D 2.6.4 Report on Research Advance

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Abstract.
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After 18 months of operation, cooperation and active participation on meetings in the research area of Knowledge Web is in place. In this deliverable we present a brief overview of the research advance achieved so far.

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Executive Summary

After 18 months of operation, cooperation and active participation on meetings in the research area of Knowledge Web is in place. In 2005 all WPs met at the Joint Knowledge Web Research meeting on 24th-25th January 2005 at Hannover, Germany and the Joint Knowledge Web Research meeting following the ESWC 2nd European Semantic Web Conference, ESWC 2005, in Heraklion, Crete 2nd-3rd May 2005.

Before M12 the area managers had emphasized *additionality* instead of *duplication* of effort, and have encouraged cross collaboration between WPs, the SDK cluster, the WSMO projects and other activities. To strengthen the cross-WP-fertilization we introduced for both meetings in 2005 a new form in addition to regular WP meetings: so-called **themed research meetings** (aka. join sessions or concertation meetings). For each themed meeting the major topic of one research WP has been highlighted as theme, in January this had been "Web Services" and in May this had been "Language Extensions". Operationalization of a themed meeting consists of a series of bi-lateral meetings of the highlighted WP with all the remaining ones.

In this deliverable we present a brief overview of the research advance achieved so far which consists of summaries of the results so far achieved in each research work package (WP2.1 Scalability, WP2.2 Heterogeneity, WP2.3 Scalability, WP2.4 Web Services and WP2.5 Language Extensions) and summaries of bi-lateral meetings among different work packages.

Our observations from the first 18 months in a nutshell:
- Individual work packages are working well
- Bi-lateral programme is successfully tying together the research work packages, and achieving its goal more effectively
- Still need to work on linking research area to industry area and education area

Contents

1 Introduction

After 18 months of operation, cooperation and active participation on meetings in the research area of Knowledge Web (KWeb) is in place. All deliverables due at M12 have been delivered and are available on the KWeb portal, deliverables due at M18 are currently going through the final steps of the quality assurance process and will be available afterwards on the KWeb portal.

In 2005 all WPs met at the Joint Knowledge Web Research meeting on 24th-25th January 2005 at Hannover, Germany and the Joint Knowledge Web Research meeting following the ESWC 2nd European Semantic Web Conference, ESWC 2005, in Heraklion, Crete 2nd-3rd May 2005. More information including the agendas of the meetings are available in the KWeb portal.

Before M12 the area managers had emphasized *additionality* instead of *duplication* of effort, and have encouraged cross collaboration between WPs, the SDK cluster, the WSMO projects and other activities. The work packages (WPs) have been encouraged to explicitly identify in their deliverables a formal statement on cross-relationships to other deliverables, both within Knowledge Web and in relevant external projects.

To further strengthen the cross-WP-fertilization we introduced for both meetings in 2005 a new form in addition to regular WP meetings: so-called **themed research meetings** (aka. join sessions or concertation meetings). For each themed meeting the major topic of one research WP has been highlighted as theme, in January this had been "Web Services" and in May this had been "Language Extensions".

We chose Web Services and Language Extensions since they play a central role for Knowledge Web. It is foreseen to continue this selection process for future meetings based on the needs at hand, observations from the results of WPs and discussions with KWeb partners.

Operationalization of a themed meeting consists of a series of bi-lateral meetings of the highlighted WP with all the remaining ones, such as illustrated in Figure 1 for the first themed meeting on web services (the structure for the meeting on language extensions has been accordingly).
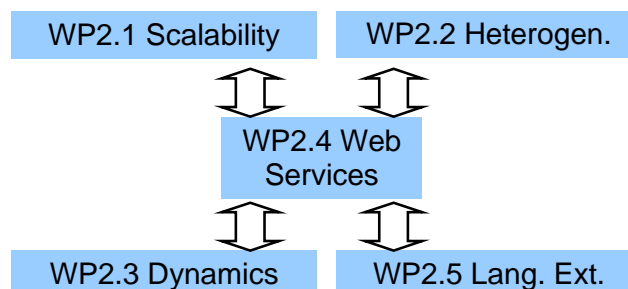

Figure 1: Operationalization of the themed meeting on Web Services

A similar structure has been implemented for inter-area fertilization. At the January meeting the industry area had been highlighted by having dedicated sessions "Industry-Research" and "Industry-Education". Part of the industry-research meeting has been e.g. the presentation of business use cases collected in the industry area where semantic web technologies such as addressed in the research WPs can be applied. To strengthen the exchange between industry and research, the "Industry-Research" meeting has been repeated in May. It is foreseen to continue the inter-area meetings on a frequent base.

