REWERSE – Annual Public Report 2007

Reasoning on the Web with Rules and Semantics

http://rewerse.net

The European Network of Excellence REWERSE develops rule-based languages and applications to process, query and to automatically reason over Web data. REWERSE's technologies thus enhance today's conventional Web towards a more intelligent "Semantic Web". REWERSE's focus on *rules and reasoning* on the Web enhances existing Semantic Web efforts that mainly deal with the *representation* of semantic information. REWERSE networks more than 100 researchers that work on three main objectives: to develop a set of inter-operable, application independent rule-languages supporting various forms of Web reasoning, to provide support tools for reasoning on the Web like rule modelling, verbalization or visualisation, and to test these technologies on various Semantic Web application domains like personalisation, reasoning with time and space or with Bioinformatics data. To foster durable impact REWERSE realises Education and Training activities targeted at Universities as well as Technology Transfer and Awareness activities targeted at European industry. As a W3C member REWERSE is involved in various standardisation activities.

Summary of Activities

Reasoning Languages and Applications

Overview. The focus of REWERSE's research activities is the definition of rule-based languages and support tools for reasoning on the Web and the application of these technologies in different application domains. In the first year, REWERSE has defined requirements and base components for the different technologies accompanied by thorough state-of-the-art surveys and use-cases. In the second year, REWERSE has defined basic parts of the languages and has implemented first prototypes of the respective technologies. In the third year REWERSE has consolidated the language definitions and has implemented functional prototypes. In the fourth and final year REWERSE has finalized its language definitions and has improved its implementations. Many groups have released stable and well documented prototypes enhanced with user-friendly interfaces. Several groups have tested the prototypes with user studies or have realized important new applications based on collaborations with other working groups. Approaching the end of the project in February 2008 the REWERSE groups have thus brought their results into a stable and documented state suitable also for use after REWERSE.

In a nutshell, in 2007 the groups have been working on the following main languages, tools and prototypes:

I1 Rule Modeling and Markup. A new release of *R2ML*, the REWERSE Rule Markup Language; *URML*, a UML-based visual Rule Modelling language with the visualisation tool *Strelka* now with a more user-friendly Eclipse based implementation; the implementation of an inference engine for the knowledge representation language *ERDF* – a rule-based alternative to OWL. All tools and languages have been embedded into an integrated set of prototype tools for rule modeling, translation, verbalization and verification.

I2 Policies. An integrated prototype for *Protune* (Provisional trust negotiation), the trust and policy negotiation framework of REWERSE; *ACE* (Attempto Controlled English), a

controlled natural language for knowledge representation with various supporting tools and applications, e.g. a bi-directional mapping between ACE and OWL.

I3 Composition and Typing. The *Reuseware Composition Framework* toolset which provides composition technology specifically for languages in the context of the Semantic Web, such as OWL, Xcerpt, Xquery; its application to Xcerpt, called *Modular Xcerpt*; work on the typing side included among others the *R2G2 Typing system* for Xcerpt; and work on HD rules, a novel hybrid reasoning method for rules and ontologies.

I4 Reasoning-aware Querying. Completion of the language specification of *Xcerpt*, a versatile rule-based Web query language; final definition of the *CIQCAG* algebra which provides scalable evaluation for Xcerpt and other Web query languages; the prototype *dlvhex*, a reasoner for HEX-programs with the goal to neatly extend existing ontologies with rules and reasoning.

I5 Evolution and Reactivity. The prototype *r3* (Resourceful Reactive Rules) providing a general Semantic Web rule engine for reactive rules, has been lifted to the semantic level and has been applied to a bioinformatics applications scenario; the event query language $XChange^{EQ}$, a declarative high-level reactivity language (enhancing Xcerpt), has been further developed and its declarative semantics has been defined; and the REX tool for verification of reactive systems has been released.

As for advanced Web applications the following languages and prototypes have been developed and extended in 2007 by the application groups A1 to A3:

A1 Time and Location. The CTTN (computational treatment of temporal notions) has been comprehensively documented. A new approach to scheduling, the Potential Field method, has been started. The CTSN system for the treatment of spatial notions has been extended with new features, in particular with indoor scenarios. A number of below listed peripheral systems and applications showcasing the main results have been developed.

A2 Bioinformatics Semantic Web. New releases of *GoPubMed.org*, an intelligent literature search engine have been launched, and new applications of the GoPubMed technology to other domains, e.g. job search have been implemented. Various bioinformatics applications have been implemented showing that the Semantic Web for Life Sciences has become a reality.

A3 Personalized Information Systems. The *Personal Reader Framework*, which implements a service-based architecture for providing various personalization functionalities on the Semantic Web, has been finished. The framework integrates user modelling and policy based protection mechanisms (realized together with the group I2). Numerous applications of the framework have been realized and very valuable recommendations for personalization on the Web have been developed.

Dissemination

In 2007 REWERSE has held various major dissemination events. Regarding education and training REWERSE successfully organized the third “Reasoning Web” Summer School (September 2007, Dresden, Germany). Regarding research dissemination the first edition of the International Conference on Web Reasoning and Rule Systems RR (June 2007, Innsbruck, Austria) – a successor of the PPSWR workshop – was co-organized by REWERSE members. Regarding technology transfer a number of successful industry

awareness events were organized by REWERSE, in particular the Semantic Web Days at the European Business Rules Conference (June 2007, Düsseldorf, Germany) and the Semantic Web Days at the I-Semantics (September 2007, Graz, Austria). As for standardisation REWERSE has been actively shaping results and activities of the W3C Rule Interchange Format (RIF) Working Group and is increasingly involved in other W3C activities, in particular the Semantic Web Education and Outreach (SWEO) Interest Group, the Health Care and Life Sciences Interest group (HCLSIG) and the Policy Languages Interest Group (PLING). REWERSE has continued its high publication activity with a total of over 548 internationally reviewed REWERSE related publications at month 44 (October 2007) of the project. A number of workshops and tutorials on REWERSE related topics (e.g. rule markup, policies, and query languages) round off the successful dissemination activities of REWERSE. Joint activities with the FP6 project MUSING complemented existing intensive co-operations with, for example, the project Knowledge Web.

Spin-off Companies

The prototype GoPubMed developed by the A2 Bioinformatics group has lead to the spin-off of *Transinsight GmBH*, which received seed funding by the Hightech Gründerfonds in Germany. The company stayed highly successful in the past year and received several awards and is involved in new projects with new customers. In Year 4, A1 has started the spin-off company *Topic Zoom* to market A1's EFGT-net.

Integration

The collaboration within REWERSE has cross-fertilized the languages and applications of the different working groups and has lead not only to interesting applications (for example, using composition technology of I3 to define a modularization of I4's Xcerpt language or using I2's Protune to improve policy protection in A3's personal reader), but also to important technical improvements of the languages (for example, typing of I3 can be used to optimize I4's Xcerpt engine,) – to mention just a few examples. Several joint activities are envisaged for the time after REWERSE.

Position of REWERSE

REWERSE has proved to be a highly productive research-oriented Network of Excellence (NoE) on Reasoning on the Web. As a research-oriented NoE REWERSE is an extremely appropriate tool for positioning European Computer Science research in international transfer activities. REWERSE has been the first "joint venture" on rules on the Web which started two years before the W3C initiated the RIF activity on this very same field, in which REWERSE is now actively involved. As for dissemination, in particular REWERSE's *Reasoning Web* Summer Schools, the *Semantic Web Days* and the *International Conference on Web Reasoning and Rule Systems (RR)* have proven to be excellent platforms for training of young researchers, for spreading novel issues to industry and for bringing various research issues fruitfully together. After the formal end of REWERSE it is already planned to run the Reasoning Web Summer School in September 2008 in Venice and in 2009 in Bozen-Bolzano. Also, the confernce RR 2008 is scheduled for beginning of November in Karlsruhe, Germany, co-located with ISWC 2008 Two EU funded projects evolving out of REWERSE activities have already been accepted in the recently launched European FP7 program, the projects KIWI (Knowledge in a Wiki) and MOST (Marrying Ontologies and Software Technology). In its final months REWERSE will focus on finalizing its prototypes, publishing the prototypes with suitable open source licenses and to complete the documentation of its results so that they are ready to be used after REWERSE has finished.

