowledge-intensive subject fields such as News Services, Education, and Clinical Studies. The project results are a Semantic Content Model and software to handle these semantics-based content objects, as well as a methodology for assessing the cost-benefit and for planning the introduction of semantics-based content applications in knowledge intensive organisations.

The Semantic Content Model is called KCO (knowledge content object) and describes a standardised data structure based on a foundational ontology. There is a defined methodology for specialising the model for new application domains, described within the “Handbook on the Integrated Knowledge Service Methodology” (METOKIS Deliverable 20).

The innovation of METOKIS lies in developing the above model together with an architecture that allows the linking of content management with semantic web technologies. The architecture is designed to enable the re-use of KCOs in other content and knowledge management systems.

METOKIS was designed as a fast-track, yet technologically ambitious 22-months targeted research project exploring a novel convergent technology for knowledge and content management. It went beyond the current state of the art in Semantic Web by defining a common object model for semantically and structurally rich multimedia content and by developing a technical infrastructure for managing this novel type of "intelligent content". The project is intended to impact on similar, longer term RTD activities primarily through its practical results in terms of design and prototype implementation. The METOKIS project has contributed to the strengthening of Europe’s technology basis in the fields of content and knowledge management, semantic web, and methodology for advanced, knowledge and content-rich information systems. METOKIS is one of the first finalised RTD projects of the 6th framework programme, in the area of Knowledge Content Technologies (KCT), thus contributing to our understanding of emerging trends and fashions such as the notion of "Web 2.0".

Summary of Activities

There were three main research activities: firstly, the definition of Knowledge Content Objects (KCOs) and their attendant technical infrastructure called the “Knowledge Content Carrier Architecture” (KCCA). The KCCA is a distributed systems middleware which allows the inclusion of heterogeneous content systems into a METOKIS federation of content management systems. Secondly, the project investigated how the DOLCE foundational ontology could be specialised to cater for KCOs on the one hand, and how it could be enhanced to also include tasks and plans which were deemed particularly important for the modelling of content based workflows. Thirdly, a methodology was developed alongside the technology, so as to teach organisations how to develop METOKIS-like Information Systems in the future. The research activities were complemented by the development of three application cases each of which was conducted by a partnership of one technology partner and one partner with commercial interest in the usage of the application. The cases were very different in character because the project should demonstrate that KCO and KCCA could offer a “canonical model” for a whole class of knowledge based content management systems.

The project results were validated through each of the application cases. The indications from the validation are that the project vision is still far advanced with respect to the current state of the art in industry, and that adopters of the technology need to pick and choose what is suitable in their respective system environments. In other words, building systems based on METOKIS-technology will remain a challenge as long as Semantic Web technologies remain unsupported by mainstream methodologies and tool suites. However, METOKIS provided significant new knowledge for anybody undertaking such a venture. The tangible outcomes of the project are the open specification of Knowledge Content Objects, based on the DOLCE foundational ontology and represented in the web ontology language OWL, as well as an implementation of the KCCA which can manage KCOs as RDF models in the Jena RDF toolkit.

One of the highly successful "side-effects" of the project was the improved design of a "semantic WIKI" which was used for the modelling and presentation of the clinical trials application. For the project partners, METOKIS provided an important stepping stone towards truly semantic knowledge content systems. We hope that the public results of METOKIS can have similarly beneficial impact on Europe’s technological progress.
2 Objectives

2.1 Problem Statement

The future knowledge economy will increase the demand for knowledge workers (e.g. professionals in health, education or law). Similarly, senior executive decision making will require increasing levels of knowledge support, either performed by executives themselves or their assistants.

The spectrum of activities of these knowledge workers ranges from highly structured and clearly bounded to very unbounded tasks for which the “input knowledge” is often fuzzy and the outputs - such as executive decisions - are not clearly attributable to the input. Examples of structured, bounded tasks include developing a project work plan or devising a treatment protocol for a clinical trial of a drug. An example of an unbounded task would be a corporate investment decision that may depend on a - formally imprecise - assessment of the regulatory and political context.

For many of these tasks highly specialised tools exist - each of them using individual (and often proprietary) input and output formats. Therefore, the increasing problem for knowledge workers is the lack of interoperability across such tools. However, viewing this problem as simply one of incompatible formats would be missing the point. Instead, one should regard knowledge tasks as taking knowledge contents as input and producing other knowledge contents as output. Only content for which its relationships with knowledge-level tasks are known and understood (e.g. declaring “I am a treatment protocol for an international clinical trial of a new drug”) should be acceptable in the knowledge economy! Content, though, however smart, does not add value in itself. It can only benefit users if it helps them create value in their respective downstream activity. For content applications to be successful, they must therefore clearly specify:

- how they link into the activities involved, and so
- how they contribute to this user value creation process.

While a key part of this clarification concerns the definition of knowledge structures, an equally important part concerns the development of a ‘service methodology’. Such a methodology needs to describe those activities knowledge workers undertake that can best be served by current and future knowledge technologies, and how. More specifically, what is needed is:

- A profound understanding of the “kinds of knowledge” in terms of their level of formality, their representational metaphors, and the subsequent problems or issues involved in providing IT support in their creation, maintenance and exchange.
- A profound understanding of the usage of knowledge in operational settings to enable the identification of knowledge-intensive tasks that may profit from IT support. Therefore business models for such usage and methodologies for introducing and operating these innovative technologies are required.
- A clearer understanding of the relationship between “content” and “knowledge” when used in information systems. Such understanding is needed to standardise the “carrier platforms” of knowledge assets. In particular, the relationship between (multi)media representations and explicit units of knowledge has to be defined in an ontologically valid fashion, or else the boundary between content and knowledge technologies will remain blurred and ill-defined.
- A better set of complementary tools to support an open-platform environment for the creation, maintenance and exchange of knowledge assets.

Without this strategic research approach, the link between content, content applications and the activities of the user will remain a mystery. And as long as this mystery is not solved the knowledge economy will not be able to deliver on its full potential.
2.2 METOKIS Objectives

Given the above, current state of affairs, the METOKIS project addressed the following issues:

- Is there a - preferably algebraic - data structure which can combine knowledge based information with multimedia content and which is sufficiently general to be used in practically all kinds of information systems?
- Is there a middleware architecture that enables step-wise interoperation by providing operations on the generic content objects and by providing wrapper services to bring heterogeneous content in line with the conceptual model of the generic content objects?
- Is there a modelling language that enables us to conceptualise the relationship between what knowledge workers do, and the content and/or knowledge that they produce?
- Assuming that the above technologies and models can be designed, what would that imply in terms of methodology for building such knowledge and content rich Information Systems?
- Assuming we have a methodology and the technologies to build these Information Systems, under which circumstances would such an endeavour be commercially viable?
- Finally, having created the technology and having defined the business case, can we validate the methodology and the tools by actually building demonstration prototypes for different applications?

These questions led to the definition and specification of planned project outcomes which are described in more detail, below.

2.2.1 KCO - an object structure that brings order to semantically annotated web content

The "K" in KCO stands for knowledge which is explicitly represented in some machine-readable and machine-interpretable form. The "C" stands for content which is primarily intended for human consumption, e.g. a text or a movie or an image. The "O" stands for computational objects. In other words, a KCO is a data structure which on the one hand, refers to arbitrary content and on the other hand, contains an explicit semantic description of all the content items, at arbitrary levels of granularity or generality. So, if some content consists of just a file called "dr_zhivago.mpeg" then the reference "http://mymoviesite.org/ dr_zhivago.mpeg" would be the minimum information that the content part of a KCO would contain. The KCO addresses the issue that at present there is no standard way in which people are able to make coherent statements about content and the ways in which it can be used. For example:

a) the author of the novel Dr Zhivago is Boris Pasternak;
b) the hero and heroines of the novel are a young doctor, a revolutionary student, and two young women during the time of the Russian Revolution;
c) the film traces their lives through the first half of the 20th Century;
d) in the movie, the young doctor, Yuri was played by Omar Sharif and the woman, Lara was played by Julie Christie.
e) The film was made in 1965 by Director David Lean and received five Oscars;
f) if you want to buy a copy of the movie then you can download it for 6 EURO from http://mymoviesite.org/ buy_that_film/dr_zhivago; the movie trailer is available at http://movietrailers_for_free.net/dr_zhivago;
g) you can edit the trailer as you wish for any private use, but for any public use of the material you are not allowed to make any changes except cutting out unwanted trailer scenes;
h) an alternative place for the trailer is http://www.imdb.com/title/tt0059113/trailers, but we do not know what licensing rules apply there;
i) according to the International Movie Database http://www.imdb.com, the film received very good reviews.

It should be noted that KCOs are not intended to act only as metadata containers for films, but are intended to capture some principles that are true for any digital content and that are particularly true for content that has (knowledge based) connections to other content. We identified the following facets which make up the semantic structure of KCOs:

- Propositional content - what is the content "about", at any desired level of granularity?
- Presentation model - how can the content and the knowledge be rendered?
- Community - who can in principle, use this KCO and for what purpose?
• Business model - under which circumstances can the content and the knowledge be used by others?
• Trust and security - to what extent can the content of this object be trusted, how safe is the content that I have contributed?
• Self-Description: in order to support interoperation with other systems, each KCO carries information about its internal semantic structure, so that it can be inspected by other applications which also follow some semantic model (but not necessarily the same model).

Using a knowledge representation language called OWL (Web Ontology Language) and a specific reference ontology (a so-called "foundational ontology"), we were able to describe the semantic structure of the KCO in a machine readable fashion. On the basis of that structure, operations were defined to manipulate KCOs in a way that is similar to manipulating database records.