In this deliverable we present a brief overview of the research advance achieved so far which consists of summaries of the results so far achieved in each research work package (WP2.1 Scalability, WP2.2 Heterogeneity, WP2.3 Scalability, WP2.4 Web Services and WP2.5 Language Extensions) and summaries of bi-lateral meetings among different work packages.

Summary of Research Advance per WP

In this chapter we provide a summary of the research advance in each research work package. Further details can be found in the deliverables of each WP.

1.1 WP2.1 Scalability

WP2.1 "Scalability"' is based on three pillars: Approximation, Modularization and Benchmarking. After an exhaustive investigation of the state-of-art all three areas advanced significantly since the beginning of the project.

Before we considered the development of new approximation methods, we tried to apply an existing and promising method, the Cadoli and Schaerf approach. But the application of this method shows only mixed results (see deliverable D2.1.2). Based on this experience, new methods have been developed. The first, which is still related to the Cadoli and Schaerf method, cannot be applied to general cases but is restricted to the specific case of instance retrieval with conjunctive queries, because the restriction leads to better results. The second approach approximates the translation of ontologies to disjunctive logic programming in order to make standard logic programming techniques like SLD resolution applicable for reasoning. Both results will be reported in the next deliverable D.2.1.2.2 about practical approximation and distributed reasoning.

Modularization can have several facets. For a classification scheme we developed a framework which allows to relate or to differentiate the various approaches. The framework includes dimensions specifying whether modules overlap or whether all modules cover a whole etc. The framework is described in deliverable D2.1.3.1. The deliverable also contains a collection of different approaches which include approaches for partitioning and applications of modularization.

The literature survey also shows that a benchmarking methodology is still missing. Therefore in WP2.1 a general methodology is being developed which must be instantiated for specific tasks. The methodology is described in deliverable D2.1.4. Because several work packages in research and also in the industrial area are faced with benchmarking, the methodology is shared with other WPs. Based on this methodology, a set of test suites and prototypes is currently being set up and first benchmarks on ontology development tools are being performed.

1.2 WP2.2 Heterogeneity

The work package 2.2 is organized into two complementary parts: the first one consists of establishing correspondences between heterogeneous ontologies and is the main topic of the first 24 months of the network; the second one considers the exploitation of these alignments in various uses cases and is the main topic of the next 24 months (of course both topics are related enough for always being in the reach of our sight).

The first work package objectives are:

— Definition of a common framework encompassing ontology and data/alignment and transformation and translation, in which the problems can be expressed and the approaches (e.g., text-based vs. statistical) can be compared and merged.
— Design of a benchmark suite for alignment and comparison of alignment methods along this benchmark that is made widely available.
— Development of transformation and merging technology for widely available ontology languages (e.g. RDF and OWL).

At the beginning there is no common framework between people dealing with this problem as is illustrated by deliverables 2.2.1 and 2.2.3. This can be seen as good news because this means that there is room for taking advantage of the various approaches. This requires time and discussion. Similarly, there was no real independent evaluation of the technology so far (though this was subject of discussion in the community).

During the first 18 months of Knowledge Web, important progress has been made. This progress came first on the raw ground of integration of many different research teams working towards the same goals and interacting. This has been embodied by exchanges of researchers.

Progress has been made towards the establishment of a framework encompassing the definition of alignment and the discovery of alignments. This work has led to independent (and compatible) conceptual, categorical and logical frameworks which raise very important issues concerning the nature of alignment. This also helps understanding the use of alignment technology within peer-to-peer distributed systems. These frameworks provide guidelines for setting up the benchmarking effort. They also raised more interest towards investigating further the categorical approach of alignment. This is especially true for defining the nature of composition of alignments (that can be useful when several alignment can be used for transforming ontologies or data). This work is currently active.