Important Work Areas

The network REWERSE focuses on three core work areas: research on Web reasoning languages and their processing, advanced Web applications requiring reasoning, and knowledge dissemination activities spreading the results to a broader audience. A tight synergy between the different work areas is taking place.

Work Area: Web Reasoning Languages and Their Processing

REWERSE integrates five research oriented working groups on Web reasoning languages and their processing.

Rule Modelling and Markup (I1). It is increasingly important to make applications like car rental systems or mortgage loan offer systems available on the Web. The processes underlying these systems are often built on the basis of business vocabularies and business rules. In order to bring the systems to the Web the vocabularies and rules have to be formulated in a suitable machine-processable way and reasoning mechanisms that can be *automatically* executed on the Web have to be defined.

The REWERSE working group I1 on "Rule Modelling and Markup" is developing tools and an integrated framework for modelling, visualisation, verbalisation and markup of rules. With these tools and technologies the practical use of rule formalisms on the Web is facilitated. The focus of the group lies on rule markup languages, which are the common basis for defining various concrete application-specific rule languages. It is expected that rule markup languages will play a central role on the Web and in distributed systems since they allow deploying, executing, publishing and communicating rules on the Web, or to exchange rules between different systems and tools. The group I1 also focuses on expressing vocabulary, facts and rules in one *visual* model for ease of usability for the end-user. Ideally, facts and rules also have to be *verbalised* for non-experts, and finally a suitable markup language is needed to publish vocabularies and rules on the Web, and to exchange them between different systems and tools.

In 2007 the group I1 has mainly worked on the following issues: a new version of the REWERSE Rule Markup Language, R2ML 0.5, has been released in August 2007 and it is planned to release version 1.0 by the end of REWERSE in February 2008. R2ML is a comprehensive and user-friendly XML rule format that allows interchanging rules between different systems and tools, enriching ontologies by rules, connecting other rule systems with R2ML based tools for visualisation, verbalisation, verification and validation. In 2007 the group has also investigated the possible use of R2ML for marking up policy rules expressed in the Protune language of the REWERSE group I2. The group I1 has also continued its work on the semi-visual rule modelling language URML (UML-based Rule Modelling Language). The group has finalized the URML metamodel which defines the abstract syntax of URML. I1 has moreover drafted an OMG (Object Management Group) Request for Proposals for a Rule Modelling extension of UML. The group has furthermore developed a concrete syntax for ERDF facts and rules and a prototype of a Jena-based inference engine for ERDF. Work on the bridge between the controlled natural language ACE (see group I2) to R2ML has been continued and a Web-accessible ACE-to-R2ML translator will be released by the end of REWERSE. Furthermore, a user-friendly new Eclipse-based version of the rule modelling tool Strelka is developed and will be released by the end of REWERSE. Prototypes are available at http://rewerse.net/I1/.

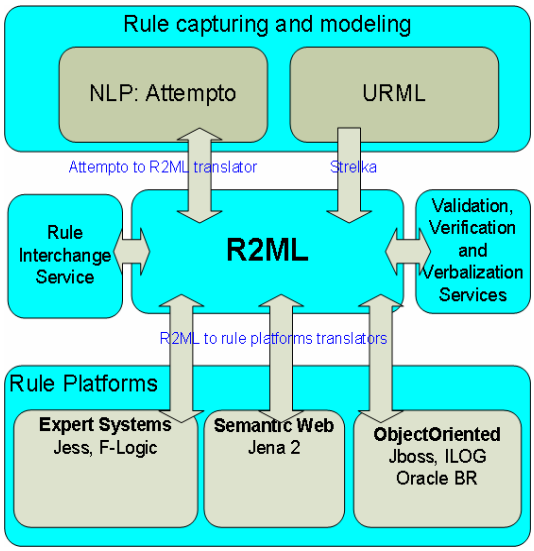


Figure 1 The I1 Rules Framework

In the final months of REWERSE and beyond the group plans to work on ERDF with the goal of establishing it as an alternative to OWL. Other plans involve the modularization of ERDF ontologies (with e.g. technologies from the I3 group), extensions of R2ML to more rule languages, and using R2ML in multi-agent applications.

Policy Specification, Composition and Conformance (I2). Granting a user access to a restricted Web service (e.g. downloading restricted project information) or performing a transaction on the Web (e.g. an order in a Web store) requires mutual interaction and trust between systems and users. The rules for establishing trust are often called *policies*. For example the system might implement a policy "Only persons that are at least 18 years old will have access". Granting access to the user requires the user's input about his/her age. To improve service usability, many of these interactions will be controlled automatically. This requires suitable languages to express and intelligent tools and systems to process and reason with policies, to generate dialogues, and to adapt the system behaviour to different situations.

The group I2 on "Policy Specification, Composition and Conformance" develops methodologies, languages and tools for specifying, enforcing, and integrating heterogeneous policies (for example security policies, privacy policies or business rules). The challenge is to reach an appropriate level of trust in systems and users under the extreme flexibility and interoperability requirements posed by modern business models, application scenarios, and software architectures. The research interests of the group include strongly related issues such as policy languages for access control and sensitive information release, trust negotiation, cooperative enforcement, natural language specifications and explanation facilities. The formulation and automated processing of controlled natural language specifications is of interest to several other working groups in REWERSE, and became a major research track within the working group I2.

In 2007 the policy track of the group I2 has been working on the completion of the Protune prototype that also integrates the explanation facility (Protune-X). By the end of REWERSE the overall framework will be integrated, tested and applied to a test case. Furthermore, the group has made significant theoretical contributions, e.g. containment checking for rule-based policies (for policy validation, policy aware service selection,

etc.). There have also been joint results between the I2 and the A3 group regarding integrating policies into the personalization system.

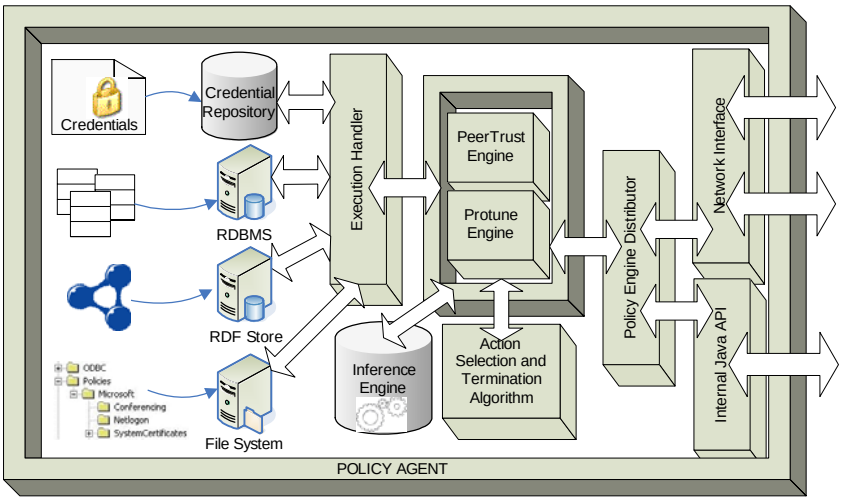


Figure 2 Protune Core Architecture

The controlled natural language thread of I2 has released version 6 of Attempto Controlled English (ACE), a powerful and expressive controlled natural language fulfilling the requirements for various applications within REWERSE and beyond. The language has reached an impressive level of maturity. In 2007, the group has also improved or newly developed various stable and user-friendly tools around ACE, among others the rule-system AceRules, the semantic wiki AceWiki, and bidirectional ACE ⇔ OWL translators (embedded in a Protégé plug-in). Most of the tools have a web-interface (http://attempto.ifi.unizh.ch/) and are thus easy to access for external users of ACE.