2.2.2 KCCA - a middleware that enables interoperation of heterogeneous content systems

In the web, we cannot assume that we have full administrative control over all information sources and information processing applications. Therefore, we use the idea of "federated, heterogeneous databases" i.e. each repository of information, content and/or knowledge can decide what it wants to show to a cluster of KCO enabled systems. In order to support this kind of qualified information sharing, we devised a kind of filtering interface which is based on a Web standard called RDF (Resource Description Framework). In essence, each site that wants to take part in a KCO-enabled federation must first decide on its KCO repository. Each content database is first mapped into a simple RDF equivalent, and then, an RDF based view is defined which structures the simple mapping in the specific way which is prescribed by the semantic structure of the KCO.

At each participating site, a so-called KCCA node (Knowledge Content Carrier Architecture) is running as a specific application server. KCCA nodes can communicate with each other using the KCTP (knowledge content transfer protocol) which is closely modelled after the FIPA Agent Communication Language (ACL) and which is specialised to communicate KCO operations, such as "add KCO K1 to repository R2".

Future work will be to align the KCCA/KCTP middleware with emerging semantic web services standards such as WSMO (Web Service Modelling Ontology) as developed in the DIP Integrated Project.

2.2.3 The combination of process models and static structures through task modelling

Although the semantic web is trying to account for the combination of organisational, human-led processes as well as machine-centred data processing, an explicit, formal account of “ICT going outside the computational box” is still very much a research issue. The METOKIS models and tools for task and content design seriously tackle this goal, albeit in a comparatively small project for European standards. Three main contributions have found some momentum in the Semantic Web community:

• The “reusable patterns” approach [Gangemi A. “Ontology design patterns for semantic web content”, ISWC2005]. Domain-independent ontologies result to be of little use in most ontology projects, mainly because it is usually difficult to understand their basic organization, and the best practices to specialize and compose them in a domain. Pattern-based fragments of domain-independent ontologies, like DDPO and KCO ontologies are ideally suited to be applied within a domain, also supporting the creation of “sustainable” interfaces for data entry in knowledge-based projects.
• The “plan modelling” approach [Oberle D., Mika P., Gangemi A., Sabou M. “Foundations for service ontologies: Aligning OWL-S to DOLCE”, WWW2004, and Kumar A, Smith B, Pisanelli DM, Gangemi A, Stefanelli M, “An Ontological Framework for the Implementation of Clinical Guidelines in Health Care Organizations”, in Pisanelli DM (ed.) “Ontologies in Medicine”, Amsterdam, IOS Press, 2004]. Planning and scheduling have a long and honourable tradition in AI as optimization tasks, but the explicit modelling of intended goals, tasks, roles, etc. has been mostly neglected, leading to scarce reuse of solutions and know-how. Semantic Web Services as well as socially- and content-intensive procedures like clinical trials firstly require intense modelling, which can be assisted and simplified by tackling directly the social tasks, roles, goals, etc. that are requested, provided, expected, envisaged, etc. by users. DDPO has
been used in both contexts, and especially within the FP5 WonderWeb STREP, and the ongoing FP6 Semantic Mining NoE.

- The “KCO modelling” approach [Behrendt W, Gangemi A, Maass W, Westenthaler R, “Towards an Ontology-based Distributed Architecture for Paid Content”, ESWC 2005], well documented within Metokis deliverables. The KCO approach is being disseminated (together with the previous two) in the AceMedia FP6 IP, in the large German SmartWeb project, as well as in starting initiatives for the modelling and negotiation of cultural heritage objects in Italy.

2.2.4 Knowledge Service Methodology

Knowledge Services
Knowledge worker productivity is a critical issue. Conservative estimates indicate that approximately a tenth of knowledge workers’ time is wasted tracing lost documents, having to recreate documents in different formats, and similar tasks. The cost to the organisation of this lost time is thousands of Euros per knowledge worker per annum. Improving this productivity means optimising the way content is moderated, whether it is through “IT agents” (such as search engines, web services, or publishing tools), “human agents” (such as work colleagues, experts or journalists) or a blend of both.

The Knowledge Service Methodology provides a framework for specific “solution blueprints” to the problem of optimising this moderating layer. With the range of different possible IT-human agent combinations, a prescriptive “one size fits all” method is clearly not feasible. Instead, a methodology is needed that outlines the stages needed to be met in any economically feasible solution. Attached to each stage of this methodology, are libraries of methods some of which may be generic, and some tailored to specific organisational needs.

Context is Consensus
To optimise the moderating layer, then, context needs to be embedded in such a way that the KCCA, the Semantic Web and IT agents can make use of it. Context comes from consensus, and the most effective and only economically viable way of embedding it is through modelling the emergent consensus. The implications for metadata are that the most economically viable and tractable metadata is that which is automatically generated (rather than human authored).

The Knowledge Service Methodology
The Knowledge Service Methodology represents a process towards this goal. It is based on the following six steps:

Step 1: Map system - “Landscape”
Identify project consensus points. Identify actors. Identify communication channels (“formal” and “emergent”). Perform content & tools audit.

Step 2: Seed system – “Sow”
Given the map of the knowledge system, identify those individuals who have the greatest effect on the group’s consensus.

Step 3: Encourage emergence – “Grow”
Encourage emergence through conversation-based social software such as blogs and instant messaging, and through document-based social software such as wikis and discussion boards. Support human intervention in this process, such as face-to-face networking.

Step 4: Remove obstacles to emergence – “Prune”
Isolate unwanted behaviours, of both human and IT agents in the system and remove.

Step 5: Develop taxonomies – “Harvest”
Use emerging taxonomies for content, user and task to construct models on which IT agents can act.

Step 6: Bridge consensus & action – “Plough”
Feedback models and constraints into the KCCA. Return to Step 2.

The Knowledge Service Methodology is supported by a preceding analysis of business models and economic considerations of knowledge sharing in various business settings.
2.2.5 Business Models and Economic Basis for Knowledge Sharing

In a nutshell, the most convincing argument for the ontology-based approach suggested by METOKIS lies in the innovation drivers, rather than the traditional improvement drivers.

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<th>cost reduction</th>
<th>efficiency, effectiveness</th>
<th>innovation</th>
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<tr>
<td>Enhanced search</td>
<td>high</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>Access to external information</td>
<td>high</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>Overcome process end media breaks</td>
<td>high</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Enhance knowledge exchange</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>Knowledge trading</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
</tbody>
</table>

**The basic rationale of the approach is:**

- Knowledge is embedded in or transferred by KCOs
  - target improvement drivers
  - target innovation drivers
- Reference to appropriate domain ontologies
  - target improvement drivers

One important question for semantics based systems is their cost benefit analysis. This is usually derived from the benefits of sharing and reusing knowledge. Sharing and reusing of knowledge requires the existence of a clear incentives structure for those who are meant to contribute their knowledge and experience. Our investigation into such incentive structures identified six main categories: altruism, general reciprocity, general repute, repute, reciprocity, and monetary rewards. Depending on the situation the actors sharing their knowledge are in, these incentives have different influence on the amount of knowledge shared. In a model based on game theory we show that knowledge sharing without incentives can be inefficient in some circumstances and thus by the establishment of incentives these inefficiencies can be overcome (for details, see Deliverable D09 - Economic Framework for Incentives in the Knowledge Economy).

2.2.6 Validation of the METOKIS concept in three independent use cases

One of the basic assumptions of METOKIS was and still is that in the knowledge economy, many activities will be supported by computing applications and therefore, these activities will take place in a virtual space which is essentially shaped by our knowledge about the activities in question and by our knowledge about the "things" that we manipulate through our activities. We had three very different application partners who were willing to test the assumption by defining their application cases using the methods and tools provided by METOKIS:
- A production workflow for educational content (Partners empolis and Klett)
- Supporting news dissemination to special interest groups (KVIEW and Templeton)
- A tool for defining, managing and visualising new clinical trials (Salzburg Research, Ymega)
Each application was required to validate the following elements:

- **Modelling** - how well were task taxonomies and KCOs suited to the domain models of each application case?
- **Methodology** - how well were the business and service modelling methods suited to each of the applications?
- **Interoperation** - how well was the KCCA suited to exchange of information between heterogeneous information systems?

We adapted the Goal-Question-Metric method (GQM) by Rombach and Basili, to the needs of our validation, by devising specific GQM questions for each of the application cases.
3 Conceptual and Methodological Achievements

3.1 A new knowledge content object model

The main idea of Knowledge Content Objects (KCO) is to create machine readable semantic enrichments that can be associated with a given content. Semantically enriched information objects (aka KCOs) can be transferred between various systems and thus, knowledge is able to flow between them. This way, a METOKIS system provides a higher level of utility for a set of users because the KCOs carry inside all information required for transferring, using, and further developing them.