Progress has also been made towards benchmarking ontology alignment algorithms. In fact we run two ontology alignment evaluation events in 2004. This was not expected but provides more insurance that we will be able to carry a continuous benchmarking effort. One of these efforts used some tools (Alignment API) that were developed partly based on the first framework we developed. In 2005 we prepared an even more convincing ontology alignment evaluation effort to be held at the K-Cap conference in October. It will feature a battery of standard benchmark test as well as two real-world challenges for aligning web directories and anatomy ontologies. We also have developed evaluation measures generalizing precision and recall in order to address concerns raised by the first evaluation.

We are defining (following the guidelines of D2.2.1) some common format for alignments that can be used in a variety of contexts raised by the use-cases (WSML mediators, semantic peer-to-peer, networked ontologies). This format will be integrated within the Alignment API, which will be improved and used in further efforts towards integration.

There have been formal meetings of WP 2.2 at many occasions in Madrid, Amsterdam, Karlsruhe (SDK), Heraklion, Manchester, Hannover, Grenoble (SDK) and Heraklion again. There have also been numerous subgroups meetings.

Contractor involved in this work (all tasks) were: Centre for Research and Technology Hellas, École Polytechnique Fédérale de Lausanne, Free University of Bozen-Bolzano, Institute National de Recherche en Informatique et en Automatique, National University of Ireland Galway, Universidad Politécnica de Madrid, University of Innsbruck, University of Karlsruhe, University of Manchester, University of Sheffield, University of Trento, Vrije Universiteit Amsterdam, Vrije Universiteit Brussel.

Based on the work carried out in work package 2.2, Jérôme Euzenat and Pavel Shvaiko have presented a tutorial on Schema and ontology matching at ESWC 2005. The material of the tutorial will be included in the REASE repository.

We organized the Ontology Alignment Contest at the EON workshop and the Meaning negotiation workshop at Hiroshima.

WP2.2 has been involved in the organization of the following Knowledge web workshops: ISWC EON workshop organization (Hiroshima), AAAI Context and ontology workshop (Pittsburg), and K-Cap Ontology integration workshop (Banff), ECAI workshop on "Semantic middleware for interoperability on the grid and the web" (Madrid). Two groups participated (and appear in the program committee) of the Information Interpretation and Integration Conference (I3CON) which features a benchmark of ontology alignment algorithms. Several group participated in the Dagstuhl seminar on "Semantic integration and interoperability" in September 2004. Of course, many papers have been presented on these topics at: ESWS (2), ECAI (1), VLDB (1), ISWC (2+3), WWW (1)...

Work package 2.2 has had coordination meeting with SEKT and DIP integrated projects through the SDK Ontology working group. It has also cooperated with 2.1 (on benchmarking), with 2.3 (on meaning negotiation for agents), with 2.4 (on generating mediators for semantic web services), and foresee more cooperation with 2.5 (on generating SW rules from alignments). See next section for further information.

All deliverable have been delivered on time. The only deviation is that this work package is ahead of its schedule. Indeed it has already run a benchmarking of ontology alignment event. Such an event was planned not before M12. For that reason, we decided to discuss this campaign in deliverable D2.2.2 and to take advantage of it to run a new evaluation campaign in 2005. This led us to postpone deliverable D2.2.4 to M24.

1.3 WP2.3 Dynamics

The General KnowledgeWeb Assembly at Crete on the 2-3 of June was held in the Aldemar Knossos Royal Hotel in Hersonissos, Crete. The agenda of WP 2.3 started at 11

o'clock on the 2nd of June, and lasted till 4 o'clock in the afternoon due to the fact there was a joint session with all research workpackages including a panel session with all work package leaders. Robert Stevens from The University of Manchester has become an active member of the work package. He is involved in the transformation of the Gene Ontology into a description-logics based OWL based ontology. He is interested in contributing to the development of an ontology-based versioning system to the Gene Ontology, which is part of the Open Biological Ontologies. Current Gene Ontology versions are maintained by CVS repositories, which handle only syntactic differences among ontologies. In other words CVS is not able to differentiate class versions for instance, being able only to differentiate text/file differences.