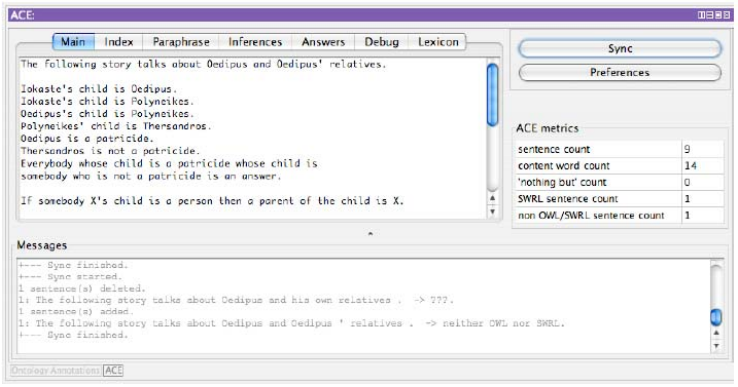


Figure 3 ACE View plug-in for Protégé

As a durable result the policy track of the working group I2 will release Protune's core implementation, free for use, by the end of REWERSE. It is planned to add a few demonstrators in the months after REWERSE.

In the remaining months the ACE track of the group I2 is working on making a public release of the ACE language. Also work on the ACE reasoner RACE will continue.

Composition and Typing (I3). The future Semantic Web will only be successful if applications can be produced very quickly. To this end, an appropriate reuse technology should be developed that treats many different ontologies, and also different ontology languages. For reuse, type systems and component models play a major role. Type sys-

tems provide reuse from the programming languages point of view; component models provide reuse from the application point of view. Interesting application fields are Web shops for companies from *different* application domains that are individually tailored yet based on re-usable inter-operable components.

The I3 group works in the two fields composition and typing. The group is creating a composition framework for service, ontology, and query components. For this, the group exploits known composition technologies of software engineering, in particular grey-box component technology, suitable for many declarative Semantic Web languages. The main challenges are to integrate different rule/ontology components and thus to enhance inter-operability. Reusability of the components will allow users to develop new Semantic Web applications much more quickly. Furthermore, type systems for REWERSE and other Web reasoning languages are developed. One final objective of the working group is also to join the two parts together, for example to provide improved compositions robustness by exploiting typing technologies. The I3 group has developed a new, partially rule-based and declarative, composition language for its Reuseware Composition Framework. The new language is an improvement over the previous language by being based on a simple pattern-matching technique. This language makes composition operator specification easier since the developer does not need to have a full understanding of the abstract syntax of the underlying language (e.g. Datalog or Xcerpt etc.). The main showcase of the Reuseware Composition Framework has been a module system for Xcerpt (*Modular Xcerpt*). Modular Xcerpt is a language extension of Xcerpt, enabling programmers to construct large query programs from smaller, better understood modules. Modular Xcerpt was developed and refined in collaboration with I4 – Munich.

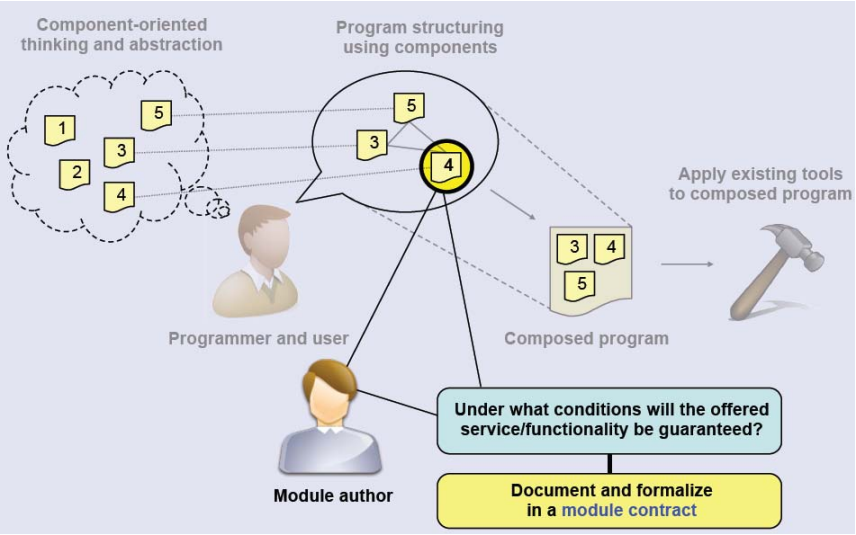


Figure 4 Modular Xcerpt: Composition

In 2007, I3 has also continued working on the *Generic Module Concept*: The module capabilities added to Xcerpt can equally well be added to other languages in a very similar way as was done to Xcerpt. Modules can be added to, for example, Datalog and its variants, requiring only minor language-specific modifications to ensure proper operation. Moreover, I3 has worked on *Role modelling with ontologies* since not only is a module concept needed for rule-based query languages, but also for other declarative languages, for example, ontology languages. The Web Ontology Language OWL has known limitations in constructing ontologies in a component-based manner. Towards improving this situation, I3 has investigated role-based modelling for ontology languages. I3 has furthermore investigated how it is possible to use the typing prototype (XcerptT – a descrip-

tive type system for Xcerpt) to check semantic conditions of the composition results. In a nutshell, in 2007 I3 has realized two component frameworks for the Semantic Web XcerptWare and OWLWare based on I3's world-first universal, grammar controlled environment Reuseware (http://www.reuseware.org).

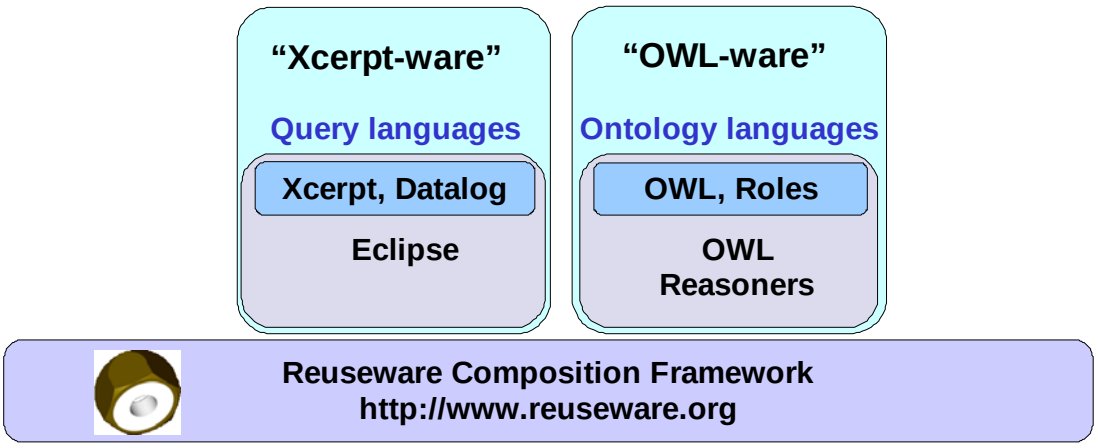


Figure 5 Working group I3's Component Frameworks for Semantic Web

In a further line of activities I3 has developed a novel hybrid reasoning method for rules and ontologies (hybrid rules with well-founded semantics). The motivation is that for the Semantic Web both rules and ontologies are needed that allow for non monotonic vs. monotonic reasoning. This approach provides a general framework that combines normal logic programs suitable for non monotonic reasoning with first-order logic providing monotonic reasoning. The semantics of the framework is based on the well-founded semantics of logic programming allowing for re-use of existing engines. A prototype approach is available at http://www.ida.liu.se/hswrl/.

For both research activities, composition and typing, I3 has developed prototypes that are linked at http://rewerse.net/I3/.

In the final months of REWERSE the group I3 will finish a tutorial on the Reuseware Composition Framework, will release an updated version of the Reuseware Composition Framework, along with examples and easy instructions on how to deploy and use the framework. The group will also provide further use-cases for Modular Xcerpt and ontology role models. Moreover, the members of I3-Dresden will be involved in the FP7 EU STREP MOST (Marrying Ontology and Software Technology) where REWERSE results will be applied and further developed.

Reasoning Aware Querying (I4). Querying, that is, the efficient and effective access to data, is one of the most essential enabling technologies for any information system. This also holds for the Web. In the Web context, *reasoning capabilities* enhance traditional search and access technologies to be able to cope with heterogeneous, incomplete, and often even inconsistent information.