KCOs can be used for communication as it is possible to undertake a cross-media information transfer without any losses. The analogy would be that you are writing a special sort of letter to someone else. The inner structure of this letter helps computers to separate out what is meant for them and what is for human interpretation. This special sort of “letter” can be exchanged between humans and humans like normal information, but also between humans and machines, or even solely between machines. For the universal use, the following generic layers of a KCO have been developed:

<table>
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<th>Facets</th>
<th>Facet Elements</th>
<th>Short Description</th>
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<tr>
<td>Content Description (CD)</td>
<td>Multimedia characterization</td>
<td>Media type, encoding, access information, of the content part of the KCO</td>
</tr>
<tr>
<td></td>
<td>Content Classification</td>
<td>Connection to established meta data standards such as Dublin Core, News ML etc.</td>
</tr>
<tr>
<td></td>
<td>Propositional Content</td>
<td>The knowledge realized by the content or segments of the content part of the KCO</td>
</tr>
<tr>
<td>Presentation Description (PR)</td>
<td>Spatio-temporal rendition</td>
<td>Description of how the content (and the Knowledge) of the KCO is presented to users</td>
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<tr>
<td></td>
<td>Interaction-based rendition</td>
<td></td>
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<tr>
<td>Community Description (CO)</td>
<td>User task</td>
<td>Description of Plans, Tasks, Roles and Goals in the context of a community which uses KCOs</td>
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<tr>
<td></td>
<td>User community</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Usage history</td>
<td>List of actions performed with the KCO during its lifecycle</td>
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<td>Business Description (BS)</td>
<td>Negotiation protocol</td>
<td>process by which a trade will be settled</td>
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<td>Contract information</td>
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The core structure of the KCO is built around the semiotic ontology design pattern provided by the DOLCE foundational Ontology, which is shown in the following graphic.
Information Objects are the core concept of the semiotic ontology design pattern and carry meaning on cognitive and abstract levels, independent of any technical realization.

The following figure shows the defined restrictions and the KCO-information information-object providing simple Metadata for a KCO.
The concepts *content-object*, *content-segment* and *kco* are defined in a separate ontology to make it easy to refer to these concepts in the currently defined and possible future facets.

### 3.2 Architecture for distributed knowledge and content management

The METOKIS Architecture defines a middleware platform for building semantic information systems, providing components and services enabling interoperability amongst varied content management platforms. It is designed to deliver functionality that addresses the following objectives:

- **Content Level Interoperability**
- **Knowledge Level Interoperability**
- **Task Level Interoperability**
- **Workflow and Collaborative Work Interoperation**

The METOKIS platform consists of two key parts: KCCA (Knowledge Content Carrier Architecture) Platform and KCTP (Knowledge Content Transfer Protocol). The KCCA Platform acts as a middleware providing support for building content management applications.

#### Key Requirements

The METOKIS architecture is a middleware platform for operations on KCOs which can be distributed over a federation of KCCA nodes.

The specification of the KCCA is based on the following functional requirements:

1. **Providing a Generic Middleware for the exchange of KCOs**

   The middleware should be independent of any particular high level protocol dependencies in order to make the system generic. The system should support existing Semantic Web Technologies and Frameworks.

2. **Supporting the definition of Domain specific KCOs**

   Most parts/components in the architecture are generic but in order to accommodate for some application domain specific aspects, appropriate support should be provided. For instance clinical trails application case in METOKIS involves the building of a clinical trial protocol design tool.

3. **Supporting Operations on Knowledge and Content**

   For efficiently operating on the Knowledge Content (KCOs in our case), we need a Services Infrastructure. Operations like add, delete, merge, query, etc. on the content should have appropriate representation(s) in the Services Infrastructure of the system.

4. **Providing Efficient Storage of content (includes KCOs, Schemas and Ontologies)**

   The system should provide efficient storage of content and enable wrapper support for Relational Database Management System, Object Oriented Database Management System and of course RDF based Repositories. We did not focus on building "yet another storage system for RDF", but showed how the framework can be adapted to suit heterogeneous storage mechanisms.

5. **Operations on Knowledge and Merging of new knowledge into existing Knowledge bases**

   One fundamental issue for the semantic web is how to declare some subset of it as the knowledge base upon which inferencing will take place. Our approach to defining the boundaries of a web-based knowledge base is to treat the sum of all KCOs in a METOKIS federation as the boundary. This way, we hope to make a contribution to the difficult problem of reliably scoping any reasoning task and being able to trace which state of the knowledge base has led to what result in the inferences made by the system.

6. **Providing Wrapping support so that any non conformant system and/or application can plug in**
The system should be flexible so that databases and external applications which may not conform to the current standards of the semantic web can easily plug into it.

7. Supporting Clusters of METOKIS nodes

We envisage a scenario in future in which multiple METOKIS nodes will communicate/co-operate and share or operate on data (KCOs) in a clustered environment. We need to have Session Management in order to make this clustered communication secure, transparent, reliable and efficient.

For instance:
- For secure communication, only registered METOKIS nodes can access data on peer nodes.
- For transparency, all the information about the communicating nodes should be shared.
- For efficient and reliable communication, user state should be maintained during a session.

8. Supporting Knowledge Discovery through a Global Registry

In order to discover other knowledge sources (which in our case will be METOKIS nodes) any particular node needs to look up some sort of directory which provide necessary information like the access point for the node and some descriptors for the services it offers. We envisage a Global Registry as such a directory. This implies one can ping such a registry for access points and service information.

9. Standardized Communication/ Messaging with peer nodes: A simple Request/ Response protocol

For effectively handling messages between systems and to provide for standardized communicating capabilities, a simple Request/ Response protocol should be defined. This also gives the liberty to the system provider to provide his own implementation of the system taking into account the core functionality that needs to be fulfilled and can also support extensions on top of it. For instance a system provider can add his own implementations for certain specific tasks on top of the existing ones which are generic in nature.

We need to describe the message parameters for specifying and carrying out the operations on the content (KCOs) accurately. For accurate communication and service procurement, various local system parameters such as the access point of the node and the services it offers should be stored in a local System Registry. Access to the System Registry will help the node in responding to the request from a different node accurately. For instance if the service requested is not present or not registered then an error message should be sent back.

10. Supporting high level services and dynamic services discovery and composition

In order to support high level services and dynamic services finding and composition, we need to model user tasks/ needs in a Semantic manner. However this is not a core requirement from the architecture but necessary in order to demonstrate the prototype. We aim to provide support for linking the METOKIS system with emerging Semantic Web technologies like Semantic Web Services (IRS – II [SWS]), etc.

The following diagram depicts the KCCA and its core components.
3.3 Usage of Foundational Ontologies and DDPO

The DOLCE+DnS Plan Ontology (DDPO) provides the logical and ontological foundation of so-called task taxonomies for knowledge content, thus contributing – in the METOKIS context – to the
development of a demonstration platform that allows a formal definition of the action types (and their ordering) involving some kind of knowledge content.

In DDPO, plans are formal descriptions that represent "action schemas", i.e. sequences of actions that lead from a given situation to a new one, and the related entities involved. These descriptions are abstract and independent from a computational system design: they are reusable and easy-to-customise representations of the objects and activities involved in multiple action domains. According to DDPO, a plan is conceived by a cognitive agent, and its typical components are tasks that provide instructions to execute (classify) actions. A plan defines or uses at least one task and one role (which must classify an object, and at least one role must classify an agent), and has at least one goal as a proper part (that goal is usually desired by the creator or beneficiary of a plan). Tasks are treated as concepts defined within plans, which refer to actions (e.g. "write a report"), and are organized into a subclass hierarchy. Control constructs (e.g. "choose between the following alternatives", or "loop on the following") from traditional planning and workflows are represented as "control tasks", also defined within plans. Ordering of tasks is formalized by using part (mereological) relations, control tasks and a successor relation (meaning that the actions to be sequenced by tasks must be temporally or causally related by a follows relation). Tasks are connected to roles by a target relation, expressing the modalities (e.g. duties, obligations, or rights) that, in given plans, roles can have towards specific tasks.

In addition, plans may include parameters that are classified by attributes (called "regions") of actions or objects. Parameters are related to roles or tasks by a requisite for relation, expressing the kind of requisites that the entities which are classified by said roles or tasks should have in a given plan. Notice that plans, as descriptions, are different from plan executions, which are situations (a different kind of entities, introduced by the DnS ontology). A satisfies relation holds between situations and descriptions, implying that at least some components in a description must classify at least some entity in the situation setting. A plan execution is a situation that (proactively) satisfies a plan description. Goal situations are situations that satisfy a goal, but that are not part of a plan execution. Plans may also have situations as pre- or post-conditions. A situation is a pre-condition for a plan if it should preliminarily satisfy some description before executions of that plan occur. A situation is a post-condition of a plan if it should satisfy some description after plan executions of that plan occur. It often holds that the goal situation is a postcondition of plans, but this is not mandatory. Of course, every plan execution has predecessor and successor situations, but only some of them are pre- or post-conditions for the plan that the plan execution is supposed to satisfy.

Finally, a plan can have further proper parts besides its goal (i.e., other descriptions such as, e.g., regulations or laws). It can also include other plans, which are called subplans, and whose goals are called subgoals to distinguish them from the main goal of the overall plan.
3.4 Economic Framework and Methodology

Rationale
The development of the WWW has had significant impact on practical software engineering, because certain types of development problems have become much more prevalent than originally envisaged by the software methodologists of the pre-Web era. We are only slowly adapting a whole set of "new" development skills in such a way that a discipline of "web-engineering" is emerging.

The emergence of the Semantic Web is posing further questions to the received wisdom of software engineering in the web era. Because of the strong technology push coming from web-related research we have positioned METOKIS at the technological far end where there is a reasonable chance that methodology and technology can co-evolve because the growth rate of the technology is still slower (at least, it can be said that the rate of maturing is still slower, because a fair amount of research is still to be done). So in the case of METOKIS, our working hypothesis was that it makes sense to develop technology and methodology together and have the two inform each other, rather than pushing technology development without adequate analysis of business and societal needs. The most adequate level at which such co-evolution can take place is the definition of "services" to some community. This is the approach we have taken for METOKIS.