The Workpackage will include three different use cases with quite different needs:
1. Anna V. Zhdanova's People Portal for Ontology Consensus Framework
2. Sebastian Kruk MarcOnt Digital Library system and
3. Robert Stevens, Gene Ontology versioning system

The agenda mainly centered in the gathering of end-user requirements and use cases for ontology versioning. Also some issues about intra and inter collaboration among workpackage members were discussed. From 14:00 to 14:30 there was a joint session with WP2.5: Semantic Web Language Extensions, session coordinated and leaded by Jeff Pan and Ian Horrocks. WP 2.3 proposed an extension to RDQL and SPARQL to enable the querying of versions through bi-temporal database features such as valid-time and transaction-time and context information.

With regard to the Workplan of the Gene Ontology we have defined the following phases:
1. Select several seed GO snapshots from CVS
2. Define OBOL-RDFS vocabulary
3. Analyze CVS comments/mine patterns and analyze documentation
4. Define consensus modelling for the GO.

We have achieved the following goals and objectives within the workpackage:
1. A People's portal first prototype for modeling consensus framework
2. A JAVA-based API for RDF/RDF-S versioning (almost completed) with the inclusion of bi-temporal abstract data types and query features
3. The selection of the Gene Ontology as a use case, expecting to have a first prototype for versioning the Gene Ontology by October/November.
4. A major collaboration within the workpackage helding monthly phone conferences, setting up a public wiki and making more active the mailing list

1.4 WP2.4 Web Services

WP2.4 aims to contribute to development of concepts and technologies of the Semantic Web Services (SWS) known as WSMO (SWS conceptual model), WSML (ontology language for SWS) and WSMX (SWS execution environment). Accordingly, work in WP2.4 addresses fundamental aspects of SWS such as service semantics, discovery and

composition of services, interoperation and invocation of services including both, theoretical concepts as well as their implementation as part of the open source WSMX system.

Within the context of the whole KW project, and in particular its research and industrial work packages, WP2.4 also aims to align research in various overlapping fields of the Semantic Web and the Semantic Web Services, further contributes to the research in other areas and gains essential input from various research groups around Europe. In particular, collaboration between various research WP of KW has started to handle the scalability of ontologies, combine work carried out in heterogeneity of ontologies to integrate new methods of ontology aligning, to handle dynamics of WSML ontologies and to coordinate joint efforts with WP2.5 in the areas of discovery and languages.

For over the past 18 months of the project, several deliverables have been finished laying down the basis for further work. In particular, first or final versions of deliverables have been finished including Requirements for web service description, Conceptual and Formal Framework for Semantic Web Services, Semantics for web services discovery and composition, Theoretical integration of discovery and composition, Analysis of the state of the art of agent-based services, and Guidelines for the integration of agent-based services and web-based services. Based on results of this work, future work will be done in concepts as well as prototype implementation of interoperation at levels of data and process mediation as well as protocol interoperation.

In addition, work on triple space computing architecture for Semantic Web Services will be carried out dealing with technical and ontological infrastructure as a distributed persistent mechanism for storing triples and semantic specification of a domain respectively. WP2.4 will also provide deliverables on reputation mechanism of services and their providers discussing their assumptions, benefits, and limitations. Selected reputation mechanism will be incorporated into the service composition algorithms. Apart from working and contributing to deliverables, partners involved in the WP2.4 extensively disseminate their research results in established conferences worldwide and also contribute to the SDK cluster dissemination events.

1.5 WP2.5 Language Extensions

WP2.5 language extensions is proceeding according to plan, and is meeting (in some cases exceeding) its key objectives.

The main results so far consist of the following three parts. Firstly, we provide several extensions, the requirements of which are well recognised, including datatype and fuzzy extensions. In particular, the work on extending OWL DL with user-defined datatypes has been published in a W3C note in the SW best practice and deployment WG. Secondly, we have provided a unified framework for rules and queries with ontologies, where we compare existing approaches of extending ontologies with rule languages, such as the axiom-based approach, logic programming approach and the DL-log approach. Thirdly, we have shown query answering RDF graphs over empty ontologies can be

reduced to standards DL query answering. Furthermore, we have surveyed many existing SW query engines, and have provided implementations and optimisation techniques for some patterns of query answering over OWL DL and OWL-E ontologies.

After the successful joint session with other research area work packages, we will work together to identify detailed practical use cases for language requirements from these work packages. Furthermore, we believe that our future work could usefully include the development of (further) implementation and optimisation techniques for various rule languages (including some sub-languages and extensions of SWRL) and query languages (such as OWL-QL and OWL-E-QL): implementation work is usually required in order to validate language design and to determine its utility.