Existing Semantic Web query languages lack a *general* support for querying and reasoning. Therefore, the goal of I4 is to develop a Web query and transformation language that enables more "meaningful" access to Web and Semantic Web data by integrating reasoning capabilities into the language. The technology is for example useful where a "traditional" Web search produces many results that need human interpretation, while using a query language that has flexible query and reasoning facilities would allow to automate

the “filtering” from large selections of data (such as those returned from a traditional search engine).

As a core activity, the group I4 is developing the versatile rule-based Web query language Xcerpt (http://xcerpt.org). Xcerpt has three major features: integrated access to both, standard Web data (in XML) and upcoming Semantic Web information (in RDF, Topic Maps, or OWL), powerful but easy-to-use reasoning capabilities and easy extensibility for new Web technologies. Xcerpt uses a rule-based, pattern-based, “query-by-example” style to access data in different representation formats. A prototype implementation of both Xcerpt and a user-friendly visualisation visXcerpt are available. The group has also developed the languages dlvhex and RDFLog and provides prototypes for these languages.

In 2007, I4’s main achievements have been the development of a scalable evaluation approach for Xcerpt and other versatile Web query languages. This approach, called CIQCAG, is an algebra that considerably advances previous Web query engines. It extends the frontier of highly scalable (linear time and space) tree query evaluation from tree data to a considerably larger class of data, viz. continuous image graphs that cover a large number of real-world data sets. The approach uses interval pointers and a novel data structure and thus can represent tree queries exponentially more succinct than traditional approaches. Overall, the CIQCAG algebra is the first evaluation approach for Web query languages that scales from path queries on tree data over tree queries on tree and graph data, to full graph queries on arbitrary graph data and yet yields the best known complexity for every restricted class. Moreover, in year 4 the group has proposed a formal rule-based foundation for any Web query language and Web format that accompanies the CIQCAG algebra, called CIQLog. RDF, XML, and other Web formats can be represented in CIQLog and thus can all be evaluated with the CIQCAG algebra. A number of implementations (e.g. for SPARQL, XQuery, Xcerpt) have been provided with linear time and space complexity on interesting classes of queries. With CIQLog and CIQCAG, the I4 group has developed one of the most innovative query engines for Web queries in recent years. It significantly advances previous results on the complexity of query evaluation on different shapes of data available on the Web. Where previously, linear time and space evaluation of tree queries has been shown only for tree data, the group has shown how to extend this property to many graphs, precisely to all continuous image graphs.

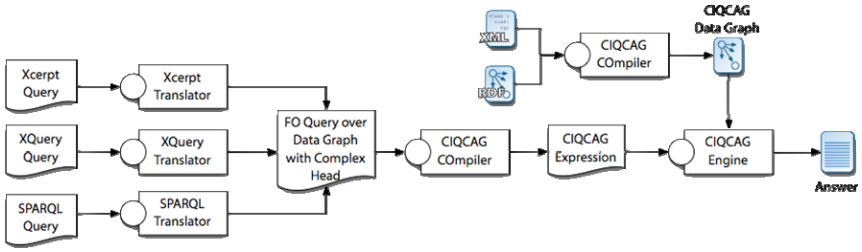


Figure 6 CIQCAG-Algebra for Xcerpt: Architecture

Beyond the initial workplan, the groups I3 and I4 have together specified a module framework for rule engines and applied that work to Xcerpt (see group I3). Progress on the implementations and APIs for I4’s languages Xcerpt and dlvhex have also been made in 2007. All results and prototypes are linked at http://queryware.com/. Under the lead of the Vienna group, I4 has conducted considerable work on the complexity and expressiveness of conjunctive and path queries on top of ontologies.

In the final months of REWERSE and beyond the group continues the development of the AMachoS prototype for the implementation of CIQCAG and its frontends for Xcerpt, XQuery etc. Work on that prototype will continue in Munich after the end of REWERSE. It is planned to use the prototpye AMachoS in several projects and cooperations in Munich.

Evolution and Reactivity (I5). The Semantic Web can be seen as a "living organism", combining evolving data sources and knowledge repositories. This dynamic character of the Semantic Web requires languages and mechanisms for specifying its maintenance and evolution. Moreover, the Semantic Web resources may need to be reactive, not only to incorporate and propagate updates (e.g. a new flight schedule), but also in that they should perceive events (e.g. a flight cancellation) and incoming messages, communicate with other components (informing the business partner) and execute actions (e.g. booking an alternate flight). Dealing with evolution and reactivity on the Web requires reasoning based on rules.

Working group I5 therefore works towards the definition of declarative rule-based languages, methodologies and tools for specifying evolution and reactivity in the Web and in the Semantic Web. Evolution and Reactivity play an important role for upcoming Web systems such as online marketplaces, scientific workflows, adaptive Web and Semantic Web systems, as well as Web Services and Grids.

Since the Semantic Web is heterogeneous it is not only important to have concrete languages for dealing with evolution and reactivity, but also to have more general frameworks within Semantic Web applications. These frameworks are ideally modular, and the *concepts* and the actual *languages* are independent. The group I5 has proposed such a general framework that is based on general Event-Condition-Action (ECA) rules. The framework deals with language heterogeneity at the rule component level for realizing reactive behaviour on the Web. For the general framework the r3 (Resourceful Reactive Rules) prototype has been developed. The prototype r3 provides a Semantic Web rule engine for reactive rules. Reactive rules are understood as RDF-resources, and the different components of each reactive rule may be specified (or even composed) using different languages. The group has developed a second prototype MARS (Modular Active Rules for the Semantic Web) that implements the general framework with sample component languages. Together with the demonstrator r3 several (sub)engines for component languages are provided. r3 can not only process rules formalized in ECA-ML, an XML ECA rule (markup) language, but it provides, in particular, engines for XChange/Xcerpt, which makes it possible to fully integrate XChange with the general framework (making it possible e.g. to use Xcerpt for querying data in the condition part of rules, or to use XChange for updating XML data in the action part of a rule). Another engine is provided for the language Prova that is being developed within REWERSE by the group A3 in Dresden. Notably, parts of the r3 prototype were implemented in Prova, thus taking advantage of the collaboration in REWERSE.

In 2007 the main achievements of the workpackage I5 were to stabilize the approach and its demonstrators and to use the ontology for reactive rules defined in the previous year to lift the approach to a semantic level. A prototype of r3 now available at the RDF/OWL level. The r3 prototype has already implemented the following languages: http, Prova, EVOLP, Xcerpt, XChange, Xquery and Xpath.

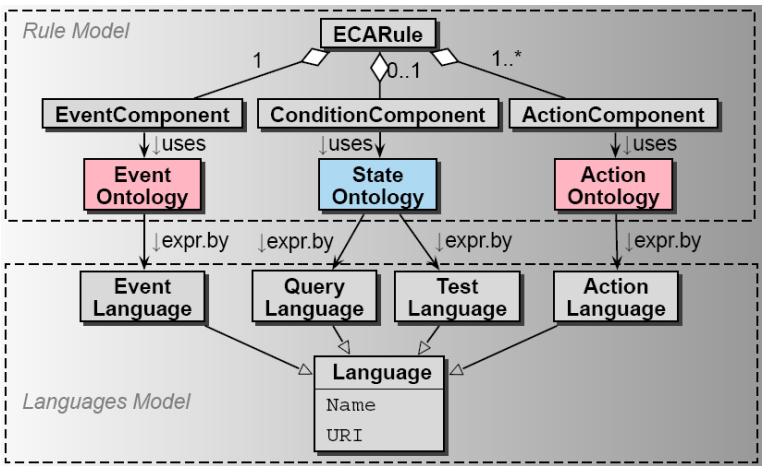


Figure 7 Modular ECA Concept: Rule Structure

The group has made various experiments with the r3 prototype, e.g. it has built two demonstrators in the domain of bio-informatics (the B-Domain for personalised mirrors of the protein databank, and the PubMed reactive classifier). The group has also continued its work on the MARS demonstrator. Furthermore, in year 4 there was progress on realistic applications in the domain of bio-informatics directly using the language Prova. Further work in 2007 was also done in the XChange update language. XChange is a declarative high-level language for programming reactive behaviour, evolution, and distributed applications on the Web. XChange embeds the facilities of Xcerpt, the query language developed by the REWERSE group I4. In 2007 in particular, the language XChange^{EQ} (where the EQ stands for *Event Queries*), as well as its declarative semantics, was defined. There was also work on verification of reactive systems that goes beyond the original workplan of the group. More specifically, the REX tool was released. REX is designed as a front end to the timed automata CASE tool Uppaal allowing users to specify rules and events in REX instead of timed automata models in Uppaal, but still taking advantage of the power of model-checking.