The Service Design Phase of the METOKIS Methodology is the place where business needs and KCO/KCCA technology meet for the first time.

The overall approach to service design is to look at the KCO and the KCCA as enablers of new services. By providing building blocks with well-defined operational semantics, we hope to move the creation of e-content solutions from "handcrafted" proprietary artefacts to "industrialised" content modules that can serve the knowledge economy of the future.

We distinguish the enabling capacities of KCOs - based on the semantic facets - from those of the KCCA infrastructure - based on the main functional blocks of the architecture. This leads to a clearer understanding for the stakeholders, where technological support is needed (in the KCCA realm) and where domain and business knowledge is required (in the KCO realm). Since at the end of the day, the technological solution and the business/service models need to be tightly integrated, a clear separation of concerns will help identify where the integration is reaching the limitations of the technology (or the limitations of the designers and implementers).

Methodology
We suggest that the METOKIS Service Taxonomy below can be used as a first guide to modelling the service that is envisaged.

![Metokis Service Taxonomy Diagram](image-url)
The methodological approach for designing an ontology-enabled infrastructure mainly encompasses four distinct steps (Analysis, Design, Implementation and Maintenance).

Analysis

In the analysis phase an overview of the business, its stakeholders and the whole environment you are acting in is analysed. The analysis phase includes the following analysis tasks:

- Analysis of knowledge sharing community and environment
- Analysis of already existing initiatives within the knowledge sharing context
- Ontology-readiness-analysis
- Analysis of the primary processes

Based on these five analyses it will be possible to draw a landscape of the existing business of your organisation and develop opportunities of how to enhance your business by using an ontology-enabled infrastructure. The target infrastructure is then described in the design phase.

Design

Within the design phase the options which can be achieved by using ontologies are drawn and their utility is estimated. The design phase consists of:

- Generation of ontology-opportunities
- Develop your business model
- Cost-Benefit analysis
- Design your Interactions
- Description of the ontological environment needed
- Design your Services
- Develop your Ontology-roadmap

The result of the design phase is a clear description of the business aspects by using an ontology-enabled infrastructure.

Implementation

1. Ontology implementation

   There are three prototypical scenarios for ontology implementation: firstly, there is no knowledge model of any sort available for the application domain. The second scenario is where there is some standard or terminology or taxonomy, but it is not formal enough to be easily transformed into a formal ontology. The third scenario is where there is already a significant domain ontology which should be adhered to, and where the challenge is to change the current business processes and applications in such a way that they become compatible with the predefined ontology. Each scenario has different challenges and at present, there is not enough knowledge about real cases to make predictions about which scenario is more costly to develop from.

2. Task specification and Workflow

   One of the tenets of the METOKIS methodology is that the procedural aspects of the target domain and the static model of the domain should be developed in parallel, because this way, it is easier to determine where the static model becomes biased because of certain process definitions or vice versa. Our approach to task specification makes use of a specific part of the DOLCE foundational ontology in order to have a standardised vocabulary with which one can specify user roles and tasks. These task descriptions become part of the domain-specific specialisation of a KCO (see KCO Model, below).

3. KCO Implementation

   Knowledge content objects can have three levels of specificity: The first level is the generic
KCO as defined by METOKIS, which should be usable in all application domains. The second level is the specialisation of the KCO with sector specific ontological extensions. The third level is when knowledge based content is added to the KCO and when that content is semantically annotated.

1. **Generic KCO**: A generic definition of the KCO, including the KCO base structure and the six defined semantic facets.

2. **Domain KCO (Domain-anchored KCO)**: The generic KCO plus sector specific ontological extensions. This may include specialisations, restrictions to the six defined facets and their elements. In addition it is typical for a domain KCO to also define a base structure/semantic for the propositional content. A domain KCO must be defined by a community (authorization, organization) of a sector and is comparable to metadata standards but definitely intended to achieve a higher level of semantic sophistication and coverage than current metadata standards.

3. **Application KCO (KCO Prototype)**: Must be compatible with the generic KCO and may be compatible with one or more domain KCOs. Like the domain KCO, the application KCO may extend some facets, and it must also define the exact schema for the propositional content. There is no prescribed level of granularity concerning the propositional content schema. All that can be said is that this schema will become the universe of discourse for any KCO that is dealt with by the application. So whatever your organisation wants to say about the content of your KCOs should be part of the controlled vocabulary (i.e. the combination of generic/domain and application ontology).

The schema for the generic KCO was defined in the METOKIS Project. The functionality of the KCCA is based on the generic KCO and is therefore compatible by default, with all domain and application KCOs. The principal idea of the KCO implementation phase is to develop from the generic KCO structure towards an application-specific KCO. At present and for some time to come, KCOs are not and will not be a widely used technology so most likely there will not be any domain-KCOs available. Nonetheless it is probably a good idea to separate domain and application specific parts of the model. The definition of both a domain-level KCO and an application-level KCO might later help to integrate with other KCO-enabled applications. This is done by mapping the different identified and designed structures, actors, processes and content elements to the different facets defined by the generic KCO.

4. **KCCA Deployment**

METOKIS developed a basic infrastructure for the deployment of KCO enabled distributed information systems. The internal structure of a KCCA node was described in the previous
section. The implementation of such a system requires an analysis of the existing information system, both in terms of front-end applications and in terms of back-end content and knowledge management. For attaching back-end storage systems, the KCCA uses RDF-based wrapper templates with which it is possible to attach a non-KCO enabled content repository to a KCCA federation. The common denominator is the semantic model of the KCO which acts as a high level database schema, thus enabling exchange of content according to a common semantics.

For front-end applications, the METOKIS methodology foresees a delegation of functionality to knowledge based systems with inferencing capabilities. One of the findings of the project was that this is a difficult step, because normally, much of the business logic can be found in the applications and the better-structured applications use configuration files to adapt the business logic.

The KCCA also supports a high-level protocol which can be put on top of lower level protocols such as http or SOAP. The primitives of this higher level protocol (kctp - knowledge content transfer protocol) constitute a query and manipulation language for KCOs.

Overall, it seems that the KCCA/KCO model is currently better suited to creating semantically interoperable back-ends than it is suited to creating knowledge based front end applications.

Maintenance of KCO/KCCA enabled Systems

It would be unrealistic to expect a mature definition of the maintenance phase, from a methodology which is the output of a leading edge technology project. The reason is that our proposed technology introduces a new kind of information system which in turn, causes a paradigm shift with respect to application building. The paradigm shift is characterised by declarative modelling of business semantics thus depleting the application layer which traditionally is the place where domain semantics are implemented.

In our view, KCO and KCCA enable solutions for some of the requirements that are currently being discussed with respect to "Semantic Web" and "Web 2.0". In a recent article, Tim O'Reilly quotes eight design patterns some of which our platform may be able to serve better than the currently available technologies:

1. leverage customer self service - in our model by standardising the knowledge content objects;
2. own your source of data for competitive advantage - KCOs are intended to be as open or closed as you specify them to be;
3. users add value - the three-level architecture of KCOs provides scalable opportunity for just that;
4. network effects by default - several KCO facets are included precisely for that reason, but we also believe in giving the users control over the amount of information they wish to give. The current models are more like "daylight data robbery" and undermine user trust!
5. Some rights reserved / Design for scalable barriers - KCOs have explicit trading and licensing models which can be adapted by the owners of content or data. The basic principle is control by the owner.
6. Continuous application development - In principle, the KCO/KCCA architecture would be very suited to this requirement, but since its introduction requires some paradigmatic shift from current web technologies, we will only be able to convince others once the first resounding successes of our architecture can be reported.
7. Cooperating data services - again, the KCO/KCCA/kctp structure provides an excellent basis for such services, but we need to wait for more substantial show cases before this can be convincingly argued.
8. Software for multiple access devices - the current applications of KCO/KCCA are not really addressing mobile and other devices, yet. The potential need for inference engines may be a problem although extensive reasoning loads could be transferred to servers in an anticipated, ambient intelligence environment.

Summarizing, it can be argued that KCOs provide a promising maintenance model for Web2.0 applications, but this needs to be demonstrated by real world applications in the near future.
4 The Application Cases

4.1 Educational Workflow - dynamic publishing of digital learning materials

The objective of the use case from KLETT was to develop a continuous work flow for the production of digital learning modules (CBTs) and to support the process of defining a new CBT (Computer Based Training) module in order to improve the reuse of existing content for new CBTs.

4.1.1 Rationale

The aim of this use case was to create a pilot editing environment that would support an educational publisher as a knowledge worker by improving his content related work. In order to achieve this improvement, the following two points were defined as essential requirements:

- development of a continuous workflow,
- creation of a domain ontology serving to unambiguously identify multimedia assets

4.1.2 Ontology

The domain ontology that was created covers all terms and concepts that are relevant to define educational materials that are to be sold in the German market. The concepts that define this domain cover generally the following fields of information: meta data for multimedia assets in general, semantic concepts based on the German syllabuses, in this case 20th century history was chosen, target group oriented concepts, i.e. the group of students that are to use the respective teaching aid in their lessons, in this case this covers the states of Germany, the types of schools that exist in Germany, the subjects taught at these schools etc.

4.1.3 Workflow

The traditional workflow in educational publishing is rather straight and, in the past. Reuse of materials has not been a point of major interest. However, this has changed and the reuse of materials is becoming increasingly important, in particular with digital content that is labour-intensive.
A workflow was created that has a circular structure, i.e. it follows the rapid prototyping approach, which in simple words assumes that as much content, structure, layout, etc. as possible should be reused when creating a similar product. This approach was applied to the creation of CBT modules in the field of educational publishing and the resulting workflow served as a starting point for the development of the pilot.