2 Summary of Bilateral Research WP Meetings

Before M12 the area managers had emphasized *additionality* instead of *duplication* of effort, and have encouraged cross collaboration between WPs, the SDK cluster, the WSMO projects and other activities. The work packages (WPs) have been encouraged to explicitly identify in their deliverables a formal statement on cross-relationships to other deliverables, both within Knowledge Web and in relevant external projects.

To further strengthen the cross-WP-fertilization we introduced for both meetings in 2005 a new form in addition to regular WP meetings: so-called **themed research meetings**. For each themed meeting the major topic of one research WP has been highlighted as theme, in January this had been "Web Services" and in May this had been "Language Extensions". As shown in Figure 2, Web Services and Language Extensions both play a central role for Knowledge Web, therefore we considered them for the first two themed meetings as most importantly.
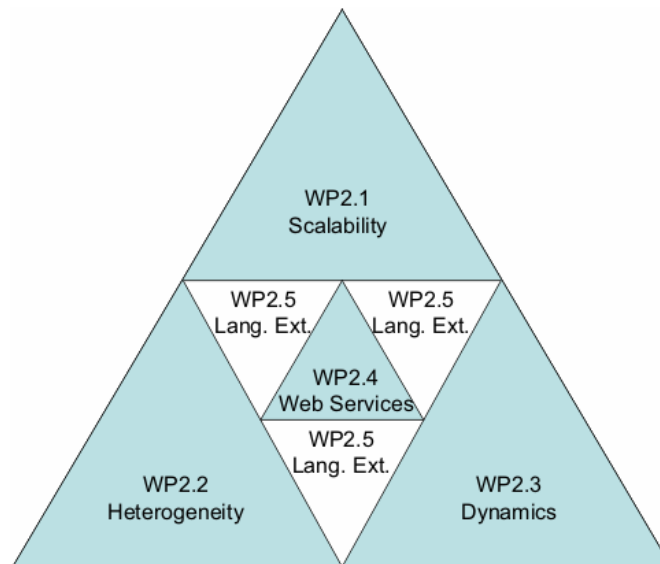

Figure 2: Structure of research WPs in KWeb

In this section we provide summaries of the bilateral research WP meetings held at Hannover and Heraklion general assemblies.

2.1 WP2.1 Scalability – WP2.4 Web Services

During the bilateral meeting of WP2.4 and WP2.1 in Hannover, research activities of WP2.1 regarding modularization, benchmarking and approximate reasoning have been identified as interested for WP2.4. In particular, guidelines for optimal modularization of complex ontologies is relevant for work in WSML and during the upcoming KW meetings, work on Conceptual and formal framework for SWS will investigate further input from modularization of ontologies in WP2.1.

Approximate reasoning techniques will be studied to be incorporated in discovery engine. Also, Manchester University offered WP2.4 researchers an access to a number of web services from bioinformatics for testing purposes, and possibly benchmarking activities in order to facilitate some use cases for SWS. Accordingly, Duncan Hull from Manchester University gave an overall presentation on these use cases during WP2.4 session in Crete. Such use cases will be further analysed giving an opportunity to provide more requirements for benchmarking in SWS as well as discovery and mediation in SWS.

2.2 WP2.1 Scalability – WP2.5 Language Extensions

In the Heraklion WP2.1+WP2.5 joint session, we mainly discussed the need for modularisation extension of OWL DL. We plan to have some detailed use cases ready by mid September, and work together on a chapter of D254 about the modularisation extension, covering use cases, some early thoughts on proposed syntax and semantics, as well as reasoning supports of the extension.

2.3 WP2.2 Heterogeneity – WP2.4 Web Services

There has been a constant coordination between WP2 and WP4 since the beginning of the Knowledge Web. This is mainly maintained through reading of deliverables and discussions. In particular, in the framework of the SDK Ontology working group (which met formally once in Karlsruhe and once in Grenoble) there has been in depth discussion of the progress of each party.