Towards the end of REWERSE the group I5 will stabilise the languages and prototypes, and will provide additional documentation so as to ease the use outside the project. The MARS and r3 prototypes will continue to be freely available, and supported, after the project end.

Work Area: Reasoning for Advanced Web Applications

REWERSE integrates three working groups on Web applications focusing on adaptive Web systems and Web-based decision support systems. The applications also function as test-beds for the reasoning languages developed in the research oriented working groups.

Event and Location (A1).

Almost all developments in the Semantic Web area – XML, RDF, query languages, rule languages, ontology mechanisms, etc. – are frameworks with very little built-in support for non-trivial concrete datatypes and theories. The frameworks would become much stronger and much more user-friendly if frequently used concepts could be directly integrated.

The working group A1 on “Event and Location” works on Web-based decision support for event, temporal and geographical data. More concretely, the group develops theories for “geotemporal” notions (*next Christmas*), “geospatial” notions (*closest pharmacy*), and for topics (*music event*) ready for the integration into, for example, query languages or ontology mechanisms. A use-scenario is for example if a user queries a Web based XML database about cinemas and movies in Munich e.g. with “Which cinema in the eastern part of Munich plays a movie about a sports event this weekend?” This query combines temporal (*this weekend*), spatial (*eastern part of Munich*) and topical (*sport event*) information. Reasoning is required to match “eastern part of Munich” for example with addresses in a database (geospatial reasoning), “this weekend” to a personal specification of “weekend” (geotemporal reasoning), and it must understand the topic “sports event”. The primary goal of the group A1 is to provide the theoretical and implementational basis for the integration of this kind of reasoning into the REWERSE query languages. The main challenges concern first the development of precise and versatile theories, and then the integration into XML query languages, ontology specification systems and logic based inference systems.

In 2007 the group continued its work on a general software architecture for both, geotemporal and geospatial information processing.

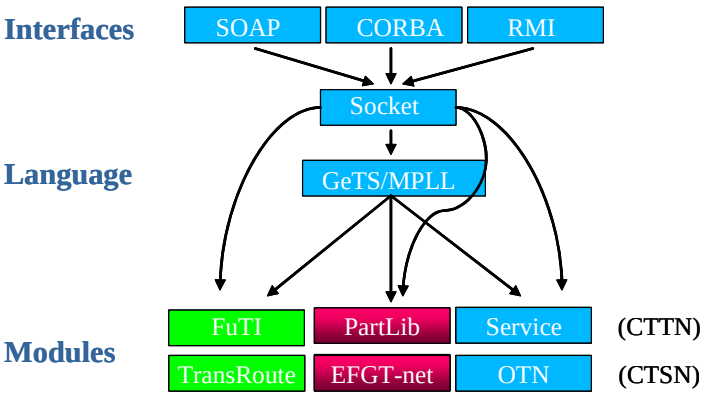


Figure 8 A General Architecture for CTSN and CTTN

For geotemporal information processing the group developed the CTTN-system (Computational Treatment of Temporal Notions) the code of which has been extensively documented in the past year. In addition a more abstract documentation of all the components is in preparation. As a next step the group developed the concept for a CTTN-based scheduling system which uses a new approach, potential field constraint solving. This approach has a number of advantages over other constraint solvers: it combines very different kinds of objects (time points, crisp and fuzzy intervals of different types), very different kinds of relations, in particular fuzzy relations between fuzzy intervals; it has a very fine grained treatment of soft- and hard constraints, it can deal very well with inconsistencies, and it can take into account global constraints, for example, equal distribution of time objects over an interval. A concrete implementation will, however, not be possible within REWERSE and is planned to be completed in new projects after REWERSE.

For geospatial information processing the group designed and partially realised the CTSN-system (Computational Treatment of Spatial Notions). In 2007, various new features have been added or investigated. The graphical user interface is now rule based where the visualisation rules are written in OWL. The transport network graphs are now hierarchically structured and can be distributed over a network of computers. A new fo-

cus of the work are indoor scenarios where first results are available on partitioning maps of buildings into smaller units which can be used as landmarks for guiding people through a building.

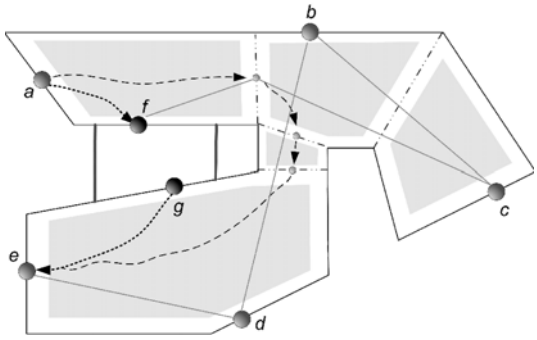


Figure 9 TransRoute Indoor Navigation: Convex Decomposition Algorithm

The group is still working on an integrated system combining all the developed features. A by-product of A1's work is the local data stream management system L-DSMS, which is a software engineering tool which allows one to specify networks of processing nodes for data streams. In 2007 this tool has been complemented by a web-based visualisation component (Visual L-DSMS), which allows one to observe and manipulate all the processing nodes at run time.

The third major system which has been developed is the EFGT Net (Events, thematic Fields, Geographical and Temporal notions). The EFGT network contains in the meantime more than seventy thousand entries about events, together with their geographic, temporal and thematic classification. A spin-off company, Topic Zoom, has been founded in the last year by Prof. Klaus Schulz to market the EFGT-net.

For the time after REWERSE the group plans to integrate the new idea of a potential field scheduler into the CTTN-kernel. Regarding geospatial information processing the group plans to integrate the various components developed so far and additionally apply the technologies in new projects. Regarding EFGT-net the technical work itself is finished. The net can in particular be used for semantic indexing of texts. The technology will be marketed in a spin-off company Topic Zoom.

Bioinformatics Semantic Web (A2). With the explosion of online accessible bioinformatics data and tools, systems and data integration has become very important for further progress. Currently, bioinformatics relies heavily on the Web. But the Web is geared towards human interaction rather than automated processing. The REWERSE group A2 on "Bioinformatics Semantic Web" works on using rules and reasoning for annotating and extracting biological data automatically thus supporting biomedical researchers.

Imagine a scientist is searching for genes with certain properties that are likely to be responsible for a certain disease. To find the information from the online accessible data often requires time-consuming manual search since the data on the Web are not designed for automated use. Solving this problem and retrieving information from Web data sources automatically requires a suitable annotation of the data, the possibility to formulate complex queries and rules for the mediation of the different data sources, techniques for the consistent integration of different Bioinformatics data and – to enhance user-friendliness – adaptive portals for molecular biologists.

The goal of the REWERSE Bioinformatics Semantic Web group A2 is to demonstrate novel, reasoning-based solutions for the above requirements thus working towards a Semantic Web for the life sciences. The group deploys rules and reasoning for ontologies and text mining, gene expression data analysis, metabolic pathways, structure prediction and protein interaction. Enabling these tools on the Web sets the foundation for a *Semantic* Web for life sciences.

In 2007 the group has continued building and improving prototype applications to demonstrate the idea of a rule-based Web for bioinformatics. In particular in the past year the group has continued its work on the ontology based literature search engine GoPubMed (http://www.gopubmed.org). GoPubMed classifies abstracts resulting from a PubMed search using Gene Ontology and Medical Subject Headings (MeSH) as background knowledge. By using ontological background knowledge GoPubMed can give an overview over large query results and can answer questions. One of the benefits of such an ontology-based literature search is the categorization of abstracts according to a specific ontology, allowing users to quickly navigate through the abstracts by category and providing an overview of the literature. It can also automatically show general ontology terms related to the original query, which often do not even appear directly in the abstract.