4.1.4 Pilot

The pilot editing environment consists of four different tools, each of which contributes to the unique system that supports semiautomatic semantic tagging of multimedia assets. These four tools are a relational database, the Orenge® Tool by empolis for defining the domain ontology which serves as the database model, Publication Build® by empolis which serves as CBT-structuring editor and which facilitates semantic retrieval of content from the in-house database as well as from external databases, and finally, the LeMOLernen editing tool by Fraunhofer ISST and Klett which is a Flash® based environment for editing CBTs.

4.1.5 Validation

The pilot system results in a platform that supports the editors and authors at all steps of content creation, making their work not only more effective but also very efficient, as the reuse of content is integrated in the workflow. The level of richness of information as supported by this application is unprecedented in the field of educational publishing.

4.2 Semantically enabled News Services

*The Rapid Browser system is designed to acquire and present news feeds from disparate sources and to enable users to find, share and act upon news items. With the semantic extensions afforded by*
KCOs and KCCA, the end user is able to filter news according to source and subject, defined according to a domain taxonomy. Based upon their role, Rapid Browser users have access rights determined by contract to different feeds. Using a set of pre-defined actions (corresponding to a task ontology), they may create, share and manipulate news items. Such actions include support for editing and publishing workflows. For example, a group moderator may create topics or agenda items, publish topics to a blog for feedback, and use the system to publish automatically a newsletter, being the export of a news filter based upon the agreed agenda topics. The KCO Business Description may be used to trigger rights warnings to a user about possible misuse of content and the KCCA is used to enable research across multiple RAPID Browser KCO repositories.

Rationale
The Templeton Oxford Retail Futures Group (ORFG) is a group of senior executives with links to retail that meets up to six times a year. The group is hosted by Templeton College. Their activities are guided by two moderators. Members join ORFG to acquire a better individual understanding of the future of retailing over the next 3-7 years and to be able to advise their companies accordingly. In this sense, the ORFG is a “knowledge service”.

The ultimate goal of a full METOKIS application in this domain would be to improve the performance and value of the ORFG knowledge service. This overall goal is ambitious.

Ontology
Somewhat in contrast to the other applications addressed in the METOKIS Project, the domain of ORFG is very open. The participating executives have and represent a very wide range of different interests and goals, and the individual executives have quite different (and busy) working styles. The ORFG service needs to bring together content sources and views that will stimulate the discussion and knowledge transfer and to bridge the gaps between the contexts of the diverse participants. To deliver this requires a combination of content, technology and human crafting. This combination has been a constant theme of METOKIS since the outset and is taken up by the Knowledge Service Methodology.

The METOKIS System for the Templeton Case focuses on supporting the “moderating layer”. That is, the requirement is to help people (moderators) work with technology (in this case browsing, editing, cooperative publishing tools) to mediate content (largely event-driven news) for the purpose of enabling executives to use and act upon it.

The objective for the application domain in the project is to test the METOKIS approach, using KCCA and KSM. The requirements and workflow are not dissimilar to other news-publishing environments in enterprise and media. In parallel with ORFG, the potential of the METOKIS approach is also being investigated in other domains such as Media Monitoring in enterprise and editorial sharing in media groups. To do so, the METOKIS application is being developed as a “knowledge service platform” that can be used by ORFG and by others.

Tasks
To guide and co-ordinate the group, the moderators set an agenda for the group’s meetings over the forthcoming year and publish a regular newsletter.

The scope of the application is illustrated by this figure, distinguishing where content, people and action are paramount.
The use case tasks are as follows:

- identify retail events
- choose retail topics
- choose the speakers
- publish the agenda
- compile the newsletter

**Pilot**

The moderator is using KnowledgeView’s Rapid Browser as extended and enhanced for this application. He uses it to aggregate, filter and act upon retail news. A blog helps the moderators and their close affiliates to define and communicate about likely topics and to generate feedback from the executives.

Rapid Browser as a system has input from various feeds (news wires, email, RSS feeds from blogs or harvested web content). These news items are classified (by subject area, person (& their organisation), agenda topic) and then displayed to the user in filters. Alerts highlight specific news items which match a classification.

The moderator can add comments to a story, set up alerts and select events of interest. Topics can be defined by creating a topic item and posting it to the blog. Feedback from the blog will then update this original topic item.

A set of these topic items constitutes the group agenda. A filter based upon these topics (represented as classifications) will then constitute a real-time newsletter. This newsletter will then be published for the meetings on paper and on demand externally to a blog for sharing with all the group executives.

The following schematic illustrates the technical platform, including the modelling of the RAPID Browser items as KCOs and the implementation of a wrapper for the RAPID Browser content store to enable it to be accessed as a KCO server node.
The publication of the newsletter for ORFG requires use of publishing software. To enable the moderators and their staff to use Adobe publishing products, plug-ins were developed for Adobe Creative Suite (InDesign/InCopy) to enable them to access the KCO store from their publishing tool as well as from RAPID Browser.

The two concrete outcomes of the Moderators’ activities are the Agenda and the Newsletter. The first prototype for the ORFG Application (March 2005) focussed on the Moderators’ task of setting the Agenda, requiring news search and aggregation, classification and topic clustering and cooperative decision-making about relevance of topics.

The demonstration of the final prototype focuses on Newsletter creation.

Publishing of the newsletter is a compound task. To publish a particular story requires at least two sub-goals to be met, namely

- Formatting the story (text, image, length, shape, etc.) appropriately for the publication medium
- Clearing rights to the story and its components for this usage

The KCO-based system should support the recognition and fulfilment of these sub-goals.

**Validation**

The objective of the validation plan for the senior executive system covers three aspects that can broadly be described as commercial (the user view), technical (the application development) and methodological (the overall methodology), including external views. The key objectives of the system are driven by the user needs, which are identified and evaluated through the Knowledge Service Methodology process and supported through appropriate application development, which in turn opens up new possibilities for users to perceive their needs in different ways and indeed aspire to different aims. The “owner” of the application is Templeton College, while the “developer partner” is KnowledgeView.

The validation of the Senior Executive system was undertaken using the GQM method, with six main goals defined.

**Goal 1: Agenda setting.** To agree between the moderators on a timely agenda for a meeting covering an important topic on retail futures from the perspective of a respected retailer or commentator, as well as providing an alternative view at an appropriate venue.

The use of the Senior Executive system does appear to have helped make the agenda more relevant in terms of the topics covered but has done little to improve the choice of speakers or venues. This may be due to the content availability. The use of RapidBrowser broadened the search capability hence better topic choice. However, the content detail available was not
always as required due to commercial considerations. One of the key source databases provided an overview of any article, but had to be accessed independently to look at the detail of the article due to the particular licensing agreement involved.

Although the system was relatively easy to use, not all the content detail was available due to commercial considerations and so this sometimes entailed an extra step that would not be necessary in a full implementation of the system.

**Goal 2: Newsletter.** To publish a pre-meeting newsletter to inform the group of senior executives of the most recent relevant retail developments.

Following a change in one of the main content feeds, the moderators generally found the right pool of materials (70%), but retrieval was hampered by the commercial licensing issues described in the previous section. The system was felt to be very successful in finding material and provided a much wider range of materials than the previous system due to its built-in search characteristics. Providing that satisfactory licensing arrangements were in place, content could easily be reused, edited and exported to a wide variety of locations.

**Goal 3: Knowledge workers.** Achieve satisfaction with the knowledge workers when working with the platform.

The moderators felt more productive and satisfied after using the system, even in relation to their existing systems. Note that the users did not have direct use of the system and so were unable to express a comment about the system directly—though indirectly, they had expressed a slight improvement in the relevance of the agenda and newsletter.

**Goal 4: Mastery of the system.** Achieve mastery of the system with little effort.

The system was felt to be easy to familiarise oneself with, taking just a couple of days to become a reasonably accomplished user. The support of staff at KnowledgeView was very important to get the most out of this learning process.

**Goal 5: Configuration.** Cost-effective configuration of the platform for this blueprint.

Preparing the platform requires the modelling of the workflow for the moderators in terms of the system view of groups, users, tasks, feeds and filters. Based on the blueprint, the configuration was effective for the newsletter tasks. The requirements of agenda-setting stretched the system model and additional modelling of topics and their manipulation was necessary.

**Goal 6: Support.** Cost-effective support of the service operation.

The blueprint also contributed to simplifying the support operation by clarifying the goals of the each stage, easing the proactive provision of help and hints, etc. Support of changes to taxonomy or classification schemes was more labour-intensive.

### 4.3 Clinical Trial Protocol Management

The objective of the Clinical Trials use case was to support the move from purely document-driven design of such studies to a knowledge-based design. We built a system for the semantically enhanced specification of clinical trial protocols. Our exploitation plans foresee that a fully-fledged system will be developed iteratively and incrementally from the current prototype.

#### 4.3.1 Rationale

METOKIS partner Ymega has been designing a database system for the management of clinical trials which is aimed at giving better-quality support than is the case with current commercial offerings. One of the weaknesses of the design process and the subsequent running of the trial is that all aspects of clinical trials are still very much paper-and-pen driven, and that digital content is at best, a Word document without any further semantic modelling. The idea was to apply the philosophy of strong ontological modelling to this application field.
4.3.2 Ontology

There are already initiatives such as CDISC\(^1\) under way which aim at least at standardisation of certain data elements, albeit without strong ontological foundation. We took the view that step-wise semantisation would be a useful way of bringing more semantics to this domain, but without overstretching the practical capabilities of practitioners who have to focus on being medical doctors in the first place. We investigated the data-element approach of CDISC, a process-centred approach using a variant of the business process modelling language and one approach combining the tasks (process view) and the data elements.