In Hannover, on 24th January 2005, bilateral research meeting took place between WP2.2 and WP2.4. It has been concluded, that the contact point between WP2.2 and WP2.4 is in the mediators and especially in O2O Mediators (ontology to ontology). The most relevant contribution from WP2.2 to WP2.4 would be the generation of WSMO mediators from alignments. This requires the completion of mediator specifications in WP 2.4 and WSML in general. This completion is due in the first half of 2005 and it will be taken as input of WP2.2 in order to be able to consider this generation. The definition of the language and its expressiveness might induce some modification of the format for delivering alignment in D2.2.6.

In general, WP2.2 doesn't expect particular problems in generating mediators. Possibly, WP2.2 would be able to effectively generate mediators that can be taken into account by WSMX or other implementations. From WSMX point of view, this should be possible as the mediators (or the actual mediation service behind them) are working with the alignment expressed using abstract mapping language. This would enable the use of the alignment generated by the API developed in WP2.2 with WSMX Data Mediation Runtime Component and in addition validate or refine this alignment using WSMX Data Mediation Design Component. As a counterpart, INRIA has developed the WSML alignment renderers that provided interoperability between the alignment format of WP2.2 and the WSML mediator format used in WP2.4.

The next step would certainly be to have some "implementation" of the WSML Mediator language embedded in the Alignment API as a Level 2 alignment format.

2.4 WP2.2 Heterogeneity – WP2.5 Language Extensions

In the Heraklion WP2.2 and WP2.5 join session, we mainly discussed the need for language extension for heterogeneity. After some discussion, we identified some possible extensions, such as the fuzzy, mapping and sharing extensions of OWL DL. We have not set any deadline for detailed use cases yet, but following the pattern of the WP2.1+WP2.5 timeline, we think it could be mid September. We plan to work together on a chapter of D254 about the above extensions, covering use cases, some early thoughts on proposed syntax and semantics, as well as reasoning supports of these extensions.

2.5 WP2.3 Dynamics – WP2.4 Web Services

The largest potential for collaboration between WP2.3 and WP2.4 is in the area of ontology versioning. The major contribution of WP2.3 to work carried out in the area of the Semantic Web Services within WP2.4 will be in D2.3.4 regarding the implementation of an OWL-light-minus and a first prototype of a WSMO-Core versioning system on top of the RDF versioning system. This deliverable is due in June 2006.

2.6 WP2.3 Dynamics – WP2.5 Language Extensions

WP2.5: Semantic Web Language Extensions: this WP has attempted to gather requirements from all WP's in order to define use cases for extending current Semantic Web languages. The General Assembly in Crete June 2-3 2005 included a joint session of WP 2.5 and rest of workpackages. The contribution of WP 2.3 was the inclusion of bi-temporal database attributes having temporal SQL as a guideline for such inclusion (valid-time and transaction time) and the inclusion of context information in the form of quads. We mainly discussed the need for time stamps (annotations on valid time and transaction time) extension of OWL DL. It was not very clear whether we simply need some annotation properties to capture time stamp, or we need to introduce some temporal constructors for OWL DL. Some practical use cases are needed to justify any further decision. We have not set any deadline for detailed use cases yet, but following the pattern of the WP2.1+WP2.5 timeline, we think it could be mid September. We plan work together on a chapter of D254 about the time stamp extension, covering use cases, some early thoughts on proposed syntax and semantics, as well as reasoning supports of the extension.

2.7 WP2.4 Web Services – WP2.5 Language Extensions

In the Hannover WP2.4+WP2.5 joint session, both representatives of WP2.4 and WP2.5 gave overviews of these two work packages. As the conclusion of the joint session, we identified three connections between the two work packages: (i) the use of DLs (such as OWL-E) on service discovery; (ii) DERI to lead a task in WP2.5 on WSML and possibly

its variants for Web service; (iii) modularization of ruled extended ontologies, which is a joint work, which potentially could be a connection with WP2.1, too.

In the Heraklion WP2.2+WP2.5 join session, we mainly discussed the future rule language for the Semantic Web, in particular the differences between the notions of DHL (Description Horn Logic) and DLP (Description Logic Program) have been discussed.

3 Summary of process and future emphasis

We briefly summarize our observations from the first 18 months:

- Individual work packages are working well
- Bi-lateral programme is successfully tying together the research work packages, and achieving its goal more effectively
- Still need to work on linking research area to industry area and education area