In the past year GoPubMed has been enhanced and now uses the competition winning algorithm for Gene/Protein name recognition, has added author disambiguation and new concepts help answering biomedical questions.

Figure 10 Figure 11 Ontology based literature search with GoPubMed

In 2007, the group A2 has also worked on ontology generation. The background is that the engineering of ontologies is still a new research field. A well defined theory and technology for ontology construction does not yet exist. This means that many of the ontology design steps remain manual and a kind of "art" and intuition. The group A2 therefore investigated a method to *automatically* generate the vocabulary for ontologies in the domain of lipoprotein metabolism and compared it with other approaches. Besides other activities in year 4 the group has also applied its methodology used in GoPubMed to other domains, viz. finding jobs for people and finding people for jobs. The group is about to finish the corresponding prototypes JobJob (Jobs for people) using TransWiki, a semantic based Wiki system based on the GoPubMed framework. To find people for jobs the group has generated AuthorProfiles from Authors in PubMed (including author disambiguation mechanisms). Other activities concerned – among others – the release of Biocham 2.7 alpha http://contraintes.inria.fr/BIOCHAM/ which uses constraint satisfaction for sequence alignment. Moreover, work has continued on KitAMO, a tool for evaluating and comparing ontology alignment algorithms (http://www.ida.liu.se/~iislab/projects/KitAMO/) and on KitEGA, an environment for

evaluating grouping algorithms (http://www.ida.liu.se/~iislab/projects/KitEGA/) with award winning results.

A2's spin-off company Transinsight remains to be very successful. The company is closely co-operating with companies like Unilever and has started a new project with the German Institute for Risk Assessment.

By the end of REWERSE the group will make its final releases of the Job search engines and will bring the other mentioned prototypes into a final state. For the time after REWERSE the group plans to contribute to W3C activities within the HCLS group regarding an Alzheimer use case, it will work on OntoPro, the goal of which is to automatically classify proteins based on formal descriptions of class membership and more and it will apply its textmining methodologies to other domains.

Personalized Information Systems (A3). The vision of the Semantic Web is that machines are enabled to understand the meaning of information on the Web. This idea calls for smarter applications that better support humans in carrying out their tasks. In particular, applications are interesting that can retrieve, process and present information in enhanced user-adapted ways. The Semantic Web thus calls for "Personalized Information Systems", that is, information producing systems that can autonomously interoperate – either with humans or with other systems –, tailoring their processing and its outcome to specific requests.

The goal of the REWERSE group A3 on "Personalized Information Systems" is to optimize the access to digital information on the Web according to the needs and requirements of each end user. The work of A3 involves three action lines: theoretical foundations of personalization in the context of the Semantic Web, algorithms and implementations of personalization functionality in the Semantic Web, and – in close co-operation with other REWERSE groups – test and validate rule and reasoning languages for the purpose of personalization. The latter is particularly interesting since to realise powerful Personalized Information Systems on the Web the reasoning mechanisms investigated in REWERSE are highly relevant, in particular reasoning about policies, mechanisms for handling failure, dealing with updates and events in the Web context, etc. Possible use-scenarios of personalization on the Web are manifold. The group particularly investigates personalized search on the Web, E-learning, tourist information systems, domotic systems, health care etc. The main challenges are the *automated* extraction of *semantic* information from the Web, the efficient use and implementation of personalization rules to reason over the data, and personalization and visualization services to syndicate the results.

The A3 group has shown how reasoning enables personalization in the Semantic Web. Various prototypes and applications have been developed, among them the Semantic Web Challenge Award laureate "Personal Publication Reader". The Personal Publication Reader is part of the more general "Personal Reader Framework" (www.personal-reader.de) that A3 is developing. The idea is that when a user is viewing some Web Content (the *Reader* part of the Personal Reader) s/he receives additional, personal information on the context of this particular Web content (the *Personal* part of the Personal Reader). The core of the Personal reader is a modular framework of components / services: for providing the user interface, for mediating between user requests and available personalization services, for user modelling, for providing personal recommendations and context information, etc.

In the past year 2007 the group has in its systems activity line completed the Personal Reader Framework (http://www.personal-reader.de). It has integrated a user modelling service for effective cross-system personalization and a policy based protection of sensible user model information to ensure privacy protection and secure communication. The used policy-framework has been developed by working group I2. Demos of these activities have been made available.

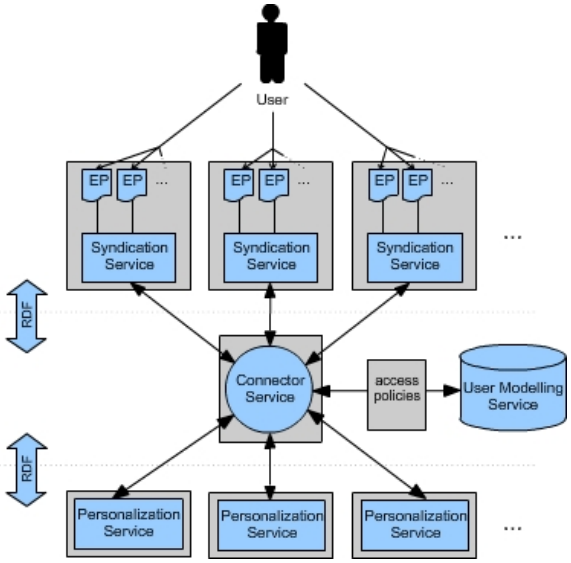


Figure 12 Personal Reader Architecture (awarded at 3rd ISWC 2006)

Regarding testbeds the group has worked on Personalization in an E-learning domain, in particular on Curricula Validation and Curricula Models resulting in the release of a new curriculum planner application. Progress has also been made on the BEATCA system offering Map-based Intelligent Navigation in WWW. The group is currently working on Enabling Advanced and Context Dependent Access Control in RDF. Regarding the more theoretical action line the group has – from the research work carried out in the previous years – derived recommendations for realizing personalized applications in the Semantic Web and in semantics-based systems and has published lessons learnt and recommendations.

In the future the group plans to apply its results on personalization in different areas, e.g. personalizable interfaces (like iGoogle), personalizable services (SOA), personalizable contents (Web 2.0). With the GroupMe! Prototype the group has already implemented an demonstrator that integrates Semantic Web technologies with Web 2.0 approaches.

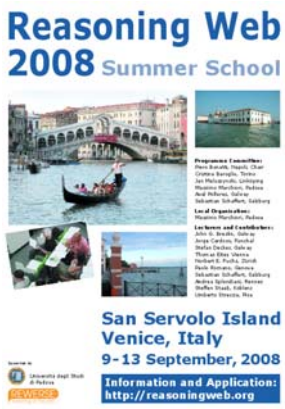
Work Area: Knowledge Dissemination on Reasoning on the Web

REWERSE integrates Activities groups that aim at the dissemination of knowledge created within REWESE. Their goal is to spread excellence throughout the European region and outside of it in a way that guarantees a durable effect. REWERSE contains four activity groups: “University Education and Training”, “Technology Transfer and Awareness”, “Standardisation” and “Presentation, Reviewing and Assessment”.

Education and Training (ET). The main objective of the group on “Education and Training” is to initiate and foster a durable education on Semantic Web issues. The group focuses on three action lines: running a yearly Summer School, developing and publish-

ing an infrastructure for Web based Semantic Web courses, and developing Web based graduate curricula and courses for Semantic Web topics.

In 2007 the group has successfully organized the third Summer School "Reasoning Web 2007" which was held on 3-7 September 2007 in Dresden, Germany, with 63 participants. The objective of the Summer School Reasoning Web 2007 was to provide a coherent introduction into Semantic Web methods and issues with a particular focus on reasoning. A highly appreciated Summer School tutorial volume appeared in the Lecture Notes in Computer Science series by Springer-Verlag as LNCS 4636. Representatives from the FP6 projects Knowledge Web and MUSING projects were active as lecturers showing the good co-operation between European funded projects. For details about the Summer School see http://reasoningweb.org/2007/.