4.3.3 Tasks

Clinical trials are research studies trying to answer health questions that involve human subjects.

Clinical trials (Phase III trials) are expanded trials executed after preliminary evidence suggesting effectiveness of the drug has been obtained. Intended to gather information to evaluate the overall benefit-risk ratio of a drug / treatment / prevention method / diagnostic method, etc. They involve from 100 to thousands of people. Phase IV trials are quite similar in structure, but they are post marketing trials with large number of participants, from hundreds to thousands of people. Such trials are long and complex. They address four basic concerns: Safety (of subjects), confidentiality (of data), efficacy (of investigation) and ethical concerns. To ensure that these concerns are not to be ignored, 3 measures are taken.

- Regulations: Good Clinical Practice (GCP) guidelines recently became a mandatory standard in USA, EU, Japan, and other countries.
- A protocol (detailed plan) of the trial must be prepared and approved before the trial is started, to promise that the trial is designed according to GCP regulations.
- Monitoring system to guarantee that the trial is executed according to the approved protocol.

Our application is focused on the design of the protocol. Preparing a protocol for a typical trial of phases III / IV takes months. It includes every aspect relevant to the safety, confidentiality, efficacy and ethics of the trial, like inclusion / exclusion criteria, randomization mechanism, treatment regimen, control design, prior results, literature support, quality assurance standards, ending points, and many more. It is typically authored by several authors: medical author(s) – experts in the health problem field, clinical author(s) – experts in designing a trial and statistician – experts in statistical validity of the results. A Principal Investigator, appointed by the sponsor, is managing the authoring procedure. We suggest an improved authoring procedure and an improved outcome: a KCO-protocol. The current state of the art is characterized as follows:

- Protocols are printed documents, prepared in Word, and rarely available in PDF or html formats. There are currently almost no ontology based protocols (a few exceptions were identified as recent developments in this field).
- Design controlling mechanisms are limited to “copy and paste” level.
- There is no acknowledged standard for protocols (hence the CDISC initiative). Every sponsoring institution (academic, commercial, governmental) has its own standard. This standard is typically very flexible and in most cases is no more than a check-list to verify compliance with regulations.

The objective of the Clinical Trials Case Study was to illustrate through semantic modelling:

- An improved protocol design methodology.
- A higher quality output KCO- protocol.
- Interoperability that enables both new important features, and the saving of time and effort during later stages of the trial.

\(^1\) Clinical Data Interchange Standards Consortium: “The mission of CDISC is to develop and support global, platform-independent data standards that enable information system interoperability to improve medical research and related areas of healthcare.” see: http://www.cdisc.org/about/index.html
4.3.4 Pilot

The front-end of the system was built using a “semantic wiki” approach. The semantic wiki is an in-house development of Salzburg Research which was extended to also address the requirements of the Clinical Trials application. The Clinical Trials application can be accessed via the demonstration web page: http://metokis.salzburgresearch.at/demonstrations/index.html#ct. The semantic wiki without the specialisation for clinical trials can be accessed via http://ikewiki.salzburgresearch.at/
The output of the semantic wiki is a KCO-compatible structure which can then be made persistent in a relational KCO database developed by YMEGA. The current prototype system is based on a custom model for persisting KCOs in a relational database (METOKIS model) in a fully-normalized format. The
A database is implemented on Oracle XE\(^2\). A middleware layer and data UI consisting of JAVA Servlets and plain JAVA objects is included (JDCO).

Currently, the middleware for the exchange of KCOs is write-only via SQL through which a KCO can be written out. The system has been specifically designed to provide a framework for supporting both the designing of KCO types (presumably domain-specific) and the definition of KCOs that are compliant with such KCO schemata (as domain-specific as constrained by the KCO schema). It provides a framework to support manipulations on Knowledge Content, formal operations could be fairly easily implemented. It is specifically designed to provide highly efficient storage of content, which is not file based. Using two layers of metadata and a data layer, it allows for the orthogonal definition and manipulation of:

- Ontologies, stored in a format that allows easy conversion to and from RDF
- KCO schemata that include all or part of ontologies
- KCOs

Extensive relational constraints are used to enforce the consistency of KCO schemata with underlying ontologies, and the consistency of KCOs with the KCO schema that it instantiates.

### 4.3.5 Validation

The impact of the project was profound; it motivated us to redesign and redevelop the application completely, and to start formulating a much refined and enhanced conceptual foundation. Given the transaction-centric nature of CT protocol management, however, the value of the KCO/KCCA in the context of the CT application could not be ascertained in the sense that it would be an indispensable part of the revised application.

The most important impact resulted from the consolidation of our process model with DDPO for the purpose of defining the CT core protocol structure and executable process models in general. The Visualizer, whose design was built upon this structure, will be a core part of the envisaged overall clinical trial data management system based on the more generic Congruens System 43 application of partner YMEGA.

Although the revision of the System 43 Metamodel had been well underway upon the start of the project, it was revised much more severely due to the feedback from the project, most of it of a substantial conceptual nature. In the process of these revisions, we were able to consolidate our ideas concerning an optimized data architecture method, parsimonious, non-redundant, orthogonal, fully integrated, and incorporating the best practices of relational, dimensional (data warehouse), and hierarchical (XML) architectures, enhanced with a high degree of abstraction, standardization, and metadata organization and exposure.

By building and revising a relational model for persisting KCOs, we were able to come up with a better bridge between the extremely abstract RDF representation of ontological information and our moderately abstract approach.

---

\(^2\) Oracle XE is the free (including commercial use) version of the database engine limited to 1 CPU, 4GB of storage, and 1GB of RAM dedicated to the database. www.oracle.com
5 Outlook

5.1 Lessons learnt and difficulties encountered

The validation of METOKIS was planned to encompass the methodological framework, the technological components and the applications. The validation phase had to be shortened significantly because the RTD work required more effort and, in particular, more time to achieve a satisfactory basis upon which any validation would make sense. Our findings are as follows:

- Although there is clear evidence of the value of the methods and tools as well as the KCO/KCCA infrastructure, it was too optimistic to believe that the methodology could be developed and tested, concurrently with developing the technologies for which the methodology was intended. The lesson learnt is that methodologies should be validated once the technologies have been tried out at least once. You can develop a methodology alongside your technology, but validation is better done externally.

- However, the "METOKIS handbook" (D20) has provided a useful, practical breakdown of the steps needed to be taken to start "semantising" the use cases. Given the huge differences between the domains (senior executives, educational publishers and clinical trials), this is an encouraging sign. In each of the use cases, the validation has provided a positive response.

- In the case of the senior executives, both the Knowledge Service Methodology and the RapidBrowser tool built to support the Retail Futures Group and other groups of senior executives proved beneficial.

- Development of the platform built to support educational publishing is expected to increase both the effectiveness and efficiency of the knowledge workers involved.

- The ontology for task descriptions proved highly valuable for re-designing the underlying data model for process descriptions in clinical trials, thus providing a basis for linking up the semantically supported design of clinical trials, the storage of this information in a relational database and, last but not least, visualisation via a user interface that uses the notation of Business Process Modelling language (BPML) with some domain dependent specialisations.

- Beyond the project partners, the methodology has been validated against various different news and news-related organisations by KnowledgeView with some success.

- The re-specification of the methodology in handbook form has provided more rigour, especially concerning the technical issues.

- Given time and resources, the opportunity for the further development of the tools infrastructure and working through a full cycle of the methodology would provide a stronger validation of the long-term value of the underlying approach.

- One avenue for future work is to examine more fully how to upgrade and extend the KCOs in line with user needs.

- The experience of METOKIS is that the expertise needed and time taken to develop and link sufficiently detailed domain ontologies to foundational ontologies, such as DOLCE, are at the very least problematic, if not prohibitive in certain situations. One of the benefits of the METOKIS distributed approach to ontologies is that such activities should not necessitate a complete overhaul of the system.

- The technical (as well as the conceptual!) infrastructure provided by KCOs is "heavy-weight" and therefore, not suitable at present for the typical SME which usually provides "mid-tech" solutions for specific niche markets. These SMEs are characterised by high competence in the market sector, but insufficient development competence for demanding and yet immature modelling machinery such as foundational ontologies and description logics. One remedy could be to develop the core technology in two-year, academic-led project phases and then to
bring on board several SMEs who can be taught how to use the technology. E.g. 24 months research, 3 months technology transfer phase, 9 months validation phase in industrial projects.

5.2 Research Outlook

Overall, METOKIS has achieved its technological and methodological objectives. The partners are, continuing to validate the METOKIS findings in subsequent projects. One has to bear in mind that METOKIS was different from standard STREPs in that it proposed to develop a prototypical infrastructure, not just specific components. The project was intended to be a pathfinder for the research theme of "intelligent content" (this was also appreciated by the evaluators of the original proposal). Rather than risking a whole Integrated Project on such an exploration, METOKIS tried to be a "trail blazer" STREP. We believe that it has served its purpose well in this respect.

There are four directions of further research work which can be derived from this project:

1. Empirical studies alongside knowledge-content projects to validate further, the technologies and methods developed in METOKIS.
2. Combination of the object-centred approach (KCO) with service-interface centred technologies (semantic web services).
3. Tool support for ontology based semantic systems development, including methodological support for developing this class of applications.
4. Scalable collaboration support, from individuals to large-scale collaboration in the development of knowledge and content based semantic information systems.

Some activities in these areas have already started.

5.3 Exploitation plans and further work

The partners of the METOKIS project intend to exploit the knowledge within their business domains. Empolis plans a direct uptake of the technologies in new releases of their system Publication Build V4.0. The innovation aspect can be seen on the one hand in the ontology based consolidation of user tasks and the assortment of content objects, and on the other hand in the fact that these Knowledge Content objects are not only aggregated from local sources but also potentially from external media repositories which are accessible via the web and managed by the METOKIS Knowledge Content Carrier Architecture.

KnowledgeView and Templeton College will create a Knowledge & News Service Platform for creating and operating information services. It provides a means for editorially active knowledge workers to share and act upon news and other information and to increase the productivity of their interactions with one another. KnowledgeView is intending to develop this as a directly operated hosted service facility using extensions to its RAPID Browser product family.

YMEGA Establishment will build its Congruens System 43 for Clinical Trials. The clinical trial system is the platform, which will be enhanced to handle KCOs. The system will consist of two main features. A protocol-controlled clinical trial management system (protocol section and generator prototype, which allows to generate forms, reports, and data interfaces necessary for trial management from protocol data) and a comprehensive, integrated metadata management system (metadata section and generator prototype).

Klett will use the knowledge gained in the project, to build concrete domain and task ontologies in order to support their business processes of highly modular delivery of knowledge products.

SRFG and ISTC-CNR will use the theoretical results (DPO - DOLCE + D&S Plan Ontology) and the practical outcomes (KCCA middleware, KCO implementations) of the project for further research activities. SRFG is also able to transfer significant aspects of this knowledge into two national competence centres - Salzburg NewMediaLab and eTourism Center Salzburg.

All partners under the lead of MCM Institute St. Gallen are also developing a methodological handbook that introduces a Knowledge Service Methodology and integrates it with Business Modelling
and an economic model for describing incentives for knowledge sharing. The handbook is aimed at practitioners who wish to implement domain and task ontologies within their ICT-environment. The handbook will include a section concentrating on the design view of how to design the organisation to implement the KCCA and a section concentrating on the moderator view of how to support the change management process within an organisation. Within the handbook the three application cases are described including their underlying business models. In Austria, the project has already led to a two-year follow-on research project combining GRID computing, semantic web services and intelligent objects based on the KCO model.

To summarise, the METOKIS project has defined Knowledge Content Objects and developed an infrastructure for their manipulation, and it has shown by way of three use cases and attendant examples, how such objects can be exchanged by different information systems serving different purposes.

As a "trail blazer" project, we have concluded that the majority of results will be made available to interested parties, particularly in conjunction with concrete exploitation projects (commercially and academic). The partners are too small and the knowledge created is too diverse to seriously envisage software patents. Engaging in such activities would be counter-productive, in our opinion. We have therefore chosen the route of making results available to the public where this helps in disseminating the "intelligent objects vision" as formulated in the work programme of FP6, and to keep control over such dissemination by making the knowledge only accessible on a case-by-case basis, depending on each partner's assessment of the costs and benefits of doing so.
## 6 ANNEX A: Deliverables, Publications and Presentations

All results can be found at the public website of METOKIS: [http://metokis.salzburgresearch.at](http://metokis.salzburgresearch.at)

### 6.1 Research Deliverables

<table>
<thead>
<tr>
<th>Del. no.</th>
<th>Deliverable name</th>
<th>Date due</th>
<th>Lead contractor</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>D01</td>
<td>METOKIS Website, <a href="http://metokis.salzburgresearch.at">http://metokis.salzburgresearch.at</a></td>
<td>M01</td>
<td>SRFG</td>
<td>PU</td>
</tr>
<tr>
<td>D02</td>
<td>Project Evaluation and Quality Assurance Plan (including Self Assessment Plan)</td>
<td>M02</td>
<td>SRFG</td>
<td>RE</td>
</tr>
<tr>
<td>D03</td>
<td>Project Presentation</td>
<td>M03</td>
<td>SRFG</td>
<td>PU</td>
</tr>
<tr>
<td>D04</td>
<td>Dissemination and Use Plan 1st Draft</td>
<td>M03</td>
<td>SRFG</td>
<td>RE</td>
</tr>
<tr>
<td>D05</td>
<td>Plan for Raising public participation and awareness</td>
<td>M04</td>
<td>SRFG</td>
<td>RE</td>
</tr>
<tr>
<td>D06</td>
<td>Gender Action Plan</td>
<td>M05</td>
<td>SRFG</td>
<td>RE</td>
</tr>
<tr>
<td>D07</td>
<td>Task Taxonomies for Knowledge Content</td>
<td>M06</td>
<td>CNR</td>
<td>RE</td>
</tr>
<tr>
<td>D08</td>
<td>Knowledge Service Methodology</td>
<td>M06</td>
<td>TEMPLETON</td>
<td>PU</td>
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<tr>
<td>D09</td>
<td>Economic Framework for Incentives in the Knowledge Economy</td>
<td>M07</td>
<td>UNISG</td>
<td>PU</td>
</tr>
<tr>
<td>D10</td>
<td>Knowledge Content Carrier Architecture - Specification</td>
<td>M07</td>
<td>SRFG</td>
<td>RE</td>
</tr>
<tr>
<td>D11</td>
<td>Open workshop #1 for knowledge and content technologies –early findings and emerging research directions</td>
<td>M09</td>
<td>SRFG</td>
<td>PU</td>
</tr>
<tr>
<td>D12</td>
<td>Service Blueprints (interim report)</td>
<td>M10</td>
<td>TEMPLETON</td>
<td>RE</td>
</tr>
<tr>
<td>D13</td>
<td>Business models for the three application cases (interim report)</td>
<td>M10</td>
<td>UNISG</td>
<td>RE</td>
</tr>
<tr>
<td>D14</td>
<td>Design and implementation of the three application cases (interim report)</td>
<td>M10</td>
<td>KVVIEW EMPOLIS YMEGA</td>
<td>RE</td>
</tr>
<tr>
<td>D15</td>
<td>User Validation Plan</td>
<td>M11</td>
<td>TEMPLETON KLETT YMEGA</td>
<td>RE</td>
</tr>
<tr>
<td>D16</td>
<td>Software Prototype for an open Knowledge Content Carrier Architecture and Knowledge Content Objects</td>
<td>M12</td>
<td>EMPOLIS</td>
<td>RE</td>
</tr>
<tr>
<td>D17</td>
<td>Technology Watch and Risk Assessment</td>
<td>M12</td>
<td>YMEGA</td>
<td>RE</td>
</tr>
<tr>
<td>D18</td>
<td>Prototypes for the three applications</td>
<td>M14</td>
<td>KVVIEW EMPOLIS YMEGA</td>
<td>RE</td>
</tr>
<tr>
<td>D19</td>
<td>Open academic Workshop #2 for knowledge and content technologies – contributions towards “pervasive smart content technologies”</td>
<td>M15</td>
<td>SRFG</td>
<td>PU</td>
</tr>
<tr>
<td>D20</td>
<td>Final Methodology and Business Principles for knowledge sharing</td>
<td>M18</td>
<td>UNISG</td>
<td>RE</td>
</tr>
<tr>
<td>D21</td>
<td>Final Design Specifications for the Knowledge Content Carrier Architecture</td>
<td>M20</td>
<td>SRFG EMPOLIS KVVIEW</td>
<td>RE</td>
</tr>
<tr>
<td>D22</td>
<td>Methodology validation and User validation - summary report</td>
<td>M20</td>
<td>TEMPLETON KLETT</td>
<td>RE</td>
</tr>
<tr>
<td>D23</td>
<td>Final Open Knowledge Content Carrier Architecture</td>
<td>M20</td>
<td>SRFG EMPOLIS KVVIEW</td>
<td>RE</td>
</tr>
<tr>
<td>D24</td>
<td>Report on using and disseminating knowledge</td>
<td>M21</td>
<td>KVVIEW</td>
<td>RE</td>
</tr>
</tbody>
</table>
6.2 Scientific paper publications

- Wolfgang Maass, Sunil Goyal, Wernher Behrendt (2004): Knowledge Content Objects and a Knowledge Content Carrier Infrastructure for ambient knowledge and media aware content systems In: EWIMT workshop "Content, user and network aware media engineering".


6.3 METOKIS Open Workshops

- Open workshop #1 for knowledge and content technologies – early findings and emerging research directions, December 2004, Salzburg Austria.

- Open academic Workshop #2 for knowledge and content technologies – contributions towards “pervasive smart content technologies”, June 2005, Heraklion, Greece.

- Open workshop #3 on industrial applications and commercial take-up, November 2005, London, UK.
6.4 Presentations, Lectures and Articles at Conferences, Workshops and Seminars

- Aldo Gangemi: Ontologie per i servizi nella pubblica amministrazione”. Presentation, Roma, Italy, 2005-06-17.

6.5 Website

The main project website is available under: http://metokis.salzburgresearch.at
6.6 Glossary

The glossary contains a general list of terms and a table which explains the KCO structure.