The fourth Summer School "Reasoning Web 2008" will be held in Venice, 7-11 September 2008, after the end of REWERSE. The focus will be on the actual use of Semantic Web rule languages in the Reasoning on the Web application fields such as Bioinformatics, Web Services, Multimedia, and Natural Language Processing. The Summer School will point out which Semantic Web ideas and techniques have actually been adopted so far, which were not (and why), and which application needs are still waiting to be tackled with semantic techniques. Furthermore, there are already concrete plans to hold "Reasoning Web 2009" in Bozen-Bolzano in September 2009.

In 2007 the Education and Training group has also – in co-operation with the Knowledge Web Network of Excellence – contributed to the Web repository REASE, a repository of the European Association for Semantic Web Education (EASE) for e-learning units in the area of Semantic Web (cf. http://rease.semanticweb.org). REASE supports sharing knowledge for Higher Education as well as for industrial education in the area of Semantic Web and is open to any member of the academic or research community. The group ET contributed a set of graduate courses, including the Reasoning Web 2007 electronic course material. Altogether , REWERSE has – by end of November 2007 – contributed 67 learning materials to REASE. REWERSE's ET group has also contributed to technological improvements of REASE and – in collaboration with the technology transfer group TTA – worked on increasing the attractiveness of REASE for industrial users. Moreover, ET contributed to the development of a Semantic Web Topic Hierarchy published on *ontoworld.org*, the wiki for the Semantic Web community (http://wiki.ontoworld.org/wiki/Semantic_Web_Topic_Hierarchy). The taxonomy gives a classification of Semantic Web related topics with short explanations. The topic hierarchy has been used for various purposes, e.g. for classification and search of REASE's e-learning material, for the development of a joint curriculum for a shared masters program in the European Academy for the Semantic Web Education (http://ease.semanticweb.org), an initiative founded by the Knowledge Web Network of Excellence and joined and supported by REWERSE. The Semantic Web Topic Hierarchy is a durable contribution initiated by REWERSE and developed jointly by REWERSE and Knowledge Web. Maintenance of the hierarchy after REWERSE's end is among the objectives of EASE.

The durable effects of the REWERSE ET group are manifold. In particular the annual Summer School "Reasoning Web" will be run after REWERSE, the repository of e-learning materials REASE (established jointly with Knowledge Web) will be run after

REWERSE's end by the European Association for Semantic Web Education EASE, and the Semantic Web Topic Hierarchy (established jointly with Knowledge Web) gives a basis for the development of Semantic Web curricula.

Technology Transfer and Awareness (TTA). The goal of the "Technology Transfer and Awareness" group TTA is to increase the awareness of REWERSE's results and research topics in industry. More generally, the group also aims at increasing the awareness of Semantic Web topics in general. The activities include in particular the organisation of awareness events and promotional material targeted at industry and the general creation of a technology transfer infrastructure within REWERSE. Furthermore, the group works – in co-operation with ET – on industry education, for example, Web based courses on Semantic Web issues.

In 2007 the activity group TTA has organised several industry awareness events, for example the Semantic Web Days at the European Business Rules Conference (18-20 June 2007, Düsseldorf, Germany) and the Semantic Web Days at the I-Semantics (5-7 September, Graz, Austria). The Semantic Web Days series (http://www.semantic-web-days.net/) that was initiated by REWERSE in 2005 provides an exchange platform for innovative companies and research institutions on industry relevant Semantic Web topics. Moreover, in 2007 the TTA group has contributed to the European Semantic Technology Conference 2007 (ESTC), (31 May - 1 June, Vienna, Austria).

Furthermore, TTA has actively participated in W3C Semantic Web Education and Outreach (SWEO) Interest Group. Within this group TTA has been responsible for the production of a Semantic Web brochure and a Semantic Web logo (see below). In 2007, the TTA group has also worked on developing specific guidelines for REWERSE tutorials targeted at an industry audience. Moreover, TTA has– in co-operation with the ET group – contributed to the further development of the REASE educational infrastructure. This comprises contribution and presentation of material and also dissemination work for REASE (e.g. a REASE flyer has been produced by TTA).

One of the many durable effects of the TTA group is its support for subsequent EU projects regarding company and press contacts and exchange of strategies. Also the various materials produced by TTA, the contributions to REASE, the development of guidelines for industrial courses, and numerous contacts to industry and awareness raising results demonstrate the important long-lasting influence of TTA.

Standardisation (STD). Since November 2005 REWERSE has a dedicated standardisation activity group. The group is devoted to promoting outcomes of REWERSE's research within standardization organisations and providing feedback towards REWERSE on relevant standardisation work. To this end, the group performs an up-to-date technology watch within standardization organisations and within the REWERSE project.

REWERSE is a W3C Member since October 2005. Currently, REWERSE members are actively involved within the standardization work of the W3C Rule Interchange Format Working Group (RIF), the W3C Semantic Web Health Care and Life Sciences Interest Group (HCLSIG), the Semantic Web Education and Outreach (SWEO) Interest group and REWERSE has been participating also within the newly established W3C Policy

Languages Interest Group (PLING). PLING has been chartered from September 2007 to June 2008 to be a forum for discussing policy languages and their combination.

In 2007, the main achievements of the Standardization Activity concentrate around technical work and on dissemination results The technical work has focused on a standard interchange format for rules within the W3C RIF WG. The dissemination activities have focused on the W3C RIF WG outcomes and, more general, the Semantic Web vision. More concretely, REWERSE has contributed to the following outcomes of the W3C RIF WG work on technical design: A refined version of the Second Public W3C Working Draft of "RIF Use Cases and Requirements" is published; REWERSE has started an initiative towards production rules (PR) and Event-Condition-Action (ECA) rules for RIF. This initiative has been a fundamental incentive for the ILOG proposal for a production rule dialect for RIF – RIF-PRD. Within RIF a simple format for interchanging logic rules – the RIF Basic Logic Dialect (RIF-BLD) – has been developed

Regarding dissemination achievements: A Semantic Web flyer for W3C was designed and produced mainly by REWERSE's groups STD, ET, and TTA. The Semantic Web flyer is currently the official W3C collateral material on Semantic Web issues. The design and printing courtesy of REWERSE is explicitly stated in the flyer thus giving a durable visibility to REWERSE. Also, REWERSE related proceedings (PPSWR, RR, Reasoning Web) can be found in the list of Semantic Web books of the W3C SWEO IG, cf. http://esw.w3.org/topic/SwBooks. The STD group has furthermore presented the main outcomes of the W3C RIF WG at different kinds of events: An industry-oriented presentation was given at the Semantic Web Days 2007 @ European Business Rules Conference (EBRC) 2007, held in Düsseldorf, Germany. A more detailed tutorial was prepared for the Springer book and the corresponding presentation at the Reasoning Web 2007 Summer School, cf. http://reasoningweb.org/2007/.

In general, the standardization efforts of REWERSE within the W3C have had great impact on and positively affected the image of REWERSE as a whole (and, of course, of its members) not only within the W3C community but also within companies interested in W3C outcomes.

Presentation, Reviewing and Assessment (PRA). The activity group "Presentation, Reviewing and Assessment" monitors all important REWERSE results and activities. The group communicates these achievements to the European Commission, to the IT professional communities and to a wide audience of interested people. In particular, the group publishes all REWERSE related publications, deliverables, demonstrators and other important information on http://rewerse.net thus creating a valuable and up-to-date research archive on topics related to Rules and Reasoning on the Web.

Furthermore, members of the PRA group have been involved in the initiation of the new conference series, the International Conference on Web Reasoning and Rule Systems (RR) the first edition of which took place on 7-8 June 2007 in Innsbruck (Austria). RR aims to be the major forum for discussion and dissemination of new results on all topics concerning Web Reasoning and Rule Systems. RR brings together three previously separate events: The International Workshop on Principles and Practice of Semantic Web Reasoning (PPSWR) initiated by REWERSE, the International Conference on Rules and Rule Markup Languages for the Semantic Web (RuleML), and

the International Workshop on Reasoning on the Web (RoW). RR 2008 will be held on 31 October - 2 November 2008 in Karlsruhe (Germany) co-located with ISWC 2008. RR 2008 will build on the success of RR 2007, which received enthusiastic support from the Web Rules community.

In the final months of REWERSE the PRA group plans to collect and co-ordinate the production of documentation and demonstration materials from the various REWERSE working groups. The goal is to give a concise and comprehensive overview of the main REWERSE results.

User Involvement, Promotion and Awareness

Main Contacts and Co-operations

FP6 projects

- Knowledge Web (http://knowledgeweb.semanticweb.org/)
- MUSING (http://www.musing-project.eu/)
- SEKT (www.sekt-project.com/)
- ASPIC (www.argumentation.org)

Others

- Salzburg Research (www.salzburgresearch.at)
- Semantic Web Company (www.semantic-web.at)
- W3C (www.w3c.org)
- DERI Innsbruck (www.deri.at) and DERI Galway (www.deri.ie)
- ELEONET (www.eleonet.org/)
- RuleML Initiative (www.ruleml.org)
- Various companies and institutions: Betfair, ILOG, NRC Canada, OMG, ruleCore, Tibco, TU Munich, IBM Research (CH), Ordnance Survey Research, Ontoprise, TMMS, T-Systems, SAP CEC, interface:projects, SKYTEC, Volvo, Transinsight, Unilever, SAP, German Insitute for Risk Assessment, Comarch, BOC, Sun Microsystems, WM-data Danmark, and more

Main Promotion and Awareness Events

Main Events

Summer School Reasoning Web 2007

3-7 September 2007
Dresden, Germany
http://reasoningweb.org/2007/

RR 2007 (“International Conference on Web Reasoning and Rule Systems”)

7-8 June 2007
Innsbruck, Austria
http://www.rr-conference.org/RR2007/

Semantic Web Days 2007

SWD @ I-Semantics

5-7 September 2007
Graz, Austria
http://www.semantic-web-days.net/semantics_start.htm

SWD @ EBRC

19-20 Juni 2007
Düsseldorf, Germany
http://www.semantic-web-days.net/EBRC_start.htm

Tutorials by REWERSE Groups

- Tutorial on “Model Driven Semantic Web Engineering” at WWW2007 in Banff, Canada (group I1)
- Tutorial on “Rule Modeling and Interchange” at ESTC 2007 in Vienna, Austria (group I1)
- Tutorial on “Rule Modeling and Interchange” at EBRC 2007 in Düsseldorf, Germany (group I1)
- Tutorial on “Semantic Web Rule Languages and Rule Interchange on the Web” at ESWC’08 in Teneriffe, Spain (planned by group I1)
- Tutorial on “Rule-Based Policy Representation and Reasoning for the Semantic Web” at the Reasoning Web Summer School 2007 (group I2)
- Course on “Foundations of Rule-Based Query Answering” at the Reasoning Web 2007 Summer School (group I4)
- Tutorial on “Answer-Set Programming for the Semantic Web” at European Semantic Technology Conference 2007 (ESTC) (group I4)
- Course on “Reactive Rules on the Web” at Reasoning Web 2007 Summer School (groups I5 and STD)
- Course on “Rule Interchange on the Web” at Reasoning Web 2007 Summer School (group STD)

Other Promotion Activities

The groups ET, TTA and STD have been responsible for the production of a Semantic Web brochure and a Semantic Web logo that has been published by the W3C Semantic

Web Education and Outreach (SWEO) Interest Group. Moreover, TTA has produced a REASE Flyer.

Figure 13 Dissemination material produced by REWERSE

Spin-off Company

The intelligent literature search engine GoPubMed.org, developed by the REWERSE working group A2 on Bioinformatics, has lead to the spin-off Transinsight GmbH, which received seed funding by the Hightech Gründerfonds in Germany. In 2007 the company has been successful in acquiring new projects.

Transinsight develops intelligent search technologies for the life sciences.

TRANSINSIGHT

Transinsight is an award-winning start-up company providing products and solutions for intelligent search technologies in the life sciences.

gopubmed
Searching is now sorted!

The search engine GoPubMed reduces search time and increases the relevance of search results significantly. GoPubMed uses a generic technology which can be adopted to other domains like medicine and the food industry.

Additionally a spin-off company “Topic Zoom” has just been founded by Prof. Klaus Schulz from the A1 group to market the EFGT-net.

Project-level involvement

Publications. At month 44 REWERSE members have in total contributed to over 548 internationally reviewed publications showing that REWERSE’s focus is perfectly targeted to current research needs (cf. http://rewerse.net/publications.html).

Standardisation. REWERSE holds a W3C Consortium membership since October 2005 granting REWERSE members access to W3C working groups. REWERSE’s standardisation activities include the establishment of a standardisation co-ordinator and a standardisation task force. REWERSE actively participates in several W3C activities, in particular

- Rule Interchange Working Group RIF (http://www.w3.org/2005/rules/wg.html)

- Semantic Web Health Care and Life Sciences Interest Group HCLS (http://www.w3.org/2001/sw/hcls/)
- Policy Languages Interest Group PLING (http://www.w3.org/Policy/pling/)
- Semantic Web Education and Outreach Interest Group SWEO (http://www.w3.org/2001/sw/sweo/)

PhD Theses. REWERSE has been very successful in the education and involvement of young researchers in its project. REWERSE expects a total of 41 PhD theses by REWERSE members, 23 of which will be completed within the lifetime of REWERSE. Beyond that a total of 22 PhD theses in the surrounding of REWERSE are expected by non-REWERSE members.

Meetings. Several project meetings and inter-WP collaboration workshops have intensified the co-operation within REWERSE and beyond.

Future Work

REWERSE will officially be finished by the end of February 2008. In its final months, REWERSE will bring its languages, results and demonstrators into a final state so that they are ready to be further used after REWERSE. The demonstrators will or have already been made publicly available, mostly as open source projects. Furthermore, tutorials and other material explaining the main features of the prototypes and the research results will be finished. Thus REWERSE has given a comprehensive definition, documentation and implementation of a number of complementary reasoning languages for the Web and their application in Advanced Web applications.

REWERSE will leave behind various durable results. First of all, a number of *events and activities* will continue: the Summer School Reasoning Web, the International Conference on Web Reasoning and Rule Systems RR, and – together with Knowledge Web – the REASE repository of Semantic Web learning units maintained by the EASE association. REWERSE's *research outcomes* are documented in a huge amount of peer-reviewed publications and prototypes that will remain available at http://rewerse.net/. Regarding *skills and networks* REWERSE has been very successful in educating young researchers in an international research environment. REWERSE expects a total of at least 41 PhD theses by REWERSE members. Beyond that, the REWERSE network created excellent international working groups with cross-fertilization across countries, institutions and different research fields. Moreover, the REWERSE activity groups ET, TTA, STD and PRA offered a very valuable *dissemination support* for the research and application groups that would have been impossible without REWERSE. This dissemination support considerably increased and still increases the outreach to industry and academia. The *transfer of the research results* to industry has already been initiated, not only by the two spin-off companies Transinsight and Topic Zoom, but also by new European funded projects with industry participation, and by a large number of contacts.

REWERSE has produced a huge quantity of results many of which go beyond the original workplan. Years will be needed to fully exploit all results. This also holds for many new issues that emerged during REWERSE and that will or can be investigated after REWERSE.

Further Information

Information on the Web

REWERSE Web Site	http://rewerse.net
Working Groups	http://rewerse.net/workinggroups.html
Activity Groups	http://rewerse.net/activities.html
Participants	http://rewerse.net/participants/index.html
Publications and Deliverables	http://rewerse.net/publications.html
Demos and Presentations	http://rewerse.net/downloads_demos/
Contact	http://rewerse.net/contact.html

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Project Facts in Brief

Project Acronym	REWERSE
Project Reference	506779
Framework	FP6
Priority	Priority 2, IST
Action Line	Semantic-based knowledge systems
Contract Type	*Network of Excellence*
Start Date	2004-03-01
Duration	48 months
Project Funding	5 150 000 € (European Commission), 360 720 € (Switzerland)
Participants	27 from 14 European countries
Website	http://rewerse.net