6.6.1 General Glossary Terms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Terminology</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL</td>
<td>Agent Communication Language</td>
<td>A communication language designed for → FIPA Agents</td>
</tr>
<tr>
<td>DOLCE</td>
<td>Descriptive Ontology for Linguistic and Cognitive Engineering</td>
<td>A so-called foundational ontology whose aim it is to serve as the basis for more specific domain ontologies. DOLCE gives us the building blocks from which we build our specific semantic models</td>
</tr>
<tr>
<td>DDPO</td>
<td>DOLCE-Descriptions-Plans</td>
<td>A library of related ontologies from the DOLCE family which can be used to specify Description and Plans</td>
</tr>
<tr>
<td>DnS</td>
<td>Descriptions and Situations</td>
<td>DnS (Descriptions and Situations), developed by Aldo Gangemi (LOA, Rome), is a constructivist ontology. It does not put restrictions on the type of entities and relations that one may want to postulate, either as a domain specification, or as an upper ontology, and it allows for context-sensitive ‘redescriptions’ of the types and relations postulated by other given ontologies (or ‘ground’ vocabularies). See: <a href="http://en.wikipedia.org/wiki/Upper_ontology_(computer_science)#DOLCE_and_DnS">http://en.wikipedia.org/wiki/Upper_ontology_(computer_science)#DOLCE_and_DnS</a></td>
</tr>
<tr>
<td>FIPA</td>
<td>Foundation for Intelligent Physical Agents</td>
<td>An industry-led consortium of stakeholders who wanted to progress on the standardisation of agent technology. See</td>
</tr>
<tr>
<td>ICH</td>
<td>International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use</td>
<td>ICH E6 is a standard for the design, conduct, performance, monitoring, auditing, recording, analysis and reporting of clinical trials that provides assurance that the data and reported results are credible and accurate and that the rights, integrity, and confidentiality of trial subjects are protected. The terms of reference can be found at <a href="http://www.ich.org/cache/html/581-272-1.html">http://www.ich.org/cache/html/581-272-1.html</a> In METOKIS, the ICH regulations were used as the basis for the domain model of the clinical trials application case.</td>
</tr>
</tbody>
</table>
| IPTC    | News Markup Language from the International Press and Telecommunications Council | NewsML 1.x versions can be applied at all stages in the (electronic) news lifecycle. Typical use would include:  

- in and between editorial systems  
- between news agencies and their customers  
- between publishers and news aggregators  
- and between news service providers and end users.  

(Source: http://www.newsml.org/pages/index.php)  
In the METOKIS project, the News application showcase was based on the NewsML thesaurus. |
| KCO     | Knowledge Content Object                                                         | Knowledge content objects are defined by six → facets each of which covers a specific semantic aspect of knowledge-enhanced media content |
| CD      | Content Description                                                             | One of six KCO facets, contains the facet elements → Multimedia Characterization. → Content Classification, → Propositional Description |
### 6.6.2 KCO Facet Structure

<table>
<thead>
<tr>
<th>Facets</th>
<th>Facet Elements</th>
<th>Short Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD</td>
<td>Presentation Description</td>
<td>One of six KCO facets, contains the facet elements → Spatio-temporal rendition, → Interaction-based rendition</td>
</tr>
<tr>
<td>CO</td>
<td>Community Description</td>
<td>One of six KCO facets, contains the facet elements → User task, → User community, → Usage history</td>
</tr>
<tr>
<td>BD</td>
<td>Business Description</td>
<td>One of six KCO facets, contains the facet elements → Negotiation protocol, → Licensing scheme, → Contract information</td>
</tr>
<tr>
<td>TS</td>
<td>Trust and Security</td>
<td>One of six KCO facets, specifies how to protect the content (vendor's interest) and how to induce trust (consumer's interest)</td>
</tr>
<tr>
<td>SD</td>
<td>Self Description</td>
<td>One of six KCO facets, Specification of the structure of the KCO (active facets, ontologies used) in machine-interpretable form.</td>
</tr>
<tr>
<td>KCCA</td>
<td>Knowledge Content Carrier Architecture</td>
<td>The inner architecture of the object management system developed for KCOs</td>
</tr>
<tr>
<td>kctp</td>
<td>knowledge content transfer protocol</td>
<td>kctp is the communication protocol defined for KCCA nodes. It is based on the → FIPA Agent Communication Language → ACL.</td>
</tr>
<tr>
<td>RDF</td>
<td>Resource Description Framework</td>
<td>A notation for describing data elements that live on the <a href="http://WWW">WWW</a>. RDF follows Subject-Predicate-Object metaphor and consists of triples where a URL has a meaning associated via the predicate label and where the predicate can have a literal value. See RDF Resource Description Framework.</td>
</tr>
<tr>
<td>OWL</td>
<td>Web Ontology Language</td>
<td>OWL is a forced acronym to denote an RDF based knowledge representation language for the Semantic Web.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facets</th>
<th>Facet Elements</th>
<th>Short Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Description</td>
<td>Multimedia Characterization</td>
<td>How to access the content. This description includes information about the Content Format, Encoding, Storage Location, etc.</td>
</tr>
<tr>
<td>Content Classification</td>
<td>How to classify the content: Keywords and concepts assigned to the content object based on a classification schema. Dublin Core or LOM are such classification schemas. The IPTC thematic thesaurus and the ICON Class classification system are well known controlled vocabularies in their domains.</td>
<td></td>
</tr>
<tr>
<td>Propositional Description</td>
<td>What the content means. This semantic description is about the subject of the Content Object and not about the Content object itself.</td>
<td></td>
</tr>
<tr>
<td>Presentation Description</td>
<td>Spatio-temporal rendition</td>
<td>How to present the content: Description of how the content (and the Knowledge) of the KCO is presented to users. Presentation includes the rendering, rendition as well as interaction models.</td>
</tr>
<tr>
<td>Community Description</td>
<td>User task</td>
<td>Description of Plans, Tasks, Roles and Goals in the context of a community.</td>
</tr>
<tr>
<td>Community Description</td>
<td>User community</td>
<td>Description of Plans, Tasks, Roles and Goals in the context of a community.</td>
</tr>
<tr>
<td>Community Description</td>
<td>Usage history</td>
<td>How the Content was used/changed: List of actions performed with the KCO during its lifecycle.</td>
</tr>
<tr>
<td>Business Description</td>
<td>Negotiation protocol</td>
<td>How to trade the content: Business processes define special plans (negotiation protocols) and roles (auctioneer, seller, buyer,) related to some business activity. This facet can be viewed as a specialisation of the community facet.</td>
</tr>
<tr>
<td>Business Description</td>
<td>Pricing scheme</td>
<td>How to trade the content: Business processes define special plans (negotiation protocols) and roles (auctioneer, seller, buyer,) related to some business activity. This facet can be viewed as a specialisation of the community facet.</td>
</tr>
<tr>
<td>Business Description</td>
<td>Contract information</td>
<td>How to trade the content: Business processes define special plans (negotiation protocols) and roles (auctioneer, seller, buyer,) related to some business activity. This facet can be viewed as a specialisation of the community facet.</td>
</tr>
<tr>
<td>Trust &amp; Security</td>
<td>none</td>
<td>How to protect the content (vendor's interest) and how to induce trust (consumer's interest)</td>
</tr>
<tr>
<td>Self-description</td>
<td>none</td>
<td>How to understand the KCO: Specification of the (inner) structure of the KCO (active facets, ontologies used, ...) in machine-interpretable form.</td>
</tr>
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</table>
### 7 The METOKIS Partners and Roles

#### 7.1 Consortium Partners

<table>
<thead>
<tr>
<th>Partner Name</th>
<th>Description</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salzburg Research Forschungsgesellschaft mbH</strong> (A, Co-ordinator)</td>
<td>Coordinator, academic research and technical lead for KCO and KCCA infrastructure.</td>
<td><a href="mailto:wernher.behrendt@salzburgresearch.at">wernher.behrendt@salzburgresearch.at</a></td>
</tr>
<tr>
<td><strong>Knowledge View Ltd</strong> (UK)</td>
<td>Application partner for the senior executives’ information moderation use case and co-development of the KCCA.</td>
<td><a href="mailto:roberto.minio@knowledgeview.com">roberto.minio@knowledgeview.com</a></td>
</tr>
<tr>
<td><strong>Empolis GmbH</strong> (D)</td>
<td>Application partner for the educational workflow use case (jointly with Klett Verlag) and co-development of the KCCA.</td>
<td><a href="mailto:jasmin.franz@empolis.com">jasmin.franz@empolis.com</a></td>
</tr>
<tr>
<td><strong>YMEGA Establishment</strong> (LI)</td>
<td>Application partner in the Clinical Trials use case (jointly with SRFG).</td>
<td><a href="mailto:hans.ladanyi@sqlselect.com">hans.ladanyi@sqlselect.com</a></td>
</tr>
<tr>
<td><strong>Templeton College, University of Oxford</strong> (UK)</td>
<td>Academic research partner for methodology and user partner in the senior executives information moderation use case.</td>
<td><a href="mailto:richard.Cuthbertson@templeton.ox.ac.uk">richard.Cuthbertson@templeton.ox.ac.uk</a></td>
</tr>
<tr>
<td><strong>Institute for Media and Communications Management University St. Gallen</strong> (CH)</td>
<td>Academic research partner for methodology (business models) and for KCO Modelling.</td>
<td><a href="mailto:wolfgang.maass@unisg.ch">wolfgang.maass@unisg.ch</a></td>
</tr>
<tr>
<td><strong>Laboratory for Applied Ontology (LOA), Institute of Cognitive Science and Technology, Italian National Research Council</strong> (I)</td>
<td>Academic research partner for the application of foundational ontologies to the METOKIS use cases, for the METOKIS task model and for the KCO model.</td>
<td><a href="mailto:aldo.gangemi@istc.cnr.it">aldo.gangemi@istc.cnr.it</a></td>
</tr>
</tbody>
</table>
7.2 Project Coordination - Contact Person